A Quantitative Analysis of China's Structural Transformation[*]

Robert Dekle　　　　　　Guillaume Vandenbroucke

University of Southern California　　University of Southern California

September 14, 2006

Abstract

Between 1978 and 2003 the Chinese economy experienced a remarkable 5.7 percent annual growth of GDP per labor. At the same time, there has been a noticeable transformation of the economy: the share of workers in agriculture decreased from over 70 percent to less than 50 percent. We distinguish three sectors: private agriculture and nonagriculture and public nonagriculture. A growth accounting exercise reveals that the main source of growth was TFP in the private nonagricultural sector. The reallocation of labor from agriculture to nonagriculture accounted for 1.9 percent out of the 5.7 percent growth in output per labor. The reallocation of labor from the public to the private sector also accounted for a significant part of growth in the 1996-2003 period. We calibrate a general equilibrium model where the driving forces are public investment and employment, as well as sectorial TFP derived from our growth accounting exercise. We show that the key driving forces behind China's structural transformation are TFP growth in the private nonagricluural sector and public capital accumulation.

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, there has been a sharp transformation of the Chinese economy, as millions of workers left the agricultural sector, to join the industrial sector, reducing the share of workers in agriculture from over 70 percent of all workers in 1978, to under 50 percent in 2003. What are the driving forces of this rapid growth and structural transformation of the Chinese economy? In this paper, we develop a quantitative, general equilibrium growth model to try to capture China's recent growth and structural transformation.

There has been a wealth of papers addressing the issue of structural transformation in the recent years. For instance, Laitner (2000) shows that saving rates can be affected by the industrialization process. Hansen and Prescott (2002) give an account of the transition from stagnation to growth in a model where, through time, the labor force moves from a land-intensive technology to a less land-intensive technology. Gollin, Parente and Rogerson (2002) study the role of agricultural productivity in the development process. In their analysis, development is associated with the declining weight of agriculture in the economy. Recently, Ngai and Pissarides (2006) show that balanced growth is compatible with a reallocation of the labor force across sectors.

Our model has three sectors, the agricultural sector, the nonagricultural private sector, and the nonagricultural public (government) sector. The agricultural and the nonagricultural private sectors are profit maximizing; but we leave the objective of the Chinese public sector unspecified; the public sector is assumed to simply extract labor and capital from the rest of the economy. China is nominally still a socialist economy. At the beginning of our period, 1978, the public sector produced nearly all of nonagricultural output. Even in 1990, public sector output was over 90 percent of nonagricultural output. It may not be appropriate to assume that the Chinese public sector is profit maximizing. Chinese public enterprises may, for example, keep redundant workers employed, to maintain social stability. In addition, provincial governments may try protect local public enterprises from interprovincial competition by erecting trade barriers, thereby creating inefficiencies. Thus, for China, it is important to separate the private from the public sectors.

The mechanism of our model is as follows. Technological progress is exogenous in all three sectors, but is highest in the nonagricultural private sector. This more rapid technological progress in the private nonagriculture sector reduces nonagricultural prices relative to agricultural prices. If agricultural and nonagricultural goods are substitutes in the utility functions of consumers, then the reduction in the relative price of nonagricultural goods will increase the demand for nonagricultural goods, resulting in a shift in labor from the agricultural to the nonagricultural sector. However, we show that this mechanism alone is not sufficient to account for China's structural transformation, especially prior to 1995, since China's nonagricultural private sector was simply too small. We show that the exogenous (policy induced) expansion of the nonagricultural public sector prior to 1995 played a crucial role in drawing labor out of agriculture. Using plausible parameter values, we simulate our model and find that the model tracks the historical employment share of agriculture, and the labor productivities of all three sectors remarkably well. Thus, the two main driving forces for China's structural transformation– or the decline in the agricultural share of employment–are the rapid technological progress in the private nonagricultural sector, and especially prior to the mid-1990s, the expansion of the public nonagricultural sector.

Our analysis is close, in spirit, to that of Ngai and Pissarides (2006). All goods have unit income elasticity. Thus, the engine of the reallocation of labor is the change in the relative price of goods. The latter is propelled by differences in productivity growth across sectors. More precisely, technological progress is exogenous in all three sectors, but is highest in the nonagricultural private sector. We show, using counterfactual experiments, that the expansion of the public nonagricultural sector and TFP growth in the private nonagricultural sector are key to understand the transformation of the Chinese economy. The intuition behind this result is that both variables operate toward a reduction of the relative price of the nonagriculural good. In the case of the public sector, the mechanism is simply that an increase in the stock of public capital acts in a way that is similar to an increase in productivity. To obtain such results, a key parameter is the elasticity of substitution between the agricultural and the nonagricultural good. We pick this parameter, along with the stock of public capital, to minimize the sum of squared differences between the model's share of employment in agriculture and its empirical counterpart. We check that the model is consistent with the fact that the Chinese economy was mostly public during this period: the share public investment predicted by the model matches closely its empirical counterpart both in terms of level and changes. Thus, the calibrated version of our model is consistent with the "size" of the Chinese government in the economy, when it is measured as its share of investment. In the model economy, a social planner would not allocate any resources to the public sector which is less productive than the private nonagricultural sector. Thus, given the size of the public sector, the model economy is largely "distorted," as was, probably, the Chinese economy.

Our model differs from traditional stories of structural transformations in developing countries and in China. In the well-known Lewis-Fei-Ranis framework, a sharp spike in agricultural productivity raises agricultural output, reducing the price of agricultural goods relative to industrial goods. If agricultural and industrial goods are complements in the utility functions of consumers, demand for both agricultural and industrial goods increase. Given the higher productivity growth in the agricultural sector, however, there is less requirement for labor in that sector, even to supply this increased demand, and labor flows from the agricultural to the industrial sector.

Although many descriptive accounts of China's structural transformation exist, to the best of our knowledge, our paper is one of the first quantitative growth models of the Chinese economy from 1978 to 2003. The only other paper that analytically tries to explain China's structural transformation is Brandt, Hsieh, and Zhu (BHZ, 2005). BHZ apply the more traditional framework in which higher productivity growth in the agricultural sector pushes labor out of the agricultural sector into the industrial sector. The authors do not examine the role of the Chinese public sector, and they also place more emphasis than we do on how frictions in intersectoral labor mobility can explain the pace of the country's

structural transformation. While we explicitly include labor mobility costs in our model, we find from our quantitative experiments that these costs play a rather minor role in explaining structural change in China.

Another contribution of our paper is the development of a consistent set of Chinese national accounts data for the agricultural sector, and for the public and private nonagricultural sectors. Young (2003) has showed by adjusting the Chinese national accounts, that labor productivity in the national accounts is significantly overestimated for the nonagricultural sector. We apply Young's methodology separately to the agricultural sector, and to the nonagricultural sector disaggregated into the public and private spheres.

We perform a growth accounting exercise using our adjusted national accounts data. Among the interesting findings is that between 1978 and 2003, annual total factor productivity growth in the public sector was essentially zero, while that in the private sector was over 7 percent. Between 1978 and 2003, out of total labor productivity growth of 5.7 percent, the contribution of structural transformation, or the reallocation of labor from agriculture to nonagriculture was a respectable 1.9 percent. However, the contribution of this labor reallocation declined over time, and was only 0.2 percent out of 5.8 percent between 1996 and 2003. During this latter period, the contribution of private sector productivity growth surged to 3.8 percent, and the contribution of the reallocation of labor from the public to the private sphere rose to 0.5 percent. Thus, currently, the greatest contributors to Chinese economic growth are the reallocation of labor from the inefficient public sector to the private sector; and technological progress in the private sector.

This paper is organized as follows. In the next Section, we describe the Chinese data, and how we adjust the data. To obtain sectoral total factor productivity growth estimates, we measure the growth in sectoral labor, human capital, physical capital, and the levels of sectoral land, capital, and labor shares. Using our adjusted data, we then conduct two growth accounting exercises. First, we decompose the growth of total output in each sector into the contributions of labor, human capital, physical capital, and total factor productivity growth. Second, we decompose the growth of aggregate labor productivity (output per labor) into the contributions of agricultural labor productivity growth, the reallocation of labor from agriculture to nonagriculture; private and public nonagricultural labor productivity growth, and the reallocation of labor from the public to the private nonagricultural sector. In Section 3, we develop our model economy, and analyze its properties. In Section 4, we calibrate our model to reasonable parameter values and compare the model with patterns in the Chinese historical data. We also conduct quantitative experiments to assess the importance of various driving factors behind China's structural transformation. For example, if the nonagricultural public capital stock remained at the 1978 level, what would the path of agricultural employment look like? What if there is no growth in private nonagricultural productivity? What if the mobility cost of transferring labor

4

from the agricultural to the nonagricultural sector is zero? Our experiments show that the main drivers of China's structural transformation are productivity growth in the private nonagricultural sector and capital accumulation (growth) in the public sector. Section 5 concludes.

