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SCHREYER HONORS COLLEGE

DEPARTMENT OF ECONOMICS

AN EMPIRICAL ANALYSIS OF CHINESE STRUCTURAL TRANSFORMATION IN THREE SECTORS

BAOQI (LAURA) KUANG
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Reviewed and approved* by the following:

James Tybout
Professor of Economics
Thesis Supervisor

David Shapiro
Professor of Economics
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

Abstract

Structural transformation refers to the reallocation of economic resources across sectors. Most papers in last decade have used two-sector models and have found that Chinese economic growth was mainly attributable to the development of the non-agricultural sector. Using a three-sector model and more recent data, I extend these findings. Among other things, I demonstrate that among the non-agricultural sectors, TFP growth in the manufacturing sector is the main driving force of labor productivity growth in China, while TFP growth in the service sector is the key driving force of labor reallocation between sectors.

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Acknowledgement

I would like to thank my supervisor Prof. Tybout for his elaborate guidance throughout this thesis. My thesis would not be possible without his help of bringing my vague idea to a feasible explicit research plan. I also want to express my gratitude to my honors advisor, who was also my former research supervisor, for his continuous help and constructive suggestions in my academic life.

1 Introduction

The Chinese economy experienced a GDP average annual growth rate of 10.1 percent from the year 1978 to 2012. It is now the world fastest growing (IMF report 2013) and largest economy (World Bank GDP ranking 2013) in the world. Furthermore, the Chinese economy has experienced remarkable structural transformation with the rapid growth. For example, we see a large decrease in the share of the agricultural sector in the national economy, from 70.5% in 1978 to 33.6% in 2012, and 13% increase in manufacturing sector, along with 23.9% increase in service sector. Therefore, China is at a significant stage of development, and it has shifted from agriculture-oriented economy to service-based economy.

The Lewis-Ranis-Fei model (1954) has demonstrated how structural transformation can be an important source of development and growth. Moreover, Kuznets (1979) shows that substantial shifts in the shares of various sectors accompany high rates of growth in output per worker. I use China as an example to understand the shift in sectoral composition that accompanies economic development.

In particular, I study the total GDP growth from the perspective of labor and capital reallocation. The analysis is organized as follows. Chapter 3 uses a simple regression analysis that suggests roles of labor and capital, and then shows how cross sector labor reallocation plays an important role in the Chinese structural transformation. It further comes up with several possible driving forces behind it. In Chapter 4, I develop a three-sector model based on Brandt, Hsieh, and Zhu (2008) to analyze the contributions of possible driving forces. In addition, using the static utility function developed by Herrendorf, Rogerson, and Valentinyi (2014), I impute the labor share in each sector. Counterfactual analysis is shown in Chapter 5, where I find how TFP growth in the service sector explains the majority of the labor reallocation. Chapter 5 also shows how reductions in barriers to cross sectoral labor mobility (namely the Hukou system) have affected China's structural transformation. Finally, Chapter 6 looks for possible past policy explanations for what happened.

2 Literature Review

In this chapter, I will give a brief overview of the growth of Chinese economy, cross sector productivity growth, and the movements of resources across sectors, as well as the misallocation of labor among sectors in previous studies.

The original idea about structural change and total factor productivity (TFP) growth, from Lewis' classical dual economy model (Lewis, 1954), made the assumption that structural change was a significant source of growth. There's an empirical analysis of the Lewis-Ranis-Fei model on China conducted by Marco and Zheng (2010). They found that the reallocation of labor away from agriculture has made a positive net contribution to China's rapid economic growth by 1.23 percent during 1965 - 2002. Additionally, they found a lower marginal productivity of agricultural labor than average productivity of agricultural labor, which implies the continued existence of disguised agricultural unemployment. Kuznets (1979) states that it must demonstrate substantial shifts in the shares of various sectors to attain high rates of growth per capita or output per worker. Dekle and Vandenbroucke (2012) showed in their quantitative analysis that the key driving forces in the Chinese economy structural transformation during 1978 - 2003 are productivity, the size of the government and restrictions to labor mobility, among which agricultural productivity played the most important role.

The IMF working paper by Nabar and Yan (2013) emphasizes the importance of the relative level of service sector productivity in TFP. The results show that eliminating market frictions is essential for the service sector to play a more important role as an engine of growth in China's next stage of development. It also mentions a strong positive correlation between the service sector productivity and the consumption of service, as well as the service sector contribution to the economic growth. Similarly, I will develop a model taking the service sector into consideration since most traditional models focus on dual economy by treating the economy as agriculture and non-agriculture.

Brandt, Hsieh, and Zhu (2008) consider a two sector (agriculture and non-agriculture) growth model with wage distortion using Chinese data from 1978 to 2004. Their contribution is that they disintegrate the non-agriculture sector further into state and non-state sectors and conclude that the key driver of China's economic growth is the non-state non-agriculture sector. Herrendorf, Rogerson, and Valentinyi (2014) integrate the results of many papers into one three-sector(agriculture, manufacturing and service) growth model.

The main purpose of this thesis is to revisit the question of what caused China's growth. In doing so it will extend Brandt, Hsieh, and Zhu's (2008) two-sector growth model into a three-sector (agriculture, manufacturing and service) model, and it will introduce non-homothetic demands by adopting Herrendorf, Rogerson, and Valentinyi's (2014) assumption of utility function.

3 Data

All data that I use in this paper, unless otherwise noted, is from the annual issues of the Chinese Statistical Yearbook (CSY),compiled by the National Bureau of Statistics (NBS) of China. The CSY is the official statistical system started in 1978, which was when the reform and opening-up market policy took place, and it was also the take-off point for the Chinese economy. The NBS of China uses slightly different terms for three sectors, and I will need to clarify their terms in this paper. The three sectors by their definition are primary, secondary and tertiary sectors, where primary sector includes agriculture, forestry, animal husbandry and fishery; secondary sector is composed of mining, manufacturing, production and supply of electricity, gas and water industries, as well as construction; tertiary industry refers to different kinds of transport, storage and post, real estate, financial intermediation, education, hotels and catering services, and others. To be consistent with conventional economic models, I use agricultural, manufacturing, and service sectors, which share the same content with Chinese official definitions. I use data from 1992 to 2012 for two reasons. There was a major discontinuity in the employment data in the 1990s, which was due to an adjustment in the statistical system, and the adjustment was not extend to years before 1990.This caused a big gap in the NBS employment measure. In addition, there was an important policy emphasizes on the service sector in 1992, called "Decision on Developing the Service Sector".

The NBS reports nominal GDP and GDP index for each year. Thus, I will compute real GDP of each year by nominal GDP of 1992 times the GDP index. The price level for each year is then nominal GDP divided by real GDP, which can be used to deflate capital and wage observed in the data to real value.

To compute the capital that is used for production in manufacturing and service sectors, I assume that the total amount of capital in year 1978 (the first year of the NBS capital data) is 10 times the newly increased fixed assets in year 1978. The total amount of capital for subsequent years is then computed as the total amount of capital multiplied by the depreciation rate plus the newly increased capital.

It is assumed that in the agriculture sector, the inputs of the production function are land and labor. The measure of land that is used in this paper is total sown areas of farm crops, which changes very little compared to capital(149 million hectares in 1992 and 165 million hectares in 2013).

The NBS reports the number of employed persons in each sector directly, therefore I use it as the input of labor without any further modifications. In addition, the average nominal and real output per worker of each sector can be computed accordingly.

I do not have direct data of the average return to labor, but the ratio of returns in each sector can be computed by the ratio of nominal output per labor in each sector if it is assumed that labor shares of income are the same in each sector.

4 Analysis of China's Growth and Structural Transformation

4.1 Evidence from Data

Labor Mobility

In the past several decades, China has experienced enormous changes in employment, especially through labor reallocation from rural to urban areas. Figure 1 shows the employment share of each sector. We easily observe the large decrease of almost a half in share of agriculture sector employment and the continuous increase in manufacturing and service sectors.

Productivity Growth

We can see that the share of primary industry decreased from 58.5% in 1992 to 33.6% in 2012, while the share of secondary and tertiary industry increased from 21.7% and 19.8% to 30.3% and 36.1%, respectively.

The labor productivity also increased a lot during the data period. Figure 2 shows the labor productivity as measured by output per worker.

The above measure of labor productivity may benefit from the increase in capital. Figure 3 shows the TFP level of each sector.

