The Rise of the Service Sector: Expansion of Distribution and Personal Services

Junmin Liao*

Abstract

This paper develops a model of structural change to study the rise of the service sector in China by disaggregating the service sector into distribution services and personal services. The former complement manufacturing production and the latter substitute for home production. After China moved from a planned economy to a market economy, the distribution service sector rose immediately to correct the distortion between supply and demand. Hence the manufacturing sector was released and operated at its full capacity, which increased income. Then the personal service sector started to grow as income grew. Meanwhile the agricultural sector grew at a fast pace and release labor to the non-agricultural sector. The model establishes a link between labor productivity and the sectoral labor employment share. Calibrated TFP growth rate can simulate the dynamics of labor allocation precisely. The quantitative results show that the income effect is the main contributor and it can explain more than half of the growth of the service sector. The role for sector-biased technological progress and capital deepening are modest. Intersectoral wage gaps are also very important in explaining the rise of the service sector.

Keywords: structural change; unbalanced growth; service economy

JEL Classification: J21; O11; O14

*Liao: Department of Economics, Washington University in St. Louis, Campus Box 1208, 1 Brookings Drive, St. Louis, MO 63130 (e-mail: liaojunmin@wustl.edu). I am indebted to Ping Wang, B. Ravikumar, and Yongseok Shin for their guidance and support. I have benefited from constructive comments by seminar participants at Washington University. All errors are my own. I also acknowledge the support from Department of Economics, and from Center for Research in Economics and Strategy (CRES) in the Olin Business School, Washington University in St. Louis.

1 Introduction

Cross-country evidence shows that the service sector gradually becomes the largest sector in terms of output and employment in the developed world. During this transformation, interesting questions would be raised: why do some countries experience a high growth rate in the service sector?

The emerging service market in post-reform China provides a great opportunity to study the early stage of development in the service sector. China has grown rapidly over the past three decades and now become the second largest economy in the world. Along with this unprecedented growth, China has also experienced a quick expansion of the service sector. Table 1 summarizes the facts of the rise of the service sector in emerging countries. In this table I calculate the per capita GDP annual growth rate, annual growth service value added and employment share for the next ten years after these countries reached $2000 per capita income level (PPP adjusted, 2005 US dollars).[1] We can see the growth of the service sector (in terms of growth of value added share or employment share) in China is among the top of these countries.[2]

Country	Year	GDP/Capita Growth %	Service/GDP VA% Growth	Service/GDP EMP% Growth	Country	Year	GDP/Capita Growth %	Service/GDP VA% Growth	Service/GDP EMP% Growth
Georgia	1997	5.65	1.80		Taiwan	1962	7.41	0.12	0.55
Sri Lanka	1993	3.08	1.08		Brazil	1955	4.00	0.08	0.53
China	1993	6.78	0.86	0.85	Colombia	1950	1.00	0.00	0.36
Japan	1950	6.47	0.41	0.64	Indonesia	1989	3.18	-0.05	0.87
Thailand	1977	3.98	0.40	0.42	Mongolia	1976	3.90	-0.10	
Bhutan	1997	4.91	0.30		Malaysia	1970	7.41	-0.15	
Morocco	1993	2.29	0.22		Egypt	1985	4.41	-0.15	
India	1996	6.64	0.18	0.27	Bulgaria	1970	6.51	-0.16	
Korea	1966	6.47	0.15	0.20	Paraguay	1970	5.77	-0.36	
Armenia	1997	9.91	0.14		Tunisia	1970	4.90	-0.91	

Year: the first year when the country reached $2000 per capita income level.

Table 1: The Rise of The service Sector in Emerging Countries

[1] See Appendix A.2.

[2] For Sri Lanka, there is a jump in the time series data. If ignoring this jump, then the growth service value added share is slower than China.

By disaggregating the sectoral data I find that in the past three decades the notable rapid growth components of the service sector in China are distribution services and personal services. Distribution services rose with the manufacturing sector. Then after the per capita income reached $2000 level, the personal service sector boomed.

This paper documents those facts about the impressive growth of the service sector in China. Motivated by this growth pattern, this paper departs from the existing literature by developing a tractable model that disaggregates services into distribution services and personal services. After China moved from a planned economy to a market economy, the distribution service sector rose immediately to correct the distortion between supply and demand. Hence constraints on the manufacturing sector were released and it operated at its full capacity, which increased income. Then the personal service sector started to grow as income grew. Meanwhile the agricultural sector grew at a fast pace and released labor to the non-agricultural sector.