2   The 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). 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), on the other hand, argues 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.

For our purposes, the main challenge 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. 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.

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, 2005). 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, 2005). 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.

In fact, even in firms with corporate forms that we classify as belonging to the private sector–such as limited liability and shareholding corporations–the government often owns significant equity stakes. When a State-owned enterprise is privatized, the privatized enterprise often takes the form of a limited liability or shareholding corporation. The corporate boards of these firms are often dominated by government officials. Thus, the government may excercise significant legal control over the investment and employment decisions of even these privatized enterprises (OECD, 2005).[1]

2.1 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.[2]

Figure 1 depicts the shares of employment, since 1978. 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.[3] 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 in 2003. The share of workers in public industry, while increasing until the mid-1990s, declined sharply since the late 1990s, as State enterprises and TVEs were privatized.

---

[1]Although China bans the direct involvement or participation of government officials in any commercial activities, in reality many government officials and their relatives invest in private enterprises.

Also, because of the lack of strong legal protection of private property, private enterprises often have to seek this protection from local government officials. With this protection, private enterprise can more easily obtain loans from banks. Naturally, this means that there is some meddling in the affairs of private enterprises by government officials (Asian Development Bank, 2003).

[2]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.

[3]In late 2005, the output of the service sector was revised upwards, reflecting the growth in law and consulting firms, retail stores, health clubs, and the like. Most of this output is believed to be generated by private firms, especially individual proprietors. Our estimates of employment do not capture this latest revision in the growth of the nonagricultural sector (Manchester Guardian, 2005).

2.2 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, 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.

Figure 2 depicts the ratio of the general price index of farm products ("agricultural prices") to the industrial price index ("industry prices"). 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 ratio of agricultural prices to industry prices increased until the late 1980s, and then declined by about 60 percent from then on to return to the 1978 level.

China's agricultural prices have been gradually liberalized from government control since the early 1980s. In the early 1980s, to increase incentives to farmers, China's leaders sharply increased the procurement prices of agricultural goods (McMillan, Whalley, and Zhu, 1989; Huang, Otsuka, and Rozelle, 2004). Since then, the government has periodically intervened through procurement plans at least until the early 1990s. Thus, only from about the early 1990s are Chinese agricultural prices largely determined by the market. We can see from Figure 2 that the ratio of agricultural to industry prices has generally declined from 1990, when agricultural prices became more market determined.

On the other hand, Brandt, Hsieh, and Zhu (2005) argue that the decline in the relative price of agriculture since 1990 is overstated in the data as depicted in Figure 2. This is because the service price index used to construct the price index for nonagricultural or industry prices is likely to overestimate the actual price increases in the services sector, owing to rapid structural shifts in the Chinese economy from personal to business services. The authors construct an alternative price index for services, and show that by using this new service price index, the ratio of agricultural to industry prices from 1990 is essentially flat.

Furthermore, since agricultural and industry prices are both indices, they suffer from the usual problems of index price measurement such as quality improvements in the same goods, introduction of new goods, etc. These measurement problems would appear most severe for manufactured goods, leading to a downward bias in the measured agricultural price-industry price ratio. This particular bias would appear to be increasing over time, as technological progress in the manufacturing sector is increasing. Given these various biases in measurement, we are agnostic about the whether the ratio of agricultural prices to industry prices in China is falling, relatively flat, or rising from the 1990s.

The *CSY* does not break down GDP, a value added measure, into the public and

private sectors for our entire sample period.[4] 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.[5] We then simply allocate total nonagricultural GDP to the public and private sectors; according to the allocation of gross outputs.

Figure 3 depicts the growth in total output, and its breakdown from 1978 to 2003. While growing strongly since 1978, total output growth stalled in the late 1980s. In 1989, total output fell by over 5 percent. Young (2003) correlates the late 1980s slowdown in total output growth to the student uprisings in Tiananmen Square. Total output growth has been especially strong since 1999, growing at over 9 percent, even according to our lower revised growth rates (compared to the official growth rates). Particularly noteworthy is the sharp increase in the share of the output of private industry since the mid-1990s.

Figure 4 depicts the trends in labor productivity. The data on private industry labor productivity are rather volatile, jumping in 1986, and fluctuating sharply between 1990 and 1997. This may be a result of poor sectoral output data; or that in earlier years, the share of private industry was small in China, so that the privatization of some huge State enterprises may have lead to large changes in average private industry labor productivity. We thus put more credence on the long-run trends in Chinese labor productivity, than on the year-to-year fluctuations.

Average aggregate labor productivity (output per labor) in our revised data grew at 5.7 percent per annum between 1978 to 2003. Average agricultural labor productivity grew at 4.5 percent per year, from 300 yuan per worker in 1978 to 1100 yuan per worker in 2003. Average nonagricultural (industry) labor productivity grew at 4.1 percent, from 2200 yuan per worker in 1978 to 5900 yuan per worker in 2003, with annual public and private industry labor productivity growing at 2.6 percent and 7.5 percent, respectively.

We can determine the contribution of agricultural and nonagricultural labor productivity to the growth in aggregate GDP per worker by performing a simple accounting exercise. Of the 5.7 percent per annum growth in aggregate GDP per worker productivity, the contribution of agricultural labor productivity growth was 0.8 percent, and the contribution of nonagricultural labor productivity growth was 3.0 percent.[6] The remainder–1.9 percent–is the contribution of the reallocation of labor, from the low labor productivity agricultural sector to the high labor productivity nonagricultural sector.

---

[4]In late 2005, Chinese growth rates from 1995 to 2004 were revised upwards because of the increased estimated output in some private sector tertiary (service) industries, such as in law and advertising (Manchester Guardian, 2005). Our data do not reflect these recent upward revisions in the shares of the service sector.

[5]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.

[6]The contribution of the primary and nonprimary sectors are measured by the growth of labor productivity in each sector, weighted by their respective shares of GDP.

Agricultural labor productivity, while growing three-fold since 1978, even now (in 2003) is only about 1/6 of average nonagricultural labor productivity. This suggests that the scope of raising the aggregate productivity of labor by transferring low productivity agricultural workers to the high productivity nonagricultural sector remains large.

2.3 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 privnces. 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 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).

Figure 5 depicts the capital-output ratios for the economy, and by sector. The capital-output ratio for the entire economy has remained constant at about 4 since 1978. That capital deepening has not occurred for China in the post-reform period is well known (Young, 2003). The capital-output ratio of public industry has risen since the mid-1990s,

9

reflecting the low productivity of capital in State enterprises and in the TVEs in recent years. In contrast, the capital-output ratio of private industry is falling, reflecting the higher efficiency of capital in private industry.

Figure 6 depicts the investment shares of the agricultural, public and private industrial sectors. The investment share of the agricultural sector has declined at a gradual pace. Since the early 1990s, the investment share of public industry has sharply declined; while that for private industry has sharply increased. These trends reflect the growth of private industry, and the relative decline of public industry. However, the level of the capital stock in public industry has continued to rise, as evidenced by the recent decline of the capital-output ratio in that industry.

Finally, while we assume that labor and capital are the only two inputs in the nonagricultural sector, we allow 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.

2.4   Growth in Human Capital by Sector

A proper measure of the growth of labor input should account for differences in the human capital of the workforce. For example, suppose that overall labor services are a constant returns to scale function of N types of labor:

$$L = H(L_1, L_{2,\ldots} L_N),$$

Differentiating, the growth of overall labor services is a weighted average of the growth of each type of differentiated labor:

$$\frac{dL}{L} = \sum_i \frac{H_i L_i}{L} \frac{dL_i}{L_i},$$

where the human capital weight H_i is revealed by the wage of worker of type i. The difference between $\frac{dL}{L}$ and the growth of overall labor undifferentiated by type can be taken as the contribution of "human capital."

While the CSY provides a reasonable measure of the overall growth of the labor force, and its sectoral distribution, it does not contain any information about the characteristics of workers, such as sector, age, and education needed in the calculation of L_i. To adjust for the changing characteristics of workers, we must use Chinese census and survey data. We obtain the number of workers by sector, age and education from the *1987 Tabulation of China's 1% Population Sample Survey* and the *2000 Population Census of China*. (Published Chinese

census data prior to 1987 do not provide education levels broken down by age.) We classify workers into 11 age, 4 education, and 2 sector (agriculture, nonagriculture) categories to obtain a total of 88 characteristics. By taking the annualized growth rate in the number of workers of characteristic i between 1987 and 2000, we can obtain the growth rate of workers of characteristic i, $\frac{dL_i}{L_i}$.