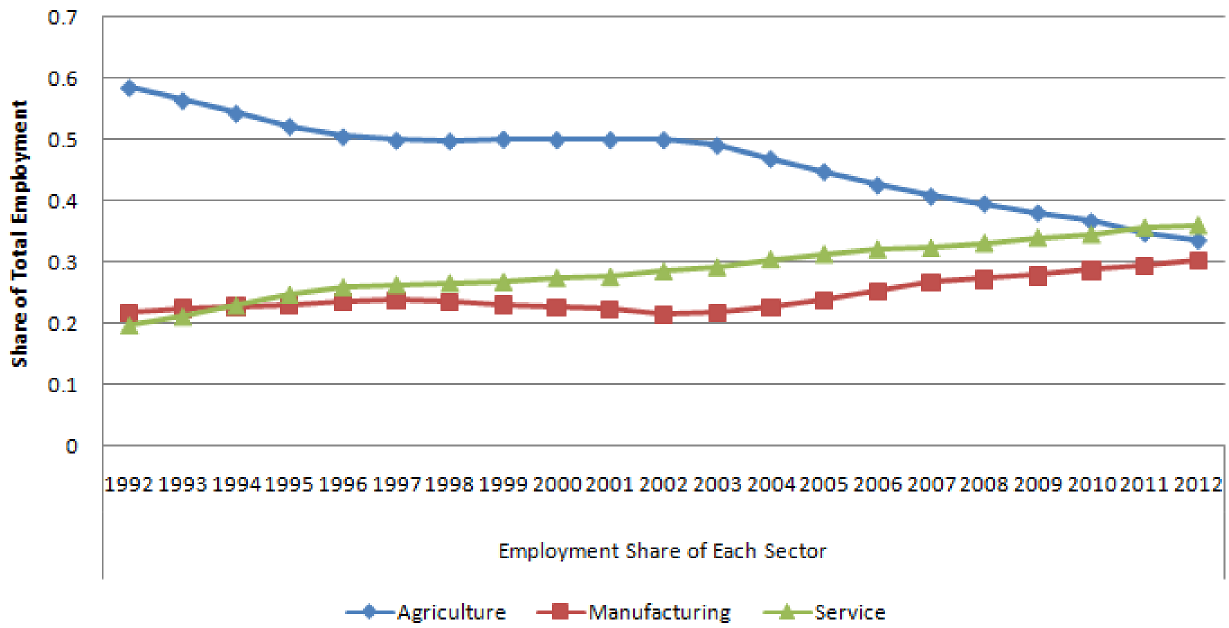

Figure 1: Employment Share of Each Sector

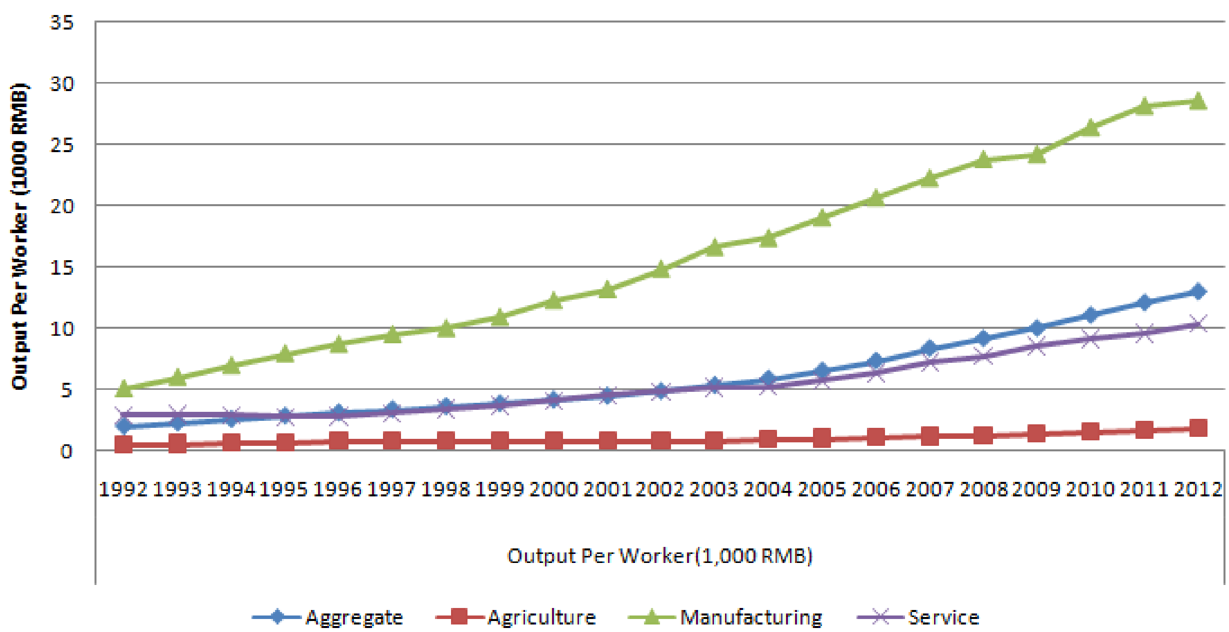

Figure 2: Output Per Worker(1,000 RMB)

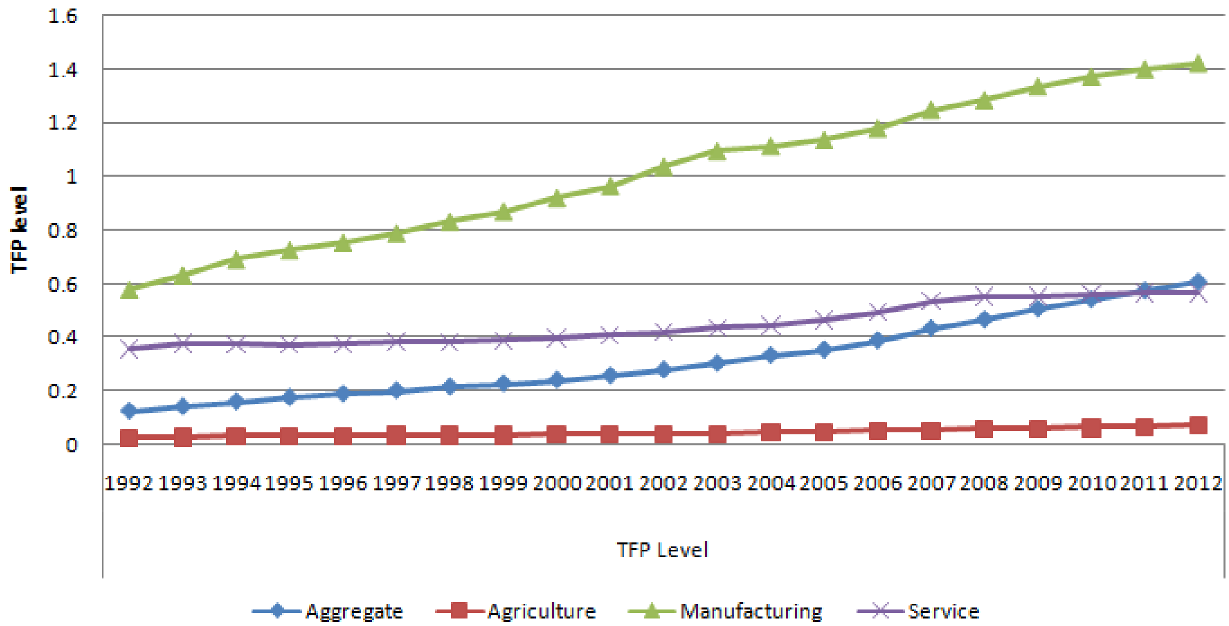

Figure 3: TFP Level

4.2 Driving Forces of Growth and Structure Transformation

Traditionally, the driving forces of growth and development have been considered to be TFP growth, physical capital(K) growth, human capital(L) growth, and factor reallocation. Until recent decades, the reallocation of factors and investment in physical capital have drawn some attention. I will introduce the following basic facts for these sources from data in this chapter, and quantify their contributions later in Chapter 6.

1. TFP growth in each sector.

2. Labor market barriers.

3. Investment in fixed capital.

TFP Growth

As shown in Figure 3, the TFP of agriculture didn't change a lot from 1992 to 2012, while the TFP of manufacturing and service sectors have shown significant increase.

The Chinese central government adopted the eighth to the eleventh "Five-Year Plan" from 1990 to 2010, and China's economic emphasis has shifted from agriculture sector only to balanced growth, and the government promoted technology growth, innovations and education. From the eighth to the tenth "Five-Year Plan", the Chinese government realized its advantage in abundant labor force, and it encouraged people to free themselves from agriculture to join the manufacturing sector with simple skills, which boosted the increase in the manufacturing sector. By the same token, along with the development of education levels and health care conditions, the TFP in the service sector increased significantly, and is still growing. Therefore, I claim that the TFP plays an important role as a driving force of growth.