I use CES aggregator to capture the complementarity (between the manufacturing sector and the distribution service sector) and the substitution effect (between personal services and home-made goods). The model of structural change establishes a link between labor productivity and the sectoral labor employment share. Calibrated TFP growth rate can simulate the dynamics of labor allocation quite precisely. Then I use this quantitative model to conduct several counterfactual analyses to determine the relative importance of various channels of structural change and discuss the implications.

I evaluate the quantitative effects of three channels which can affect structural change dynamics: sector-biased productivity growth, capital deepening, and income effect. The income effect, which contributes most to the total growth of service employment, explains almost 60%. Sector-biased productivity growth and capital deepening together (growth of distribution services) explain about 30%. I also evaluate the role of sectoral wage gap, which also has a significant impact on structural change. The personal service sector, which grows at a rapid speed, also benefits from cheap labor released from the agricultural sector.

To the best of my knowledge, this paper is the first to document the facts about rapid growth of the service sector in China and different growth patterns between distribution services and personal services, which relate to the early development stage of the service sector. Existing literature on China's economic growth and transforma-

tion mainly focus on the decline of the agricultural sector (Dekle and Vandenbroucke (2012); Cao and Birchenall (2013)) or the rise of the non-state sector (Brandt and Zhu (2010); Song, Storesletten and Zilibotti (2011); Zhu (2012)). Comparing to the latter literature, this paper provides another view to decompose the non-agricultural sector in China.

Based on the disaggregation, the demand side (income effect) and supply side (sector-biased technological progress) reasons of structural change are combined in a logic and reasonable way. This disaggregation can successfully replicate the overall growth of the service sector in China. Existing literature which uses Stone-Geary preferences cannot generate a large and late income effect to services. Without disaggregating services, it is the best to calibrate Leontieff preferences for the models using only the CES aggregator. This paper also contributes another viewpoint to study China's growth. Existing literature on China's rapid growth focuses on the intensive and extensive margin of the source of growth and ignores the composition of the economy especially the service sector. This paper shows that considerable economic resources are moving to the service sector and we need a model emphasizing service sector to quantify its contribution to growth.

The rest of this paper is organized as follows. After quickly reviewing the existing literature in the field, Section 2 provides the background and motivation by showing the empirical facts. Section 3 and 4 state the model formally. Section 5 analyzes the model quantitatively. Section 6 summarizes and concludes.

Related Literature

This paper is related to a large existing literature on structural change, disaggregation of service, and development of China.

The two main theoretical perspectives which are used to explain structural change are emphasized in the paper. They are related to the supply side or demand side of the products and labor input. The supply-side views start with Baumol (1967). He noticed that different sectors have different technological progress which results in different sectoral growth rate. Then because of different relative costs or prices, the industrial structure will change. This paper follows Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008) to use CES aggregator to capture the relationship between the

manufacturing sector and the service sector.[3] But without disaggregating services, it is the best to calibrate Leontieff preferences for the models. My paper particularly focuses on the complementarity between the manufacturing sector and distribution service sector.

Demand-side reasons basically assume different income elasticities of demand for different sectoral goods, hence nonhomothetic preferences are required. Stone-Geary preference and its varieties are widely used in the literature of this category.[4] It is proven to fit the decline of agriculture and the initial rise of service very well, but it cannot generate a large and late income effect to services. This paper follows Gollin, Parente and Rogerson (2002) to emphasize income effect in the agricultural sector and follows Rogerson (2008) to use CES aggregator to highlight the substitution effect between personal services and home production.[5]

The idea of service heterogeneity in this paper is related to several other papers. Greenfield (1966) defined producer services as the services that are sold to the producer rather than to the consumer, and noticed that they contributes the major part of service GDP. Katouzian (1970) emphasized complementary services, such as trade and transportation, are complement goods of manufacturing goods and are not related to per capita income. Other literature disaggregate services into traditional and modern services. As technology advances, modern services show different development direction and speed. Comparing to what Baumol called stagnant service sectors, Wolff (2002) proposed a concept of progressive service sectors which consist of those service industries that are heavier information and communication technology users. Based on this idea, Kapur (2012) developed this idea to fit the post war US experience. Comparing to the literature, my paper mainly focus on documenting the different growth patterns between distribution services and personal services.

This paper also relates to a vast literature on growth accounting of China. For

[3]For other treatment, see Hansen and Prescott (2002).

[4]See Matsuyama (1992), Echevarria (1997), Laitner (2000), Kongsamut, Rebelo and Xie (2001), Caselli and Coleman II (2001), Gollin, Parente and Rogerson (2002), and Wang and Xie (2004).