These growth rates must weighted by H_i, or by wages. Predicted wages of workers of characteristic i are obtained in the usual way from estimated Mincer equations for Chinese workers. We calculate the growth in human capital separately for the agricultural and nonagricultural sectors. For nonagricultural workers, we use the Mincer equation estimated by Young using Chinese household level data (2003, Table 17). Reliable estimates of Mincer equations for Chinese agricultural workers do not exist. This is because Chinese farms are generally operated by families–not paid workers–who subsist by keeping a portion of agricultural proceeds, according to the household responsibility system (Huang, Otsuka, and Rozelle, 2004). Thus, for the predicted wages of those employed in the Chinese agricultural sector, we use Mincer equations estimated for employees in Chinese rural industry, on the assumption that on the margin, the wages of employees in rural industry should capture the marginal revenue product of Chinese agricultural workers. For these employees in rural industry, we use the Mincer equation estimated by Zhang, Huang, and Rozelle (2002). The estimated returns to eduction for employees in Chinese rural industry are considerably lower than the returns to education for the general sample of Chinese nonagricultural workers.

We subtract from our calculated $\frac{dL}{L}$ for the agricultural and nonagricultural sectors, the growth in the overall labor forces in these sectors between 1987 and 2000, to arrive at annualized growth rates of human capital of 1.4 percent in nonagriculture, and 1.1 percent in agriculture. Given the lack of appropriate Chinese census data spanning other periods, we assume that these growth rates hold on average for the entire period 1978 to 2003. Since we do not have the characteristics of workers by type of nonagricultural industry, we assume identical growth rates of human capital for both the public and private sectors of Chinese industry.

2.5   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* or from the input-output tables. Young (2003, Table 21) finds that on average between 1978 and 1995, the labor share of output for the nonagricultural sector was 0.46 using both the provincial or the input-output data. 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 (1978) 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 growth.

2.6 Total Factor Productivity Growth by Sector

Table 1 summarizes our accounting of Chinese economic growth from 1978 to 2003. Total factor productivity (TFP) growth is estimated in the usual way:

$$\text{TFP Growth} = \frac{dY}{Y} - w_k\frac{dK}{K} - w_L\frac{dL}{L} - w_T\frac{dT}{T}$$

where w_k is the capital share, w_L is the labor share, and w_T is the land share. We have shown above 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.

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

	Aggregate	Agriculture	Nonagriculture	Public	Private
Output	8.4	5.6	9.1	5.2	24.2
Labor	2.5	1.0	4.8	2.5	15.5
Human Capital	—	1.1	1.4	1.4	1.4
Physical Capital	—	3.5	8.1	6.5	16.8
Agricultural Land	—	0.06	—	—	—
Total Factor Productivity	—	3.5	1.9	-0.05	7.3
Output per Labor	5.7	4.5	4.1	2.6	7.5
Output per Labor (Level) (in 100s of 1978 yuan)					
1978	9	3	22	22	13
2003	35	11	59	42	80

We estimate that total factor productivity growth in Chinese agriculture averaged 3.5 percent per annum between 1978 and 2003. McMillan, Whalley, and Zhu (1989) estimate that for the 1978 to 1984 period, total factor productivity growth in Chinese agriculture averaged almost 6 percent. However, this earlier period was marked by enormous increases in agricultural productivity, owing to the introduction of the household responsibility system and administrated increases in agricultural prices, which sharply raised incentives for farming. For the more recent period of 1979 to 1997, Fan and Zhang (2002) find that total factor productivity growth in Chinese agriculture was 3.3 percent per annum, which is close to our estimate.

We estimate that TFP growth in the Chinese nonagricultural sector averaged 1.9 percent per annum between 1978 and 2003. Since our methodology for adjusting Chinese statistics follows Young (2003), our estimate of nonagricultural total factor productivity growth is close to the 1.4 per annum Young found between 1978 and 1998. Our estimate is somewhat higher than Young's estimate, since Chinese nonagricultural TFP accelerated between 1999 and 2003. Using *unadjusted* data from the Chinese national accounts, Li (2003) finds TFP growth of 3.2 per annum between 1978 and 1998. This higher estimate shows that the use of unadjusted Chinese national accounts data–by overestimating GDP growth and underestimating investment–may result in very high TFP estimates.

We find essentially zero, or slightly negative TFP growth in public nonagricultural industries. The 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 firms had TFP growth rates

between 121 percent and 46 percent higher than firms with varying degrees of state control. However, our definition of public industries include Township and Village Enterprises and other collectives, in addition to State-owned enterprises. As expected and consistent with the OECD's (2005) firm level findings, TFP growth rates in Chinese private nonagricultural industries are very high.

2.7 Role of the Reallocation of Labor, or of "Structural Transformation"

We can further examine the role of the reallocation of labor in accounting for Chinese growth. The growth in total output can be broken down into the growth of labor supply; and the growth in aggregate labor productivity (output per labor). The growth in aggregate labor productivity–in turn–can be broken down into the contribution of agricultural labor productivity, of nonagricultural labor productivity; and of the reallocation of labor from low productivity agriculture to high productivity nonagriculture. The contributions of the agricultural and nonagricultural sectors are measured by the growth of labor productivity in each sector, weighted by their respective shares of output. Finally, the contribution of the reallocation of labor is equal to the growth in nonagriculture's share of total employment weighted by the gap in labor productivity between the two sectors, measured as a percentage of aggregate labor productivity.

Of the 8.4 percent growth in aggregate output, the growth in labor productivity contributed 5.7 percent between 1978 and 2003. Of this 5.7 percent, the growth in agricultural labor productivity contributed 0.8 percent; and the growth in nonagricultural labor productivity contributed 3.0 percent. The reallocation of labor from agriculture to nonagriculture contributed 1.9 percent to aggregate and per capita output growth, owing to the low productivity level of agricultural labor, compared to the higher productivity level of nonagricultural labor.

TABLE 2: Role of the Reallocation of Labor
(1978-2003; in percent per annum)

	1978-2003	1978-1995	1996-2003
Output Growth	8.4	8.5	7.8
Labor Growth	2.5	3.2	1.1
Output per Labor (Labor Productivity) Growth	5.7	5.2	6.6
Contribution of Agricultural Labor Productivity Growth	0.8	0.7	1.0
Contribution of Nonagricultural Labor Productivity Growth	3.0	2.4	5.4
Of Which:			
Contribution of Public Sector Productivity Growth	1.7	1.6	1.1
Contribution of Private Sector Productivity Growth	1.0	0.6	3.8
Labor Reallocation from Public to Private Sector	0.5	0.3	0.5
Labor Reallocation from Agriculture to Nonagriculture	1.9	2.0	0.2

The role of the reallocation of labor from agriculture to nonagriculture in accounting for overall growth has declined over time. While this reallocation contributed 2.0 percent between 1978 and 1995, it contributed only negligibly (0.2 percent) between 1996 and 2003. On the other hand, the contribution of nonagricultural labor productivity growth has increased sharply, from 2.4 percent in 1978-1995 to 5.4 percent in 1996-2003.

The contribution of nonagricultural labor productivity growth can be further broken down into the contribution of public sector labor productivity growth, of private sector labor productivity growth, and the reallocation of labor from the public to the private sector. The contribution of public sector productivity growth has fallen from 1.6 percent in 1978-1995 to 1.1 percent in 1996-2003. In contrast, the contribution of private sector productivity growth increased from 0.6 percent in 1978-1995 to 3.8 percent in 1996-2003. The contribution of the remainder–the reallocation of labor from the public sector to the higher productivity private sector–was 0.5 percent to both aggregate productivity growth and aggregate output growth. Thus, since the mid-1990s, the largest contributors to Chinese aggregate productivity and output growth were the high productivity growth in the private sector; and the reallocation of labor from the public to the private sector.

2.7.1 Frictions in the Reallocation of Labor

Much attention has been paid to the discriminatory treatment received by rural residents who migrate to urban destinations for work under the household registration, or *hukou* system, which categorically divide 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, by denying pension, health, education and other benefits to rural migrants. This discriminary treatment of rural migrants has ebbed and flowed, but has generally decreased over time. Until

1984, farmers were prevented from conducting businesses outside their home villages (Cai, Park, and Zhao, 2004). In 1985, regulations were relaxed to allow farmers to freely work in nearby towns at, for example, the TVEs. Thus, most labor mobility until the mid-1980s was the movement of farmers out of farms for work in the TVEs and other collectives in rural towns. The period from the mid-1980s to the mid-1990s introduced some additional liberalization measures, such as giving farmers able to invest a minimum amount of money in the cities, temporary urban registration cards. The liberalization measures have accelerated since the late 1990s, to the extent that today, rural migrants enjoy almost the same priviledges as urban residents, especially in the coastal provinces.

It is difficult to evaluate the extent to which the hukou and other migration restrictions were actually limiting the flow of migrants. As early as 1988, the flow of rural to urban migration involving a change in the hukou was officially about 20 million people, while the stock of illegal immigrants (the so-called "floating population") was estimated to be about 70 million. In 1999, the flow of the change in hukou immigration was about 17 million, while the stock of illegal immigrants was estimated to be 100 million (out of a total urban labor force of 254 million) (Cai, Park, and Zhao, 2004). Thus, in practice, there appears to be considerable labor mobility–even if illegal–from the rural areas to the cities. Nonetheless, in the model below, we consider the effects of these labor market frictions on China's growth and structural transformation by explicitly introducing mobility costs into the model.