Labor Market Barriers

There is a strict barrier to geographic mobility in the Chinese labor market, which is called Hukou. This is a residential system that divides the country's residents into urban and rural. We usually think that people who work and live in urban areas have more access to urban education and health service, however, the Hukou system restrains these benefits for those who hold a rural Hukou. The barrier, as can be seen in the data, is decreasing in the past decades and result in a significant reduction in the share of employment in agriculture sector. Many previous papers have studied this effect, like I discussed in Chapter 2.

In addition, there is also a barrier between manufacturing and service sector. Even after the 1978 reform, the government policy still discriminates against the service industry and focuses on the manufacturing sector. The central government, as well as most social media, advocates the importance of manufacturing and claims that the service sector makes little contribution to their economic growth. The social norm encourages people to work in the manufacturing sector, and undermines the need of the service sector. Additionally, the service sector requires more skills than the manufacturing sector, and individuals in past decades might not have as many opportunities and the financial support to be educated and skillful. Therefore, all these partially contribute to the influx of cheap labor force in manufacturing sector.

We do not have direct measures of such barriers in the data. If labor could move freely among sectors, the wage difference cross sectors will be zero. Therefore, I use an alternative measurement to indicate barrier - wage ratio to indicate barriers cross different sectors. The wage ratio, as mentioned earlier, can be computed as the ratio of nominal output per worker. Figure 4 shows the labor market barrier between agriculture and manufacturing and between service and manufacturing. As for the barrier between the manufacturing and service sectors, it has also experienced a significant reduction since 1995.

Throughout the years 1992 to 2012, the barrier between agriculture and manufacturing didn't change a lot and it fluctuated around 0.8, compared with the barrier between services and manufacturing sectors, it showed great fluctuations.

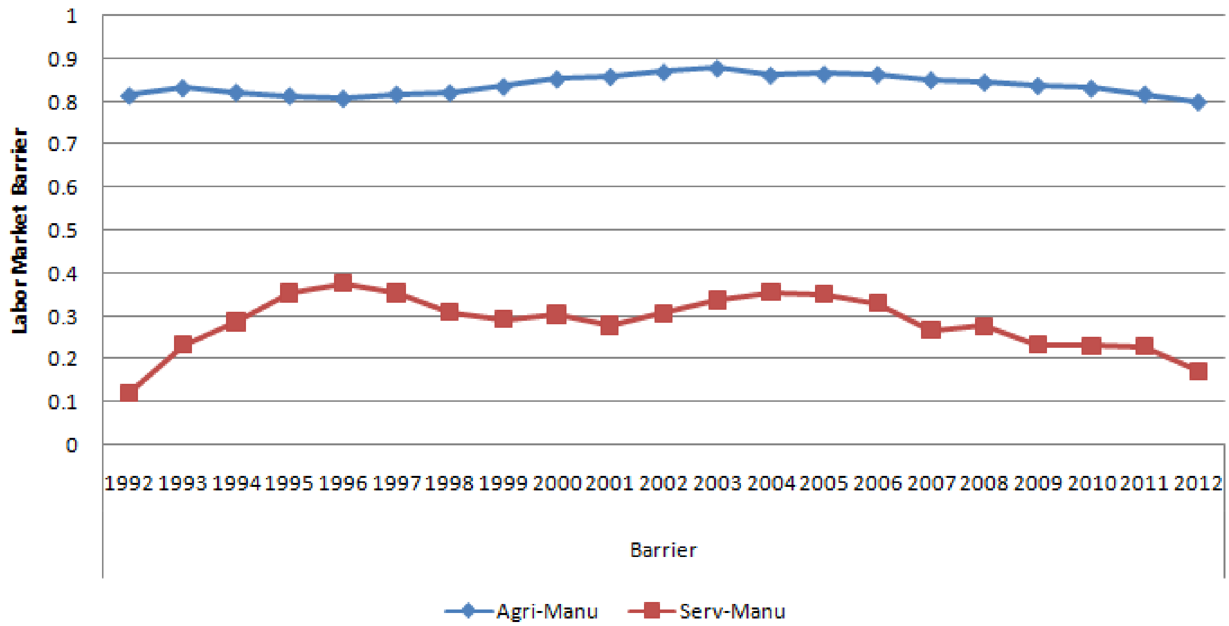

Figure 4: Labor Market Barrier

Investment in Fixed Capital

China also experienced a huge increase in investment since Xiaoping Deng's 1992 speech about moderately tight economic policy. Figure 5 shows the investment rate from 1992 to 2012.

This thesis aims to explain the potential source of (1) labor reallocation from agricultural to manufacturing and service sector, (2) the growth of labor productivity from 1992 to 2012.

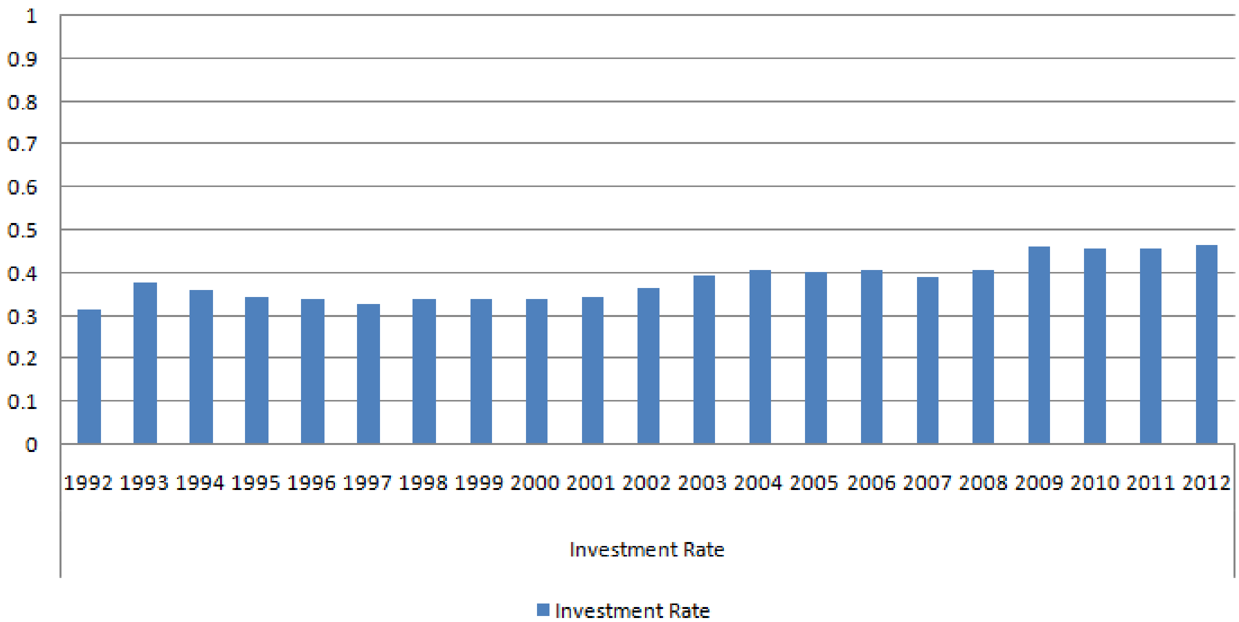

Figure 5: Investment Rate

5 Model

We consider the economy in three sectors: agriculture, manufacturing and service sector, and we present a dynamic model in this paper, where investment rate is assumed to be exogenous. As is standard, we study the competitive equilibrium in which the agents on both production and demand sides make optimization decisions, taking price as given, and the price bundle clears the market.

5.1 Supply Side

We develop a three-sector model from the two-sector model presented by Brandt, Hsieh, and Zhu(2008). Let subscripts a, m and s denote agriculture, manufacturing and service sectors. And let A_i be productivity, K_i be capital, L_i be labor, w_i be wage, r_i be capital rental price and p_i be the price of output in each sector $(i = a, m, s)$.