[5]Buera and Kaboski (2009) pointed out that the traditional structural change theories cannot explain the rise of the service sector in the US after 1980s. They also posited some possible solutions to this issue: introducing hierarchic consumption (see Murphy, Shleifer and Vishny (1989), Matsuyama (2002), and Buera and Kaboski (2012*a*,*b*)), home production (see Ngai and Pissarides (2008) and Rogerson (2008)), and higher level of disaggregation.

example, Brandt and Zhu (2010), Dekle and Vandenbroucke (2012), and Cao and Birchenall (2013) emphasized the labor movement from the agricultural sector to the non-agricultural sector. This paper complement the literature by pointing out that rural surplus labor are mainly absorbed by the personal service sector.

2 Empirical Evidence

Growth of the service sector driven by the growth of traditional services (i.e. trade, transportation, catering and lodging, etc) can be supported by relatively low per capita GDP. The emerging service market in after-reform China gives us a great opportunity to study this wave of growth in the service sector. This section first documents the macro trend of labor reallocation in the service sector of China, then the different growth patterns between the distribution service sector and the personal service sector. Finally the evidence from multiple countries are shown.

2.1 Macro Trend of Labor Reallocation

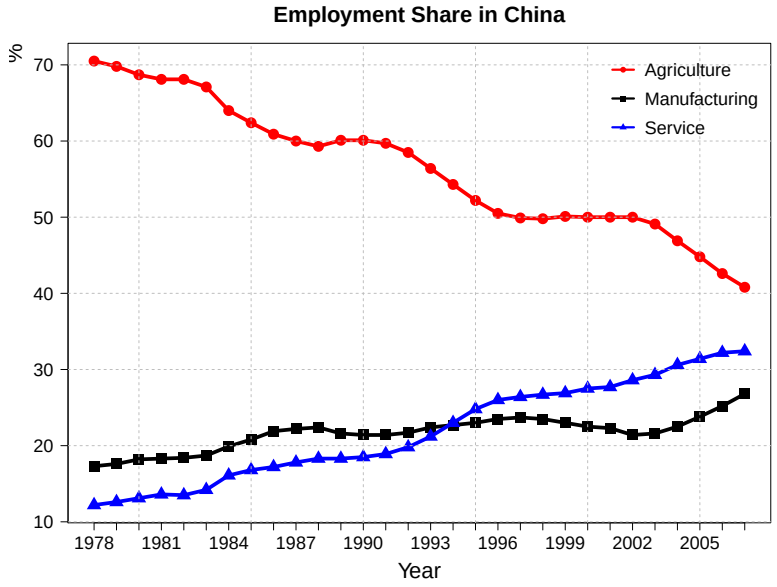

Figure 1: Employment Share by Sector: 1978-2007

I use sectoral employment data from *China Statistical Yearbooks* (CSY) to illustrate the labor reallocation in China from 1978 to 2007. From Figure 1 two significant facts are noticed. The first one is that agricultural employment share (red dots) declines very fast after China began its reform. It has been shrinking from more than 70% to 40% in less than 30 years, which implies a huge growth in agricultural productivity. The second one is the rapid growth of service employment share (blue triangles). It surpasses the manufacturing sector share before the manufacturing sector starts to decline. Therefore more than 20% employment share goes from the agricultural sector to the service sector.

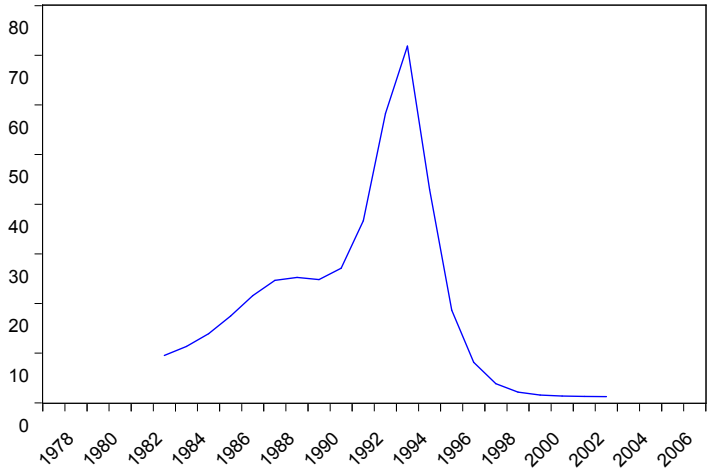

Figure 2: Quandt-Andrews Structural Break Test: LR F-Statistic, 15% Trimmed Data

With simple time series analysis we find structural break in the growth of service employment share. Figure 2 shows the graph for Quandt-Andrews structural break test F statistics with 15% trimmed data. The test is based on the following regression:

$$\ln(1 - Service\%) = c_1 + c_2 * t.$$

The test rejects the null hypothesis that there are no breakpoints in the sample period at a 1% significant level, and year 1994 is the break point (if assuming single break point). This result is also robust for linear regressions on service share with time t. It will be

interesting to study what factors drive this structural change.