3   The Model Economy

3.1   Environment

Time is discrete and indexed by $t = 0, \ldots, +\infty$. There is a single infinitely-lived 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 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 by two different entities: a private nonagricultural sector and a public sector run by the government. Both use capital and labor to produce m. The private sector rents labor, capital and land from the household. 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 rates during period t are denoted by w_{at} and w_{mt}, for the agricultural and nonagricultural sectors, respectively. Good a is used for consumption only, while good m is used for consumption and capital

accumulation.

The government is also a producer of good m. It has access to the same technology as the private nonagricultural sector, but its total factor productivity is different. This captures the idea that government's businesses tend to be less efficient than private businesses. How does the government acquires the resources (i.e., capital and labor) needed to operate the nonagricultural technology? It is assumed that it hires labor and pays the market wage, but it does not rent capital. Instead, it accumulates capital through lump-sum taxation. It does not maximize any objective function: instead, public employment and the level of taxation (i.e., the level of public investment) are determined exogenously and constitute policy variables. The government's revenue, after paying public workers, is rebated to the household as a lump-sum transfer.

Each period, the household chooses how much of its time to allocate between the two private sectors. Mobility is not perfect, however, and there is a time cost γ to switch from agriculture to nonagriculture. This cost is paid each period, so it can be interpreted as the cost paid by a worker moving from a rural area, where he works in the agricultural sector, to an urban area where he works in the non-agricultural sector.

3.2 Households

Preferences are represented by

$$\sum_{t=0}^{\infty} \beta^t U\left(c_{mt}, c_{at}\right)$$

where c_{jt} is consumption of good j $(j = a, m)$ during period t. The momentary utility function is defined by

$$U\left(c_m, c_a\right) = \ln\left(\left[\omega c_m^{(\varepsilon-1)/\varepsilon} + (1-\omega) c_a^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}\right), \text{ with } \varepsilon > 0.$$

The parameter ε represents the elasticity of substitution between c_m and c_a. The representative household solves the following maximization problem

$$\max \quad \sum_{t=0}^{\infty} \beta^t U\left(c_{mt}, c_{at}\right)$$

$$\text{s.t.} \quad c_{mt} + p_t c_{at} + s_{t+1} = n_{at} w_{at} + (n_{mt} + n_{gt})(1-\gamma) w_{mt} + (1+r_t) s_t + T_t \quad (1)$$

$$k_0 \text{ given.}$$

The variable s_{t+1} represents savings of the household during period t. They consist in capital and land: $s_{t+1} = k_{t+1} + q_t l$. In equilibrium, land and capital must deliver the same return, i.e., $(i_t + q_t)/q_{t-1} = 1 + r_t$. Thus, the return on saving is $1 + r_t$. The variables n_{at}, n_{mt} and n_{gt} represent the time spent working in each of the three sectors. Finally, T_t is a

net lump-sum transfer. Note that, in equilibrium, the wage ratio is

$$\frac{w_{at}}{w_{mt}} = 1 - \gamma.$$

3.3 Private 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

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

The variables h_{jt} and k_{jt} $(j = a, m)$ represent hours worked in sector j and the capital stock, respectively. Total factor productivity can differ across sectors and is given by z_{jt}. The nonagricultural sector solves

$$\max\left\{F_m\left(k_{mt}, h_{mt}\right) - w_{mt} h_{mt} - (r_t + \delta)\, k_{mt}\right\} \tag{2}$$

and the agricultural sector solves:

$$\max\left\{p_t F_a\left(k_{at}, h_{at}, l\right) - w_{at} h_{at} - (r_t + \delta)\, k_{at} - i_t l\right\}. \tag{3}$$

Define private capital k_t by $k_t = k_{at} + k_{mt}$.

3.4 Public sector

The public sector is characterized by a sequence $\{h_{gt}, k_{gt}\}_{t=0}^{\infty}$ of public hours of work and capital. Public capital accumulates through

$$k_{gt+1} = (1 - \delta)\, k_{gt} + x_{gt}$$

where x_{gt} is net public investment. Given public employment and capital, the public sector produces a quantity y_{gt} of good c, in line with

$$y_{gt} = z_{gt} k_{gt}^{\alpha} h_{gt}^{1-\alpha}.$$

The government's budget constraint is given by

$$w_{mt} h_{gt} + T_t + x_t = y_{gt}.$$

In words, public expenditures consist of wage payments, net transfer payments and the purchase of new capital. Public resources are given by production. Define the total capital stock in the economy by $\mathbf{k}_t = k_t + k_{gt}$.

3.5   Competitive Equilibrium

Given government's policies $\{h_{gt}, k_{gt}\}_{t=0}^{\infty}$, *an equilibrium is a sequence of prices* $\{r_t, w_t, p_t, q_t, i_t\}_{t=0}^{\infty}$ *and allocations* $\{n_{mt}, n_{at}, c_{mt}, c_{at}, k_{m,t+1}, k_{a,t+1}, l\}_{t=0}^{\infty}$ *such that*

1. *Given prices, the sequence* $\{c_{mt}, c_{at}, n_m, n_a, k_{t+1}\}_{t=0}^{\infty}$ *solves problem (1) ;*

2. *Given prices, the sequence* $\{k_{mt}, h_{mt}\}_{t=0}^{\infty}$ *solves problem (2);*

3. *Given prices, the sequence* $\{k_{at}, h_{at}, l\}_{t=0}^{\infty}$ *solves problem (3);*

4. *Markets clear:*

   (a) *The market for a clears:* $c_{at} = y_{at}$;

   (b) *The market for m clears:* $c_{mt} + \mathbf{k}_{t+1} = y_{mt} + y_{gt} + (1 - \delta)\,\mathbf{k}_t$;

   (c) *The labor markets clear:* $h_{mt} = (1 - \gamma)\,n_{mt}$, $h_{gt} = (1 - \gamma)\,n_{gt}$, $h_{at} = n_{at}$ *and* $n_{at} + n_{mt} + n_{gt} = 1$.

4   Quantitative Analysis

4.1   Baseline Calibration

In this Section, we will examine if our model is capable of replicating some stylized patterns in the post-reform Chinese economy. Can the model capture the changes in employment shares between agriculture and nonagriculture? How about the changing levels of labor productivity (output per labor) in the three sectors? The nature of the computational experiment is as follows. Suppose first that preference and technology parameters are given. The exogenous driving forces of the economy are productivity paths $\{z_{mt}, z_{at}, z_{gt}\}$, paths for the policy variables, $\{k_{gt}, h_{gt}\}$ and a labor mobility cost path $\{\gamma_t\}$. Imagine starting the economy off at date $t = 1$, corresponding to 1978, when the levels of the exogenous forces are given by z_{m1}, z_{a1}, z_{g1}, k_{g1}, n_{m1} and γ_1. Given paths for the driving forces, one can compute the equilibrium trajectory of the economy, and assess the extent to which the mechanisms embedded into the model can account for the transition experienced by China.

To build the path of exogenous variables, proceed as follows. First the government's share of employment, n_{gt}, is set to 0.34 for all t. This corresponds to its average value on the 1978-2003 period (See Figure 1.) Observe that there is no obvious trend in this series.

Second, in the data the stock of capital owned by the government increases at an annual rate of 6.5% between 1978 and 2003 (see Table 1). Given an initial capital stock k_{g1}, the path for k_{gt} is then built as:

$$k_{gt} = k_{g1}e^{0.065(t-1)}$$

The productivity paths $\{z_{mt}, z_{at}, z_{gt}\}$ are assumed to grow at constant rates g_m, g_a and g_g respectively:

$$z_{jt} = z_{j1}e^{g_j t}, \ \ j = m, a, g.$$

The initial values, z_{m1}, z_{a1} and z_{g1} are normalized to unity. The g_js are derived from the information provided in Table 1 regarding the growth in Total Factor Productivity and human capital. Namely

$$
\begin{aligned}
g_m &= 0.073 + (1 - \alpha) \times 0.014, \\
g_a &= 0.035 + \mu \times 0.011, \\
g_g &= -0.005 + (1 - \alpha) \times 0.014.
\end{aligned}
$$

Factor shares α, μ and θ were discussed in Section 2.6. The mobility cost, γ_t, is set to $\gamma_t = 1 - 0.36$ for all t. This value is computed from the average ratio of the agricultural to the nonagricultural wage rate. The annual depreciation rate is set to 5%, the discount factor β to $1/1.07 = 0.93$.