The production function in each sector is assumed to be Cobb-Douglas:

$$Q_i = A_i K_i^{1-\alpha} L_i^{\alpha} \ (i = a, m, s)$$

From the firm's perspective, we have the profit function $p_i Q_i - w_i L_i - r_i K_i = p_i A_i K_i^{1-\alpha} L_i^{\alpha} - w_i L_i - r_i K_i$. Thus by differentiating the function with respect to L_i we have wage equals the value of the marginal product of labor:

$$w_a = p_a \alpha A_a K_a^{1-\alpha} L_a^{\alpha-1} \tag{1}$$

$$w_m = p_m \alpha A_m K_m^{1-\alpha} L_m^{\alpha-1} \tag{2}$$

$$w_s = p_s \alpha A_s K_s^{1-\alpha} L_s^{\alpha-1} \tag{3}$$

We further assume that capital in agriculture sector(land) is determined exogenously. However, the allocation of capital between manufacturing and the service sector is determined endogenously. In addition, we assume that there is no capital misallocation between manufacturing and services, which means that $r_m = r_s = r$. Thus by differentiating the profit function with respect to K_i we have capital rental price equals the value of the marginal product of capital:

$$r = r_m = p_m(1-\alpha)A_m K_m^{-\alpha} L_m^{\alpha} \tag{4}$$

$$r = r_s = p_s(1-\alpha)A_s K_s^{-\alpha} L_s^{\alpha} \tag{5}$$

Denote wage distortions between agriculture and manufacturing as $1-\xi = \frac{w_a}{w_m}$, and wage distortions between services and manufacturing as $1+\theta = \frac{w_s}{w_m}$. As mentioned in Chapter 4, ξ and θ are assumed to be exogenous. They are measurements for the labor market barriers between sectors and they are unobserved. In order to compute them, we have

$$1-\xi = \frac{w_a}{w_m} = \frac{p_a}{p_m}\frac{A_a}{A_m}(\frac{K_a}{K_m})^{1-\alpha}(\frac{L_a}{L_m})^{\alpha-1} = \frac{p_a Q_a/L_a}{p_m Q_m/L_m} \tag{6}$$

$$1+\theta = \frac{w_s}{w_m} = \frac{p_s}{p_m}\frac{A_s}{A_m}(\frac{K_s}{K_m})^{1-\alpha}(\frac{L_s}{L_m})^{\alpha-1} = \frac{p_s Q_s/L_s}{p_m Q_m/L_m} \tag{7}$$

Note that $p_i Q_i/L_i$ is the nominal output per worker in each sector, which can be observed from data. Therefore the ratio of nominal output per worker can be used to infer the wage distortions ξ and θ.

5.2 Demand Side

Next we need additional equations to back out share of labor employment in each sector. Therefore we need to bring in consumer preference.

Assume the total amount of labor L is exogenous but its allocation across sectors, as measured by $l_a = \frac{L_a}{L}$, $l_m = \frac{L_m}{L}$, and $l_s = \frac{L_s}{L}$ is determined by consumer preferences.

Specifically, following Herrendorf, Rogerson and Valentinyi(2014), I assume the utility function of an agent as

$$\log C = \log[\omega_a^{\frac{1}{\varepsilon}}(c_a - \bar{c}_a)^{\frac{\varepsilon-1}{\varepsilon}} + \omega_m^{\frac{1}{\varepsilon}} c_m^{\frac{\varepsilon-1}{\varepsilon}} + \omega_s^{\frac{1}{\varepsilon}}(c_s + \bar{c}_s)^{\frac{\varepsilon-1}{\varepsilon}}]^{\frac{\varepsilon}{\varepsilon-1}}$$

where ε represents the elasticity of substitution between agricultural, manufacturing and service goods and the ω_i are weights on different consumption goods, that satisfy $\omega_a + \omega_m + \omega_s = 1$.

The parameters $\bar{c}_a > 0$ and $\bar{c}_s > 0$ allow the preference to be non-homothetic. When $\bar{c}_a = \bar{c}_s = 0$, if income changes, the share of consumption of the three goods will not change at all. Allowing for positive $\bar{c}_a$ and $\bar{c}_s$ means that while income changes the share of consumption also changes. Note that the positive $\bar{c}_a$ can also be interpret as the subsistence food constraint.

The representative agent solves

$$\max_{c_a, c_m, c_s, l_a, l_m, l_s} \log C$$

$$s.t.\ c_a p_a + c_m p_m + c_s p_s = r_a K_a + r K_m + r K_s + \tfrac{w_a}{1-\xi} l_a L + w_m l_m L + \tfrac{w_s}{1+\theta} l_s L$$

Here ξ and θ are exogenous labor market barriers between sectors. Since $\frac{w_a}{1-\xi} = w_m = \frac{w_s}{1+\theta}$, any allocation of labor between three sectors is optimal for the agent.

Then by first order conditions of c_a, c_m and c_s we have:

$$(\frac{p_a}{p_m})^{\epsilon} \frac{c_a - \bar{c}_a}{c_m} = \frac{\omega_a}{\omega_m} \tag{8}$$

$$(\frac{p_s}{p_m})^{\epsilon} \frac{c_s + \bar{c}_s}{c_m} = \frac{\omega_s}{\omega_m} \tag{9}$$

Now assume that manufacturing sector output is either consumed or invested, output from the other two sectors is used as consumption only, and the investment rate δ is assumed as exogenous. Also assume that there is no trade, and all production that doesn't go to investment is consumed at home. Then market clearing conditions imply

$$c_a = Q_a = A_a K_a^{1-\alpha} L_a^{\alpha} = A_a K_a^{1-\alpha} (l_a L)^{\alpha} \tag{10}$$

$$c_m = (1-\delta) Q_m = (1-\delta) A_m K_m^{1-\alpha} L_m^{\alpha} = (1-\delta) A_m K_m^{1-\alpha} (l_m L)^{\alpha} \tag{11}$$

$$c_s = Q_s = A_s K_s^{1-\alpha} L_s^{\alpha} = A_s K_s^{1-\alpha} (l_s L)^{\alpha} \tag{12}$$

Thus, substituting (10), (11) and (12) into (8) and (9) we have

$$(\frac{p_a}{p_m})^{\epsilon} \frac{A_a K_a^{1-\alpha} (l_a L)^{\alpha} - \bar{c}_a}{(1-\delta) A_m K_m^{1-\alpha} (l_m L)^{\alpha}} = \frac{\omega_a}{\omega_m} \tag{13}$$

$$(\frac{p_s}{p_m})^{\epsilon} \frac{A_s K_s^{1-\alpha} (l_s L)^{\alpha} + \bar{c}_s}{(1-\delta) A_m K_m^{1-\alpha} (l_m L)^{\alpha}} = \frac{\omega_s}{\omega_m} \tag{14}$$

Also, from (1), (2) and (3) we have

$$1 - \xi = \frac{p_a}{p_m} \frac{A_a}{A_m} (\frac{K_a}{K_m})^{1-\alpha} (\frac{l_a}{l_m})^{\alpha-1} \tag{15}$$

$$1 + \theta = \frac{p_s}{p_m} \frac{A_s}{A_m} (\frac{K_s}{K_m})^{1-\alpha} (\frac{l_s}{l_m})^{\alpha-1} \tag{16}$$

Also note that the share of employment sums up to 1:

$$l_a + l_m + l_s = 1 \tag{17}$$

We have direct measures of Y_i, K, L, L_i and δ in the data. ξ and θ can be computed from (6) and (7). Note that we don't have to identify A_i and K_i respectively in equation (13) - (16) as they show up as $A_i K_i^{1-\alpha}$ each time and the later one can be estimated by $A_i K_i^{1-\alpha} = \frac{Q_i}{L_i^{\alpha}}$. We can solve for $\frac{p_a}{p_m}$, $\frac{p_s}{p_m}$, l_a, l_m and l_s with all of the known variables above and appropriate parameter values (there are 5 equations and 5 unknown variables).

5.3 Computing K_i and A_i

We cannot identify A_i and K_i respectively based on the above information. However, equation (2) and (4) imply

$$\frac{w_m}{r} = \frac{\alpha}{1-\alpha}\frac{K_m}{L_m} \tag{18}$$

Similarly, equation (3) and (5) imply

$$\frac{w_s}{r} = \frac{\alpha}{1-\alpha}\frac{K_s}{L_s} \tag{19}$$

Therefore from equation (18) and (19) we have

$$\frac{w_s}{w_m} = \frac{K_s}{K_m}\frac{L_m}{L_s} = \frac{K_s}{K_m}\frac{l_m}{l_s}$$

which means

$$\frac{K_s}{K_m} = (1+\theta)\frac{l_s}{l_m} \tag{20}$$

Here the variables on the right hand side of the equation are all already solved as shown above.

Since we observe K and by assumption $K_s + K_m = K$. Together with equation (20) we can solve for K_s and K_m.

Note that K_a (Land) is assumed to be exogenous and can be observed in data. The TFPs in each sector can then be estimated by $A_i = \frac{Q_i}{K_i^{1-\alpha} L_i^{\alpha}}$.

6 Result

6.1 The Quantitative Exercise

Observing the nominal GDP (p_iQ_i) and GDP index of each sector in the data set from 1978 to 2012, I am able to calculate real GDP (Q_i) by multiplying the nominal GDP of 1978 times the GDP index. Now that I have the nominal GDP and the real GDP, I can use the ratio of the nominal GDP divided by the real GDP to measure the price level p_i of each sector.