The remaining parameters are ε, ω and k_{g1}: the elasticity of substitution between the two goods, the weight on the nonagricultural good in the utility function and the initial value for the government's capital. Those are picked in order to minimize the sum of sqared differences between the actual employment share in agriculture and its model counterpart. More precisely, define $\hat{n}_a (\varepsilon, \omega, k_{g1}; t)$ the model's prediction for the employment share in agriculture at date t for given values of ε, ω and k_{g1}. (The rest of the parameters being set to the values discussed above). Then solve

$$(\varepsilon, \omega, k_{g1}) = \arg\min_{x,y,z} \sum_{t \in T} (n_{at} - \hat{n}_a (x, y, z; t))^2$$

where $T = (1978, 1979, \ldots, 2003)'$ and n_{at} is the actual employment share in agriculture. The calibrated values of the parameters are summarized in Table 3.

TABLE 3: Baseline Calibration	
Preferences	$\beta = 0.93, \omega = 0.16, \varepsilon = 1.8$
Technology	$\alpha = 0.54, \theta = 0.12, \mu = 0.76, \delta = 0.05$
Driving variables	$z_{m1} = 1.0, g_m = 0.079$
	$z_{a1} = 1.0, g_a = 0.043$
	$z_{g1} = 1.0, g_g = 0.001$
	$k_{g1} = 5.0, k_{gt} = k_{g1}e^{0.065(t-1)}$
	$n_{gt} = 0.34$ all t
	$\gamma_t = 0.64$ all t

Figure 7 represents the employment share in agriculture predicted by the model, vis à vis the Chinese data. Figure 8 shows the predicted share of total investment done by the public sector, compared with the actual share. Remember that, in the model, public investment is exogenous but private investment is not. Therefore, public investment's share of total investment is endogenous. Furthermore, the model is not calibrated to that share. Thus, under the baseline calibration, the model is in line with the data as far as the "size" of the Chinese public sector relative to the rest of the economy is concerned. Figure 8 also captures the degree of "privatization" observed in the Chinese economy, by replicating the trend in the share of public investment.[7]

Figure 9 shows the patterns of output per worker in each sector. Private nonagriculture output per worker is growing at the fastest rate, as in the Chinese data. Agricultural output, however, is growing more slowly and is dominated by public output for most of the period. Unlike in the actual Chinese data, however, agricultural output per worker ends up growing faster than public output per worker. This is largely due to the rise in the price of agricultural goods relative to industrial goods in the model. This relative price trends up (in the model) because of the faster growth in nonagriculural TFP compared with agricultural TFP. Note that the calibrated value for ε is above one. To generate a shift out of agriculture when the relative price of the agricultural good is rising, the model requires the goods to be substitutes.

In sum, we find that our model replicates well, the movement of labor out of agriculture into nonagricultural, and does reasonably well in capturing the patterns in output per worker growth in the three sectors. The model does somewhat poorly in tracking the actual trend in the agricultural price-industry price ratio, but as we pointed out earlier, it is likely that this measured price ratio is plagued with measurement problems, and that we are actually agnostic about how this measured price ratio behaves.

---

[7]It is, of course, simplifying to call "privatization," the reduction in the share of public investment. There is no question that privatization is a much more complex phenomenon, but this is the only sense in which we can capture "privatization" in the model.

4.2 Counterfactual Experiments

What are the main driving forces behind China's structural transformation? To answer this question, consider the following experiment: suppose that the government's capital stock remained constant at its 1978 level, as calibrated in the baseline economy above. All other exogenous driving forces and parameters remain unchanged. What would the path of agricultural employment look like? The same counterfactual experiment can be conducted, in turn, by keeping TFP in agriculture, nonagriculture and in the public sector constant. The results are displayed in Figure 10.

Observe that departures from the baseline case are the largest when (i) there is no growth in the public capital stock; and (ii) there is no growth in z_m, the total factor productivity in the nonagricultural sector. Note that no driving force acting alone is capable of accounting for the structural transformation. Consider first the case when public capital remains constant. Here, workers in the public sector become less productive. This increases the relative price of the nonagricultural good. As a result, consumers substitute agricultural goods for nonagricultural goods, and more workers flow into agriculture to satisfy the increased demand for agricultural goods. At the same time, in this experiment, nonagricultural TFP keeps growing. This continued increase in nonagricultural TFP tends to reduce the relative price of the nonagricultural good, and tends to stimulate a transition of labor out of agriculture. This is why, in this experiment, agricultural employment is above its baseline value, but is decreasing over time. The reverse reasoning applies to the case when z_m is not growing, but the public capital stock is growing. Observe that the growth rate in z_g is too small for it to have a noticeable effect on the movement of labor. Finally, shutting down the growth rate in z_a speeds up the transition of labor to nonagriculture: the agricultural good becomes more expensive faster than in the baseline case.

Now shut down z_m and public investment at the same time. That is, shut down the reason why the nonagricultural good is getting relatively cheaper. The result of this experiment is displayed in Figure 11. Observe now that the structural shift of the labor force out of agriculture disappears. That is, without public capital accumulation and productivity growth in the private sector, there is no structural transformation of the Chinese economy. This suggests that the main causes of China's structural transformation are the simultaneous growth in public sector capital, and in private sector productivity.

Finally, consider Figure 12. There, we explore the consequenes of declining or zero labor mobility costs. In the first case, the time path for γ is given by $\gamma_1 = 1 - 0.36$ and $\gamma_{t+1} = 0.9 \times \gamma_t$, that is, labor mobility costs decrease by 10% per year. When mobility costs decrease, the transition out of agriculture occurs faster than in the baseline calibration, but compared with the effects of lower or no private sector TFP and public capital growth, the effects of reduced labor mobility costs appear surprisingly small. When mobility costs

are simply set to zero: $\gamma_t = 0$ all t is more noticeable. The transition our of agriculture happens faster, and accelerates relative to the baseline case as the economy grows (and the agricultural wage rate increases faster).

4.3 Conclusions

Some critics may argue that the Chinese economy in 1978 was a distorted, centrally-planned construct; but that since 1978, new distortions have arisen that are as bad as those in the centrally-planned period. For example, Young (2000) has pointed out that as central controls over factor and material allocations were relaxed, local governments throughout the country moved to develop manufacturing industries and restrict the outward movement of raw materials, to capture the rents implicit in centrally mandated price wedges. A variety of administrative and physical barriers to interregional trade were set up to keep price margins between industrial final products and raw materials high. In an economy rife with such price and other distortions, a critic may argue that there is no sensible way to use a customary general equilibrium growth model such as ours to understand the evolution of the Chinese economy since 1978. Our results show, however, that our model captures well, the growth and structural transformation of China the reallocation of labor from agriculture to nonagriculture, and the patterns of labor productivity growth in the agricultural, private, and public sectors.

References

[1] Asian Development Bank (2003), "People's Republic of China: The Development of Private Enterprise," mimeographed.

[2] Brandt, L., Hsieh, C., and X. Zhu (2005), "China's Structural Transformation," mimeographed, University of California, Berkeley.

[3] Cai, F., Park, A., and Y. Zhao (2004), "The Chinese Labor Market," mimeographed, University of Michigan.

[4] Chow, G. (1993), "Capital Formation and Economic Growth in China," *Quarterly Journal of Economics*, pp. 809-842.

[5] Fan, S. and X. Zhang (2002), "Production and Productivity Growth in Chinese Agriculture: New National and Regional Measures," *Economic Development and Cultural Change,* pp. 819-838.

[6] Gollin, D., S. Parente and R. Rogerson (2002), "The Role of Agriculture in Development," *American Economic Review*, 92(2), 160–164.

[7] Hansen, G. D. and E. Prescott (2002), "Malthus to Solow," *American Economic Review*, 92(4), 1205–1217.

[8] Hayami, Y., and V. Ruttan (1985), *Agricultural Development: An International Perspective,* Baltimore, Maryland, Johns-Hopkins University Press.

[9] Hsueh, T. and Q. Li eds. (1999), *China's National Income, 1952-1995,* Boulder, Col.: Westview, 1999.

[10] Huang, J., Otsuka, K., and S. Rozelle (2004), "The Role of Agriculture in China's Development," mimeographed, UC-Davis.

[11] Jefferson, G., Rawski, T., and Y. Zheng (1989), "Growth Efficiency and Convergence in Chinese Industry: A Comparative Evaluation of the State and Collective Sectors," Department of Economics, University of Pittsburg Working Paper, 251.

[12] Jorgenson, D. and K. Nomura (2005), "The Industry Origins of Japanese Economic Growth," manuscript, Harvard University.

[13] Laitner, J. (2000), "Structural Change and Economic Growth," *The Review of Economic Studies*, 67(3), 545–561.

[14] Li, K. W. (2003), "China's Capital and Productivity Measurement Using Financial Resources," Economic Growth Center Discussion Paper 851, Department of Economics, Yale University.

[15] Macrochina (2006), "Population Projections for China," Macrochina website.

[16] McMillan, J., Whalley, J., and L. Zhu (1989), "The Impact of Chinese Economic Reforms on Agricultural Productivity Growth," *Journal of Political Economy,* pp. 781-807.

[17] Manchester Guardian (2005), "China to Overtake Britain after Beijing Understates Growth," December 14.

[18] Naughton, B., (2005), "Township and Village Enterprises," mimeographed, University of California, San Diego.

[19] Ngai, L. R. and C. A. Pissarides, (2006), "Structural Change in a Multi-Sector Model of Growth," *American Economic Review*, forthcoming.

[20] OECD (2005), *Economic Surveys: China,* Paris: OECD Publishing, September.

[21] People's Republic of China, National Bureau of Statistics of China (1988), *1987 Tabulations of China 1 percent Population Census of China (Zhongguo 1987 nian 1 % renkou chouyang diaocha zilao).* Beijing: China Statistical Publishing House.

[22] People's Republic of "China, State Council and National Bureau of Statistics of China (2002), *Tabulation on the 2000 Population Census of the People's Republic of China (Zhongguo 2000 nian renkou pucha zilioa).* Beijing: China Statistical Publishing House.

[23] People's Republic of China, National Bureau of Statistics of China (various annual issues from 1981), *China Statistical Yearbook (Zhongguo tongli nianjian).* Beijing: China Statistical Publishing House.

[24] Provincial Statistical Yearbooks (1997-2004) (*tongli nianjian*) for 25 provinces.

[25] Rawski, T., (2004), "China's Growth Prospects," mimeographed, University of Pittsburg.

[26] Research Institute of Economy, Trade, and Industry (RIETI) (2004), "The Huge Debate over Privatization and Management Buyouts–Can the Drain on State-owned Assets Be Justified?", mimeographed, July.

[27] Young, A., (2000), "The Razor's Edge: Distortions and Incremental Reform in the People's Republic of China," *Quarterly Journal of Economics,* pp. 1091-1135.

[28] Young, A., (2003), "Gold into Base Metal: Productivity Growth in the People's Republic of China During Reform," *Journal of Political Economy*, pp. 1220-1261.

[29] Zhang, L., J. Huang, and S. Rozelle, (2002), "Employment, Emerging Labor Markets, and the Role of Education in Rural China," *China Economic Review,* pp. 313-328.

Employment Shares of Agriculture, Public, and Private Industrial Sectors
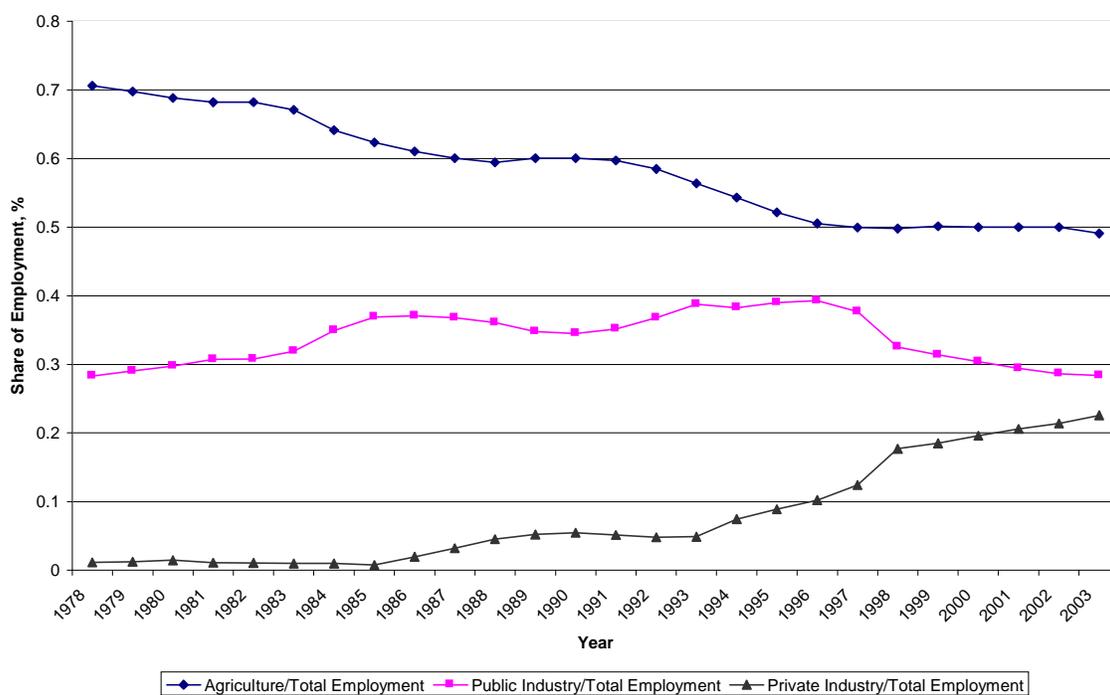
Figure 1: Employment Shares, 1978-2003.

Agriculture-Industry Price Ratio
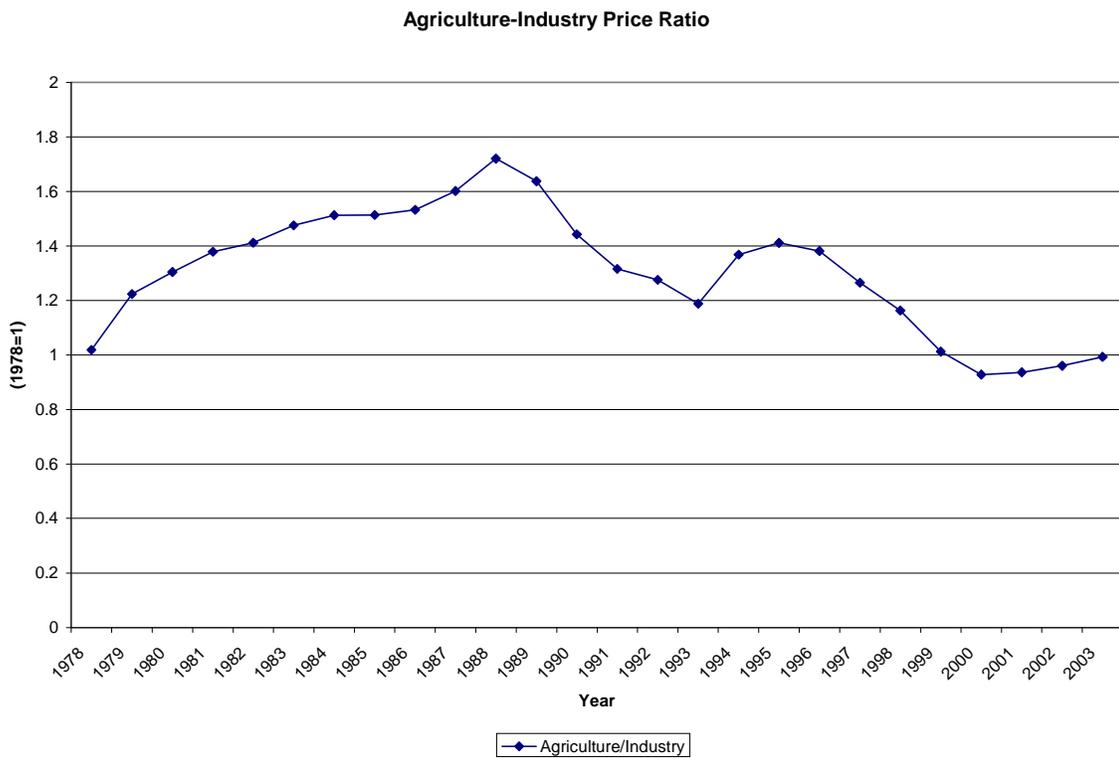
Figure 2: Prices of Agricultural Goods Relative to Industrial Goods.