Since we are unable to observe the total amount of fixed capital, we observe newly increased fixed capital for each period. We assume that the total amount of fixed capital in year 1978 is the newly increased fixed capital in year 1978 times 10. The total amount of fixed capital in subsequent years is computed by multiplying the total amount of fixed capital from the previous year times one minus the depreciation rate plus any new increases in capital. In this quantitative exercise, the depreciation rate is assumed to be 0.1.

Additionally, there are several unknown parameters in the model that I intend to measure. I also look to quantify all other values such that the solution to the model matches up with the data given from 1992 through 2012. In following the work of Brandt, Hsieh, and Zhu(2008), I assume that $\alpha = 0.5$ for all three sectors in the Cobb-Douglas production function. I must choose the values for the elasticity of substitution, ε, the weights of consumption, ω_i, and the non-homothetic preference parameters, $\bar{c}_a$, $\bar{c}_s$. I choose values such that the solution to the price ratio and share of employment matches the data precisely from 1992 to 2012.

As a result, the value of ε used in our model is 1.4, demonstrating a low elasticity of substitution between consumption goods. The value of the weights of consumption are $\omega_a = 0.1191$, $\omega_m = 0.2217$, and $\omega_s = 0.6593$. The value I use for the non-homothetic preference parameters are $\bar{c}_a = 869.5$ and $\bar{c}_s = 4463.7$. The exact procedure to compute these parameter values can be found in Appendix A. Given the average output of agriculture during the 1992 to 2012 period is 3199, the subsistence consumption of the agriculture good is 27.2% of the output of total agriculture production.

Given the above parameters and exogenous variables, I can compute the labor share and price ratio for each year. In figures 6-14, I am able to compare the given data to the model. Figures 6-9 characterize the difference in labor productivity as measured by output per worker. Figures 13-14 characterize the difference between the share of employment when looking at the data and the model. Figures 10-12 characterize the difference in price ratio between the data and the model.

From the results, we can see that the model's predicted value does match up reasonably well with the given data. Therefore we can use our model to conduct counterfactual analysis in measuring the contribution of different sources to the growth and structure of transformation.

One additional note is that in figure 14, the data and model predicted value for price ratio coincide for each year. To see this, on one hand, $1+\theta = \frac{L_m}{L_s}\frac{K_m}{K_s}$, on the other hand, $1+\theta = \frac{P_s Q_s/L_s}{P_m Q_m/L_m}$, which means $\frac{K_s}{K_m} = \frac{P_s Q_s}{P_m Q_m}$. Therefore $\frac{p_s}{p_m} = (1+\theta)\frac{Q_m/L_m}{Q_s/L_s} = \frac{L_m}{L_s}\frac{K_s}{K_m}\frac{Q_m/L_m}{Q_s/L_s} = \frac{K_s/Q_s}{K_m/Q_s} = \frac{p_s Q_s/Q_s}{p_m Q_m/Q_m} = \frac{\text{Nominal GDP}_s/\text{Real GDP}_s}{\text{Nominal GDP}_m/\text{Real GDP}_m}$. The left hand side of the equation is model predicted value of price ratio, and the right hand side of the equation is data implied value of price ratio.

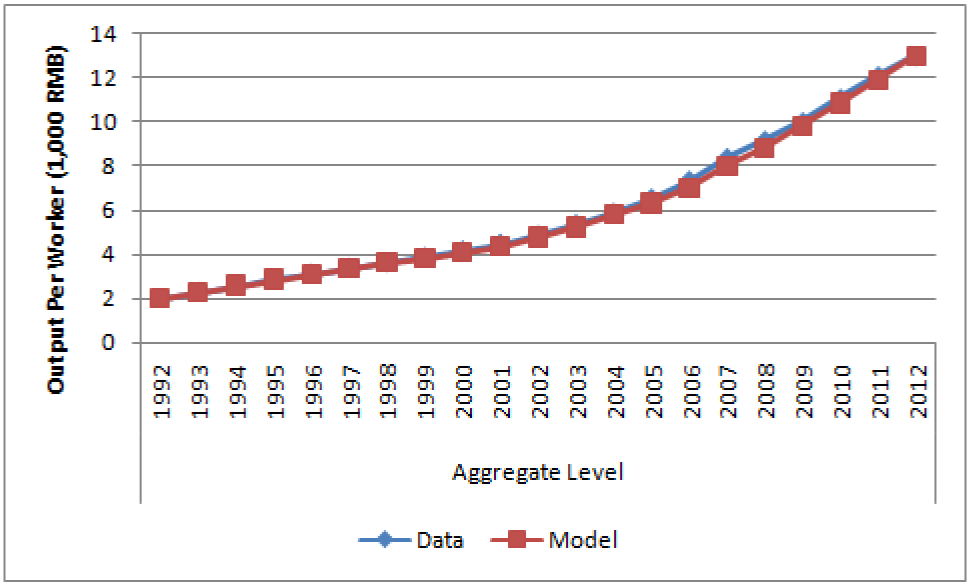

Figure 6: Output Per Worker at Aggregate Level

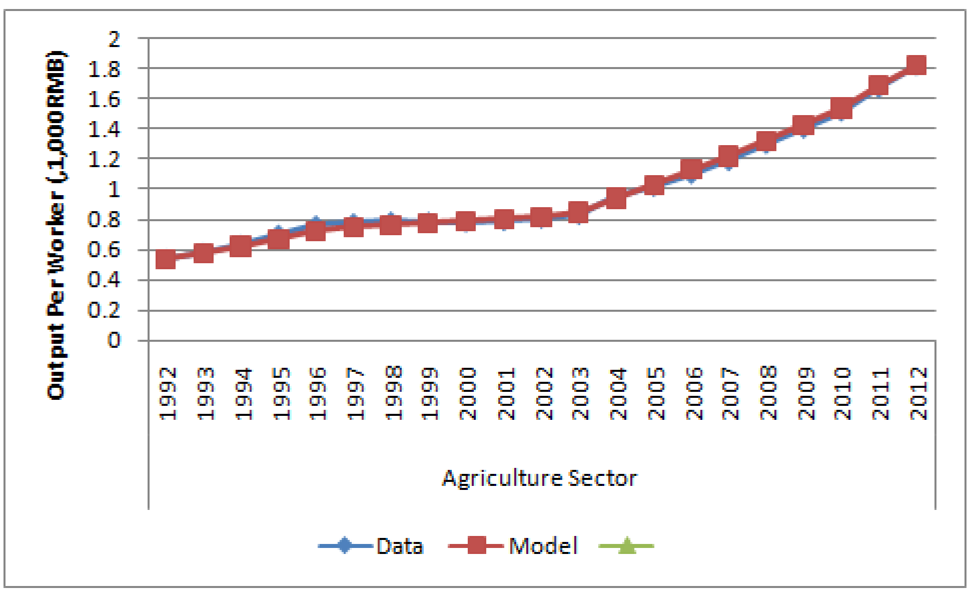

Figure 7: Output Per Worker of Agriculture Sector

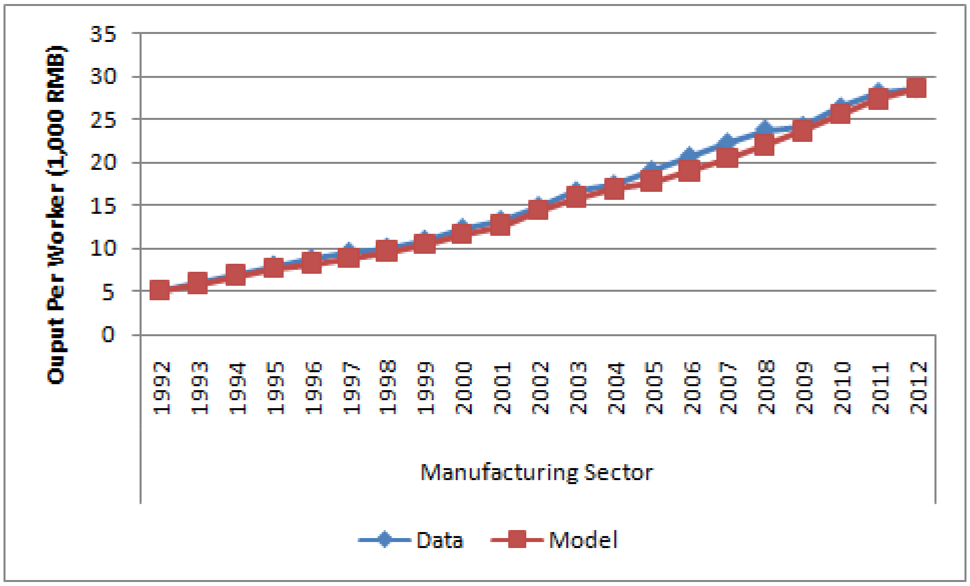

Figure 8: Output Per Worker of Manufacturing Sector

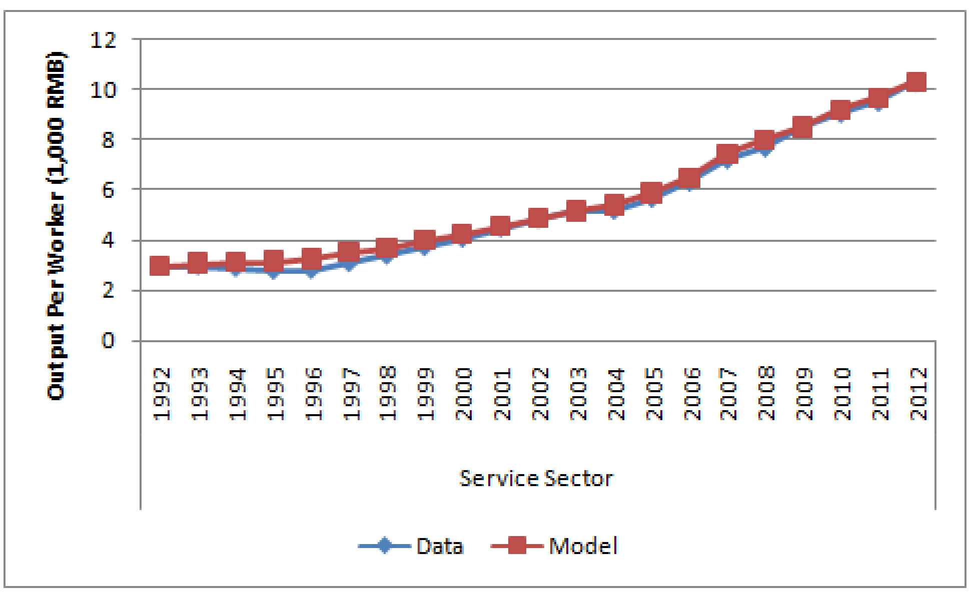

Figure 9: Output Per Worker of Service Sector

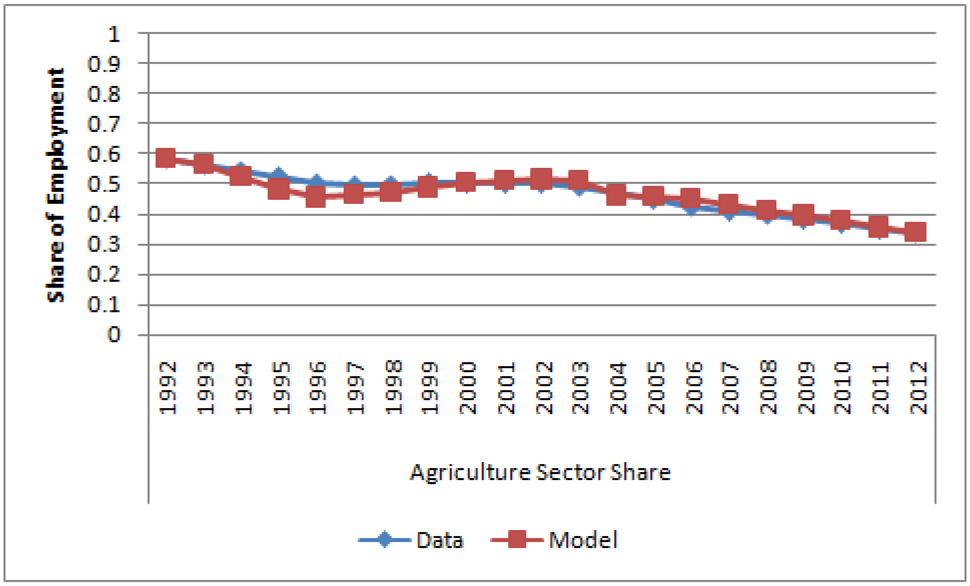

Figure 10: Share of Employment of Agriculture Sector

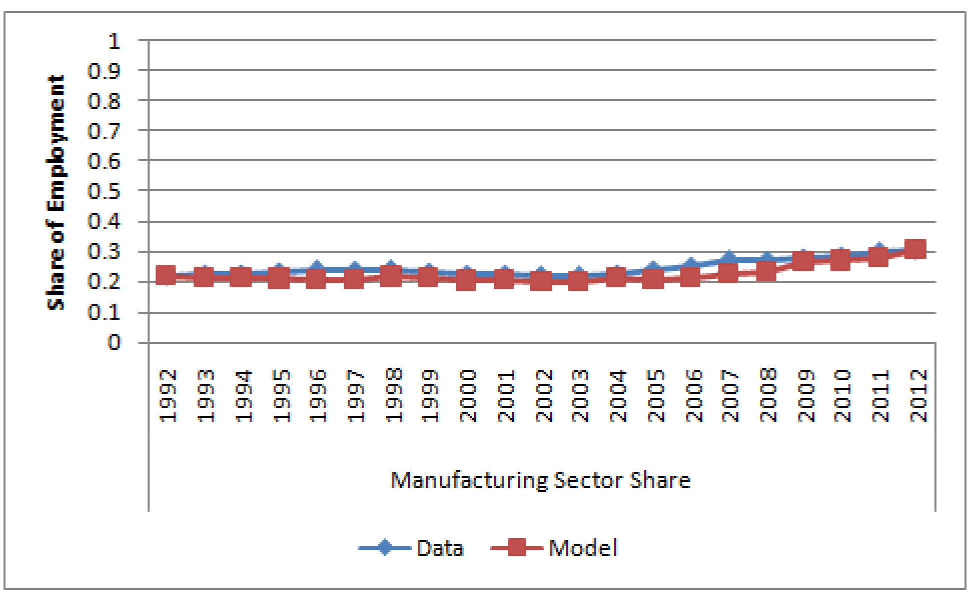

Figure 11: Share of Employment of Manufacturing Sector

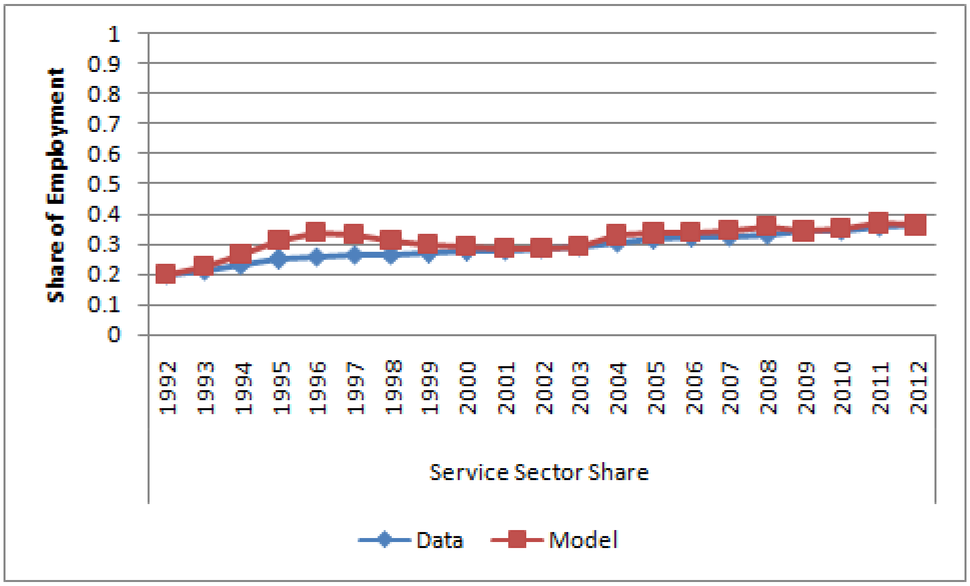

Figure 12: Share of Employment of Service Sector

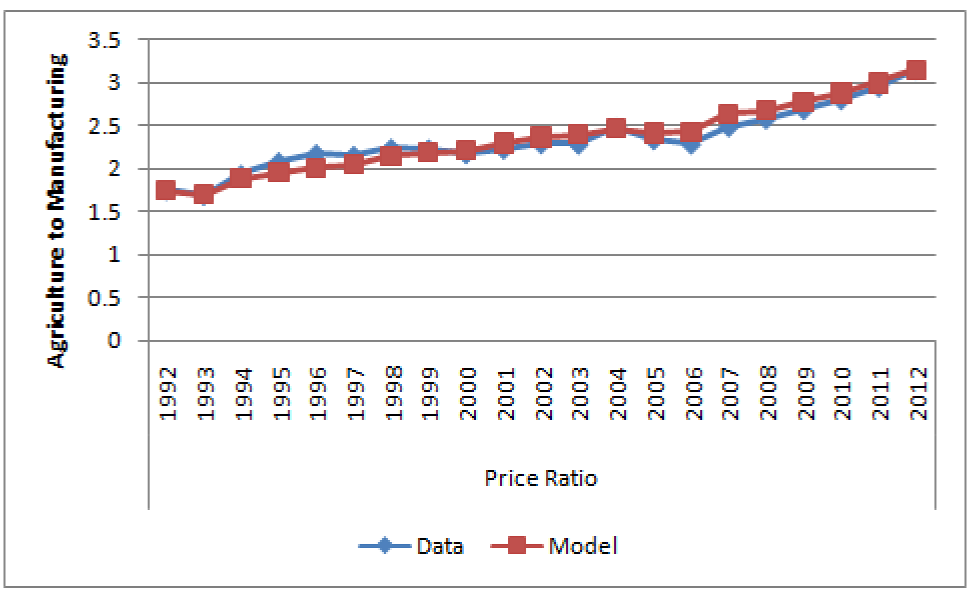

Figure 13: Price Ratio of Agriculture to Manufacturing

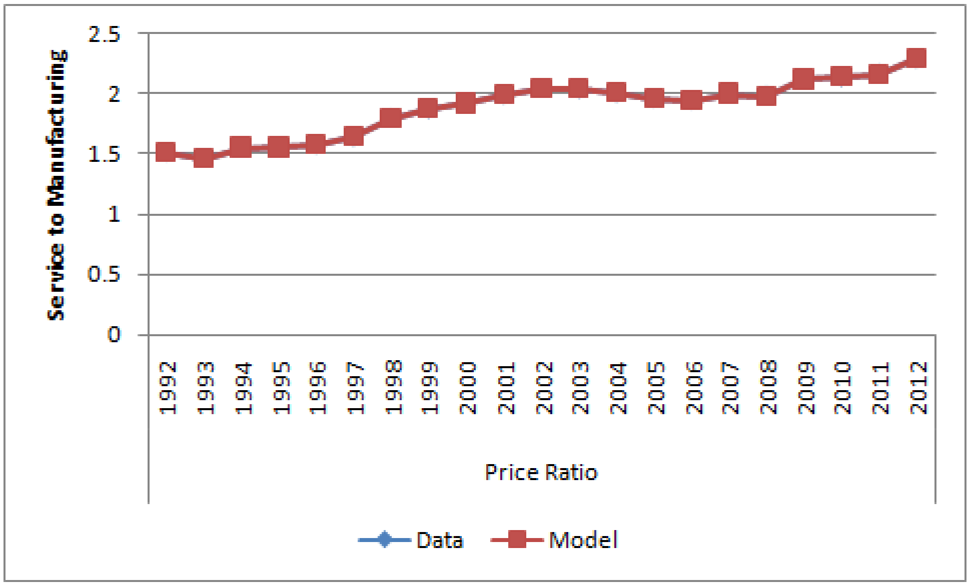

Figure 14: Price Ratio of Service to Manufacturing

6.2 Counterfactual Analysis

I conduct counterfactual analysis in TFP growth, barriers of the labor force, and investment rate in order to analyze the contribution of different sources to the growth and structural change.

No TFP Growth

If there were no TFP growth in agriculture, the rural labor that should have been driven out to the urban area as a result of TFP growth, will instead stay in the rural area. From the counterfactual, it can be seen that the reduction of the agriculture labor share is only 23.8% without TFP growth in comparison to the 24.9% reduction in the data. The counterfactuals also show that the TFP growth in the manufacturing and services sector affect the reallocation of the labor force from rural areas to urban areas more than the TFP growth in agriculture does with a reduction of 23.8% and

22.7%, respectively.

The labor productivity growth in agriculture is 1.20% in comparison to 6.28%, which shows that the TFP growth in the agricultural sector contributes to 80.9% of labor productivity growth in agriculture. However, without TFP growth in the agricultural sector, the aggregate is 9.60% compared to 9.81% in the data, which means the TFP growth in agriculture contributes little to the growth of the aggregate economy.

If there were no TFP growth in manufacturing, however, the growth rate of the aggregate labor productivity would have decreased from 9.81% to 6.96%. This counterfactual shows that even in the past decade, the TFP growth of manufacturing still contributes to a major part of economic growth in China. Finally, the TFP growth in the services sector also contributes little to the aggregate labor productivity. Current TFP growth is 9.34%, but it could have been 9.81% as measured by the data.

No Reduction in Labor Market Barriers

Since there is not a significant reduction in the barriers of the labor force in both agriculture-manufacturing and manufacturing-service as measured by the wage ratio from 1992-2012, we should expect that these variables did not contribute much to the structure transformation and growth.

The counterfactuals show that if there was not a reduction made for the agriculture-manufacturing barrier, the reduction of share in agriculture would be 23.0% in comparison to 24.9% in the data. If there was not a reduction made for the service-manufacturing barrier, the reduction of the share in agriculture would be 23.1%. If there was not a reduction in any of the sectors, the reduction of share in agriculture would be 21.3%. The data shows that the barriers slow down any structure changes, but only at a very small rate.

The reduction in barriers also contributes little to the labor productivity growth. The productivity growth is 9.81% as measured by data. If there were no reduction in any of the barriers, the productivity growth would be around 9.6%.