Real Outputs of Agriculture, Private, and Public Industries

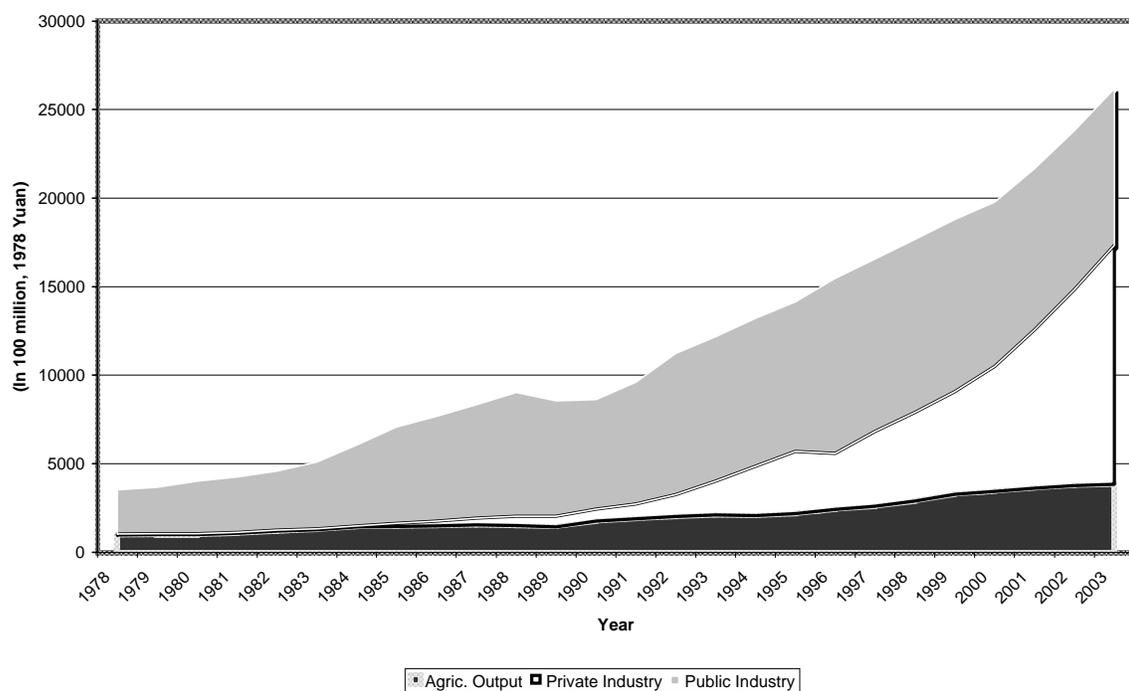Figure 3: Real Outputs of Agriculture, Private and Public Industries, 1978-2003.
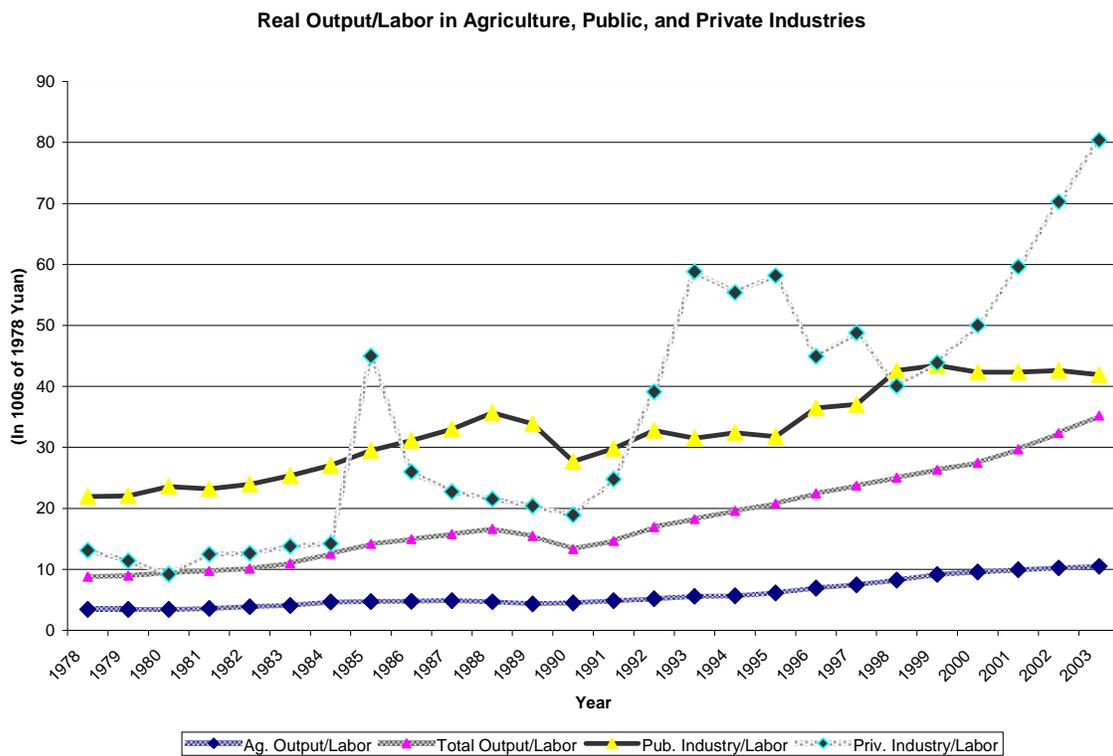
Real Output/Labor in Agriculture, Public, and Private Industries

Figure 4: Real Output per Worker Ratios (Labor Productivity) by Sector, 1978-2003.

Capital Output Ratios
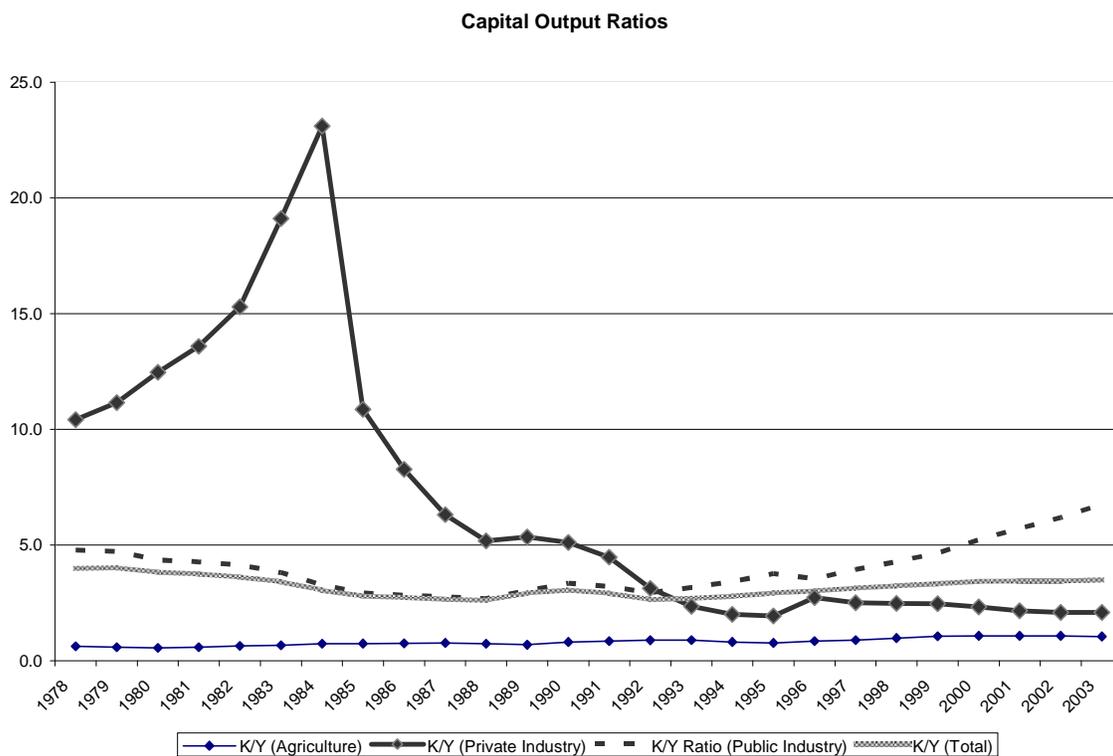
Figure 5: Capital-Output Ratios for the Economy, and by Sectors, 1978-2003.

Investment Shares of Agriculture, Public, and Private Industrial Sectors
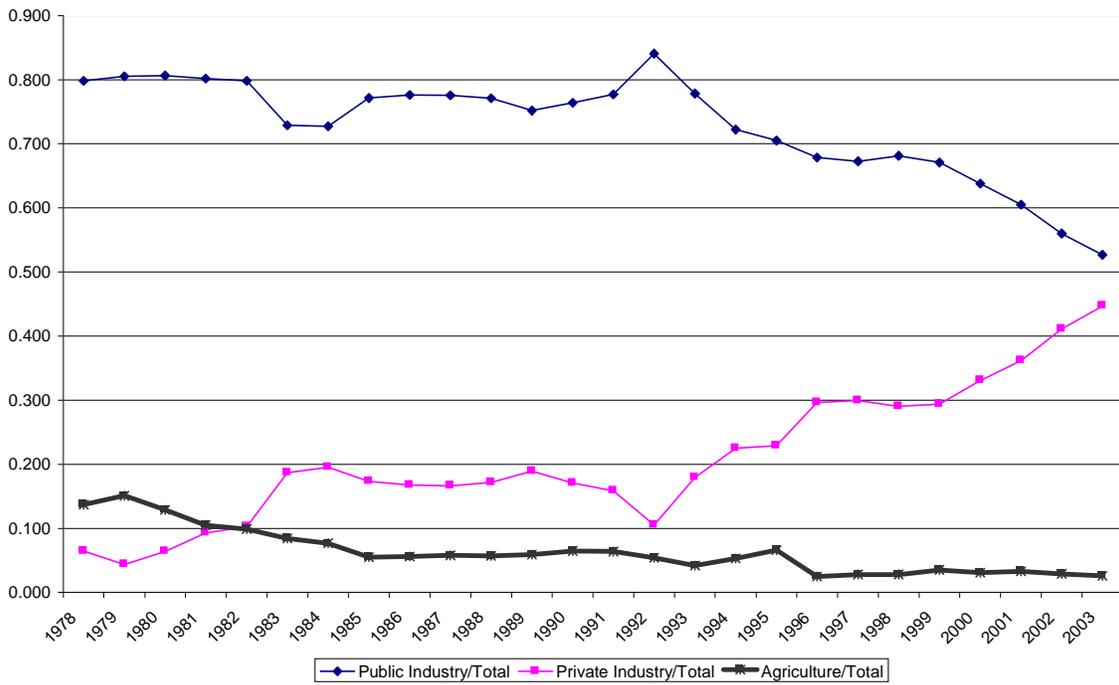
Figure 6: Investment Shares, 1978-2003.
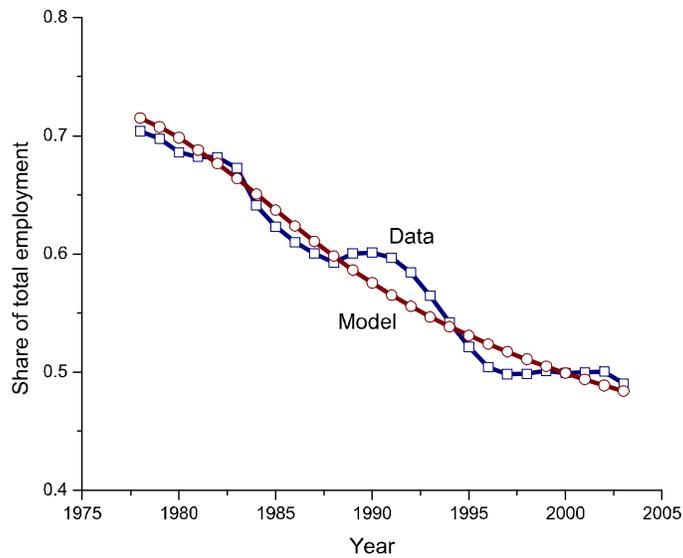
Figure 7: Employment Share of Agriculture, Chinese Data and Model, 1978–2003.
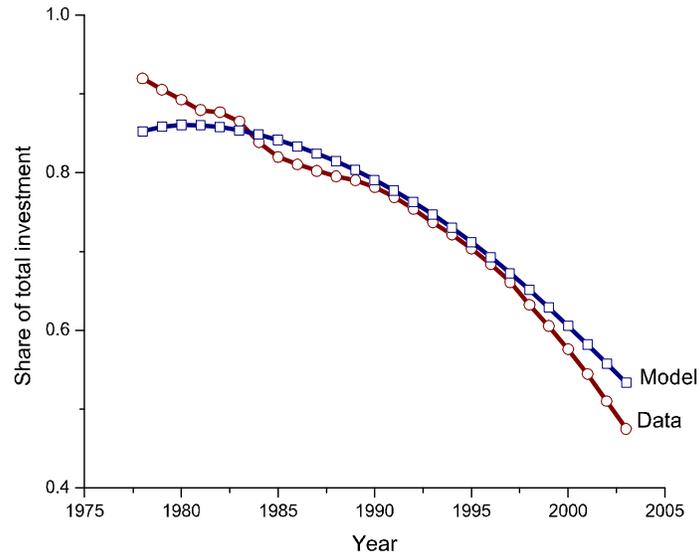
Figure 8: Share of Public Investment in Total Investment, Chinese Data and Model, 1978-2002.
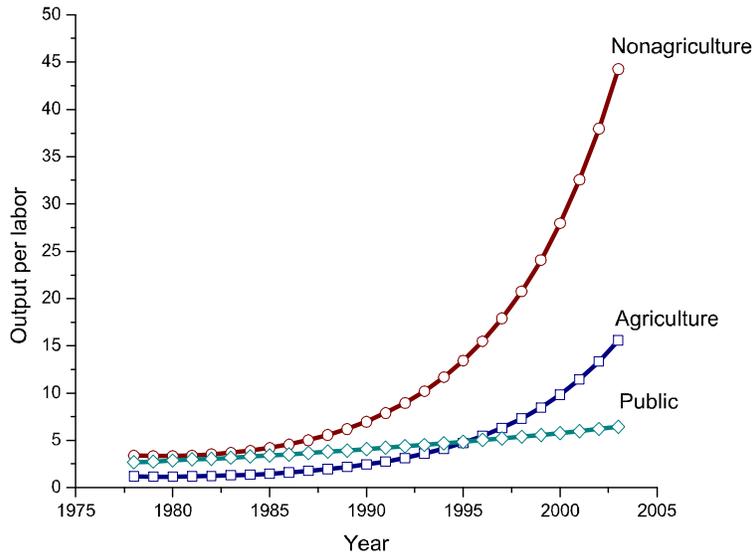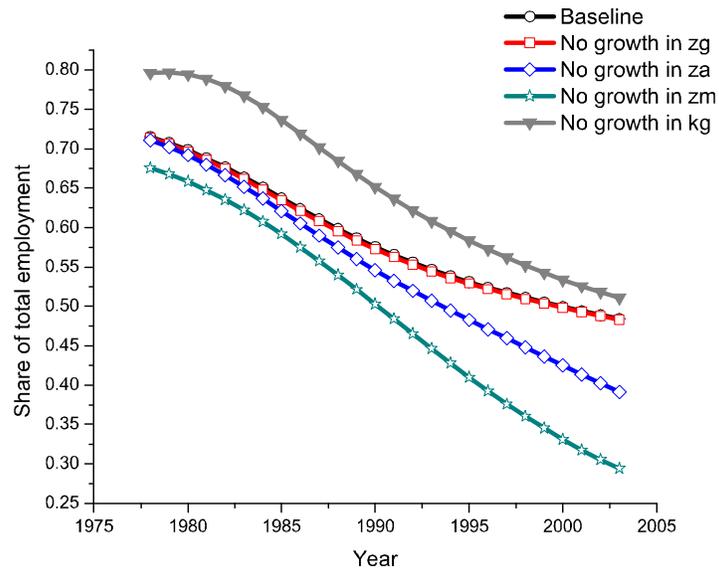

Figure 9: Simulated Output per Worker.

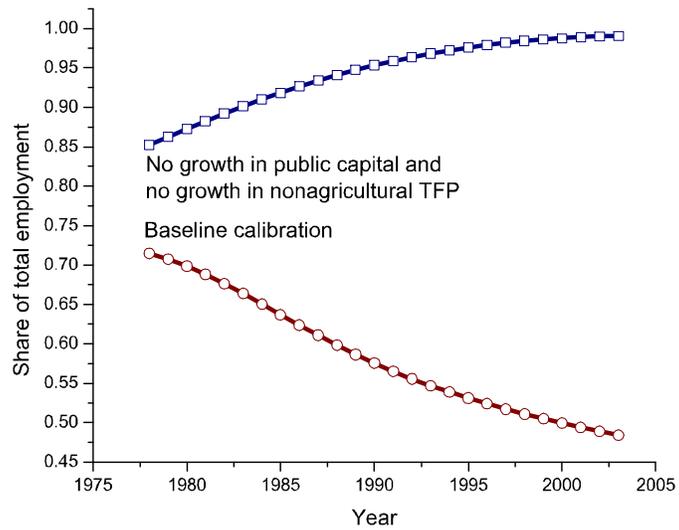Figure 10: Employment Share of Agriculture, Baseline Calibration and Counterfactual Experiments.

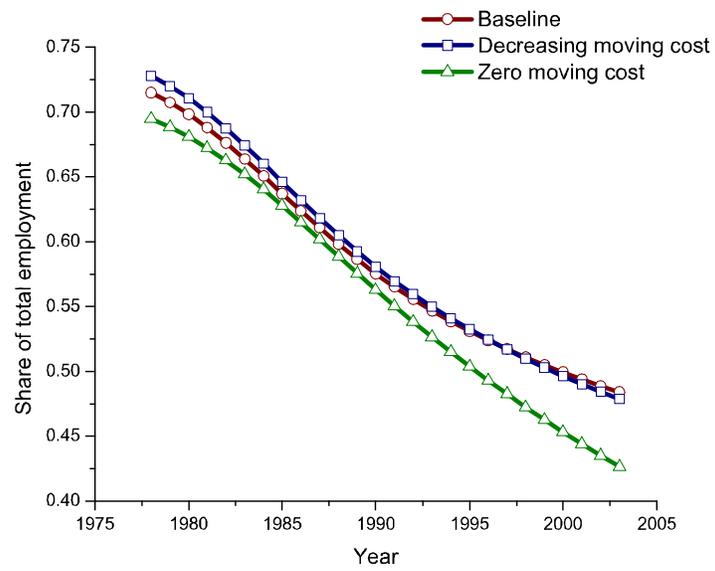Figure 11: Employment Share of Agriculture, Baseline Calibration and a Counterfactual Experiment.

Figure 12: Employment Share of Agriculture, Baseline Calibration and Counterfactual Experiments.