No Increase in Investment Rate

If there were no increase in the investment rate, the reduction in labor reallocation would be 23.2%. Therefore, the increase in the investment rate contributes to the labor reallocation. This contribution, however, is minimal.

The increase in the investment rate does contribute to the growth of labor productivity even more than the reduction in labor market barriers. The growth rate is 9.57% when the investment rate is fixed at the 1992 level from 1992 to 2012 in comparison to 9.81% in the data.

Table 1: Driving forces of labor reallocation

	Reduction of share in agriculture(L_a/L)
	1992-2012
Data	24.9
Model	24.9
Counterfactuals:	
No TFP growth in agriculture	23.8
No TFP growth in manufacturing	22.5
No TFP growth in service	22.2
No reduction in barriers	21.3
No reduction in agri-manu barriers	23.0
No reduction in serv-manu barriers	23.1
Fixed investment rate	23.2

Table 2: Historical and counterfactual estimates of average annual labor productivity growth

	Average labor productivity growth			
	Aggregate	Agriculture	Manufacturing	Service
Data	9.81	6.28	9.04	6.49
Model	9.81	6.31	9.08	6.56
Counterfactuals:				
No TFP growth in agriculture	9.60	1.20	9.13	6.60
No TFP growth in manufacturing	6.96	6.13	4.94	6.24
No TFP growth in service	9.34	6.11	8.78	4.64
No reduction in barriers	9.57	6.17	9.08	6.99
No reduction in agri-manu barriers	9.73	6.12	9.14	6.63
No reduction in serv-manu barriers	9.64	6.38	9.03	6.94
Fixed investment rate	9.57	6.18	9.57	6.33

7 Conclusion

In this paper, I study the structural transformation of the Chinese economy during the 1992 to 2012 period. My goal is to pin down the effect of the different driving forces on the labor reallocation from the rural to the urban area as well as the labor productivity growth during the 1992 to 2012 period.

To analyze the effect of different driving forces, I extend the two-sector model presented by Brandt, Hsieh, and Zhu(2008) into a three-sector model. I also adopt the specification of the consumer's utility function from Herrendorf, Rogerson, and Valentinyi (2014).

The predicted value of the model deviates very little from the data itself and therefore can be used for counterfactual analysis. The counterfactual analysis shows that the TFP growth in the service sector is the key driving force to the reallocation of labor from rural to urban areas.

The investment rate is treated as an exogenous variable in the model, which may affect the result. Future research can incorporate an endogenous investment rate by considering a dynamic model of consumer choice. Additionally, because of the different measures used by NBS in their data prior to and post-1990, I only analyze the period from 1992 to 2012. To conduct more complete research, I can integrate the data from 1978 through 1992 for a more rigorous assessment of China's structural transformation.

Appendix A

Exact Procedure to Compute Parameter Values in the Model

We use $\epsilon = 1.4$, $\omega_a = 0.1191$, $\omega_m = 0.2217$, $\omega_s = 0.6593$, $\bar{c}_a = 869.5$, and $\bar{c}_s = 4463.7$ in the model. This appendix shows how they are computed.

As mentioned in Chapter 6, the parameters values are chosen such that the model predicted value of price ratio and share of employment match data value in 1992 and 2012 exactly. This actually means that we use the data value of price ratio and share of employment in year 1992 and 2012 to compute them based on equation (13) and (14).

In fact, from equation (13) and (14)

$$(\frac{p_a}{p_m})^\epsilon \frac{A_a K_a^{1-\alpha}(l_a L)^\alpha - \bar{c}_a}{(1-\delta)A_m K_m^{1-\alpha}(l_m L)^\alpha} = \frac{\omega_a}{\omega_m}$$
$$(\frac{p_s}{p_m})^\epsilon \frac{A_s K_s^{1-\alpha}(l_s L)^\alpha + \bar{c}_s}{(1-\delta)A_m K_m^{1-\alpha}(l_m L)^\alpha} = \frac{\omega_s}{\omega_m}$$

and real output $Y_i = A_i K_i^{1-\alpha}(l_i L)^\alpha$, we have

$$(\frac{p_a}{p_m})^\epsilon \frac{Y_a - \bar{c}_a}{(1-\delta)Y_m} = \frac{\omega_a}{\omega_m}$$
$$(\frac{p_s}{p_m})^\epsilon \frac{Y_s + \bar{c}_s}{(1-\delta)Y_m} = \frac{\omega_s}{\omega_m}$$

By plugging in the data from year 1992 and 2012 we have four equations:

$$(\frac{p_{a_{1992}}}{p_{m_{1992}}})^\epsilon \frac{Y_{a_{1992}} - \bar{c}_a}{(1-\delta_{1992})Y_{m_{1992}}} = \frac{\omega_a}{\omega_m}$$
$$(\frac{p_{s_{1992}}}{p_{m_{1992}}})^\epsilon \frac{Y_{s_{1992}} + \bar{c}_s}{(1-\delta_{1992})Y_{m_{1992}}} = \frac{\omega_s}{\omega_m}$$
$$(\frac{p_{a_{2012}}}{p_{m_{2012}}})^\epsilon \frac{Y_{a_{2012}} - \bar{c}_a}{(1-\delta_{2012})Y_{m_{2012}}} = \frac{\omega_a}{\omega_m}$$
$$(\frac{p_{s_{2012}}}{p_{m_{2012}}})^\epsilon \frac{Y_{s_{2012}} + \bar{c}_s}{(1-\delta_{2012})Y_{m_{2012}}} = \frac{\omega_s}{\omega_m}$$

There are 4 unknown variables($\frac{\omega_a}{\omega_m}$, $\frac{\omega_s}{\omega_m}$, $\bar{c}_a$, and $\bar{c}_s$) and 4 equations if we take ε as given. Therefore by solving the above equations we have,

$$\frac{\omega_a}{\omega_m} = \frac{Y_{a2012} - Y_{a1992}}{\frac{(1-\delta_{2012})Y_{m2012}}{(\frac{p_{a2012}}{p_{m2012}})^{\epsilon}} - \frac{(1-\delta_{1992})Y_{m1992}}{(\frac{p_{a1992}}{p_{m1992}})^{\epsilon}}}$$

$$\frac{\omega_s}{\omega_m} = \frac{Y_{s2012} - Y_{s1992}}{\frac{(1-\delta_{2012})Y_{m2012}}{(\frac{p_{a2012}}{p_{m2012}})^{\epsilon}} - \frac{(1-\delta_{1992})Y_{m1992}}{(\frac{p_{s1992}}{p_{m1992}})^{\epsilon}}}$$

$$\bar{c}_a = Y_{a2012} - \frac{(1-\delta_{2012})Y_{m2012}}{(\frac{p_{a2012}}{p_{m2012}})^{\epsilon}} \frac{\omega_a}{\omega_m}$$

$$\bar{c}_s = \frac{(1-\delta_{2012})Y_{m2012}}{(\frac{p_{s2012}}{p_{m2012}})^{\epsilon}} \frac{\omega_s}{\omega_m} - Y_{s2012}$$

Note that $\omega_a + \omega_m + \omega_s = 1$, we can then compute each of them respectively.

Thus, for each value of ε, the value of ω_i and $\bar{c}_k$ are uniquely pinned down and hence the model predicted value. We then vary ε from 1.0 to 3.0 and choose the value such that $\omega_i \in [0, 1]$, $\bar{c}_k > 0$ and there is minimum distance between model predicted value and data.

Appendix B

Another Approach to Compute Labor Barrier

Chapter 5 shows one way to compute labor barriers, i.e., equation (6) and (7). In this appendix we present another way to compute them. The resulting model predicted value of labor productivity and employment share will be exactly identical to data for each year in this approach (recall that in the figures presented in Chapter 6, the model predicted value of labor productivity and employment share are only identical in year 1992 and 2012). However, the counterfactual results are almost same for both approaches.

In Chapter 5, we derived 4 equations:

$$
\begin{aligned}
(\frac{p_a}{p_m})^{\epsilon}\frac{A_a K_a^{1-\alpha}(l_a L)^{\alpha} - \bar{c}_a}{(1-\delta)A_m K_m^{1-\alpha}(l_m L)^{\alpha}} &= \frac{\omega_a}{\omega_m} \\
(\frac{p_s}{p_m})^{\epsilon}\frac{A_s K_s^{1-\alpha}(l_s L)^{\alpha} + \bar{c}_s}{(1-\delta)A_m K_m^{1-\alpha}(l_m L)^{\alpha}} &= \frac{\omega_s}{\omega_m} \\
1 - \xi = \frac{p_a}{p_m}\frac{A_a}{A_m}(\frac{K_a}{K_m})^{1-\alpha}(\frac{l_a}{l_m})^{\alpha-1} \\
1 + \theta = \frac{p_s}{p_m}\frac{A_s}{A_m}(\frac{K_s}{K_m})^{1-\alpha}(\frac{l_s}{l_m})^{\alpha-1}
\end{aligned}
$$

which can be used to solve price ratio and share of employment taken ξ and θ as given. However, on the other hand, they can also be used to solve price ratio, ξ and θ, taken share of employment as given. Thus, use the share of employment in the data, we have another way to compute ξ and θ, which is to solve the above system of equations conversely.

The counterfactual result of this approach are given as below, we can see that they are almost identical to the result presented in chapter 6.

Table 3: Driving forces of labor reallocation(Another Approach)

Driving forces of labor reallocation

	Reduction of share in agriculture(L_a/L)
	1992-2012
Data	24.9
Model	24.9
Counterfactuals:	
No TFP growth in agriculture	23.8
No TFP growth in manufacturing	21.7
No TFP growth in service	19.7
No reduction in barriers	22.1
No reduction in agri-manu barriers	23.0
No reduction in serv-manu barriers	24.1
Fixed investment rate	23.2

Table 4: Historical and counterfactual estimates of average annual labor productivity growth(Another Approach)

	Average labor productivity growth			
	Aggregate	Agriculture	Manufacturing	Service
Data	9.81	6.28	9.04	6.49
Model	9.81	6.28	9.04	6.49
Counterfactuals:				
No TFP growth in agriculture	9.60	1.18	9.09	6.54
No TFP growth in manufacturing	6.23	6.04	3.27	6.08
No TFP growth in service	9.16	5.90	8.49	3.21
No reduction in barriers	9.76	6.05	9.01	6.69
No reduction in agri-manu barriers	9.73	6.11	9.11	6.59
No reduction in serv-manu barriers	9.83	6.23	8.93	6.62
Fixed investment rate	9.57	6.15	9.53	6.27

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ACADEMIC VITA

Baoqi(Laura) Kuang
1400 Martin Street, State College, PA, 16803
bzk5175@psu.edu

EDUCATION:

The Pennsylvania State University, University Park, PA Expected: Dec. 2014

Schreyer Honors College

Bachelor of Science in Economics, Minor in business

ACADEMIC ACTIVITIES:

Bates White Research Experience for Undergraduates (REU) student, as well as Summer Research Assistant for Prof. David Shapiro's project about women fertility rate in Sub-Saharan Africa, *Spring – Oct. 2014*

Undergraduate Teaching Assistant of Intermediate Microeconomics, Fall 2013 to Spring 2014

Undergraduate Teaching Assistant of Development and Growth Economics, *Fall 2014*

Attended selected exchange program in Coventry University, UK, *Aug. 2011*

Dean's List all semester.

Professional Experience:

Everbright Financial Holding Asset Management Co., Ltd. Beijing, China *May – July 2014*

National Development and Reform Commission, Jiangxi, China *June – Aug. 2013*

Standard Chartered Bank (British Bank), Nanchang, Jiangxi, China *July – Aug. 2012*

SKILLS:

Computer: Microsoft Excel and Word, STATA, TeX

Language: Native in Mandarin, Fluent in English