2.2 Disaggregation of Service Employment Share

Subsector	Description	Composition	NACE rev. 1 code
Distribution Services	Complements of manufacturing goods	Wholesale, retailing, transportation and storage	50–52 and 60–63
Personal Services	Substitution of home production	hotels, restaurants, community and personal services	H, O, and P

NACE means statistical classification of economic activities in the European communities.

Table 2: Disaggregation of the Service Sector

Services are demanded by both firms and individuals. On the one hand, distribution services required by the manufacturing sector can be viewed as complements to the manufacturing goods. On the other hand, personal services demanded by households substitute for home-made products. Table 2 summarizes this disaggregation of services.

By disaggregating sectoral data we find that during this sample period the notable rapid growth components in the service sector are distribution services and personal services. Figure 3 shows the disaggregation. Some comments are needed here. Although China's reform began in 1978, it started from the agricultural sector first. Around 1983 private enterprises are allowed to enter sales and trade industries. A jump of distribution service employment share also confirmed it, while personal service share grew smoothly with no jump at the same time. If ignoring the decline between 1989-1992 (which resulted from a national political movement), distribution service employment share shows the same pattern as the manufacturing employment share in Figure 1. However, personal service employment share started to boom in 1993 which is in accord with our structural break test result. If comparing with per capita GDP data, the strong growth trend in personal service data indicates a large income elasticity.

Distribution service and manufacturing sectors are complement goods. The manufacturing sector depends heavily on distribution services. Input-Output Tables shows

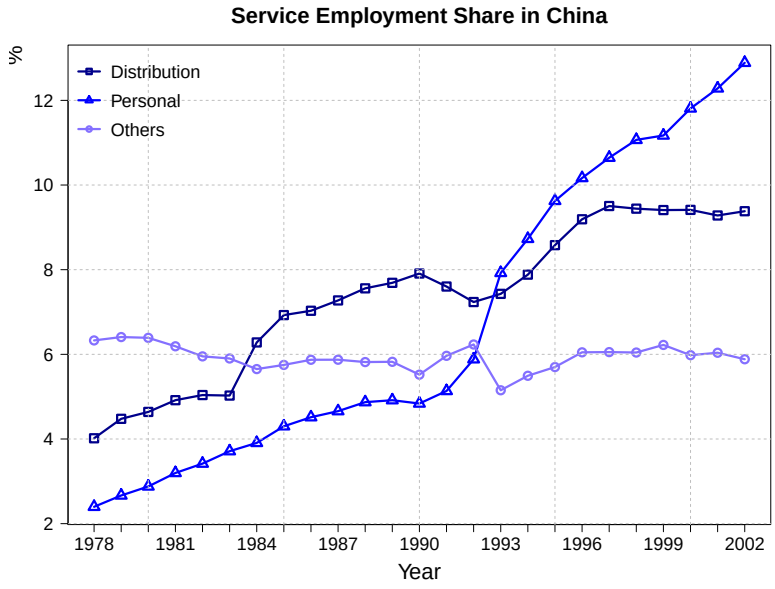

Figure 3: Disaggregation of Service Employment Share

that about 12% intermediate input of manufacturing sector comes from distribution services while only a negligible 0.7% comes from personal services.[6]

Personal services substitutes home production. When income reaches a certain level, more and more people who have comparative advantage on the work would prefer to purchase the service from the market rather than making it at home. As a consequence, the personal service sector starts to take off. Evidence from demand side confirms this income effect.

I collect data of consumer expenditure share of dining out and household service from various issues of *China Statistical Yearbooks*. Although this time series is only as far back as 1992, it features a structural break at 1994 which is in accord with the rise of personal service employment. Figure 4 shows this change in consumer preference.

2.3 Evidence from Multiple Countries

I also find similar evidence in Japan and Korea. From Figure 5 we can see that the employment share of the distribution service sector rose with the manufacturing sector

[6] Average data of Input-Output Tables, 1987-2002, KLEMS China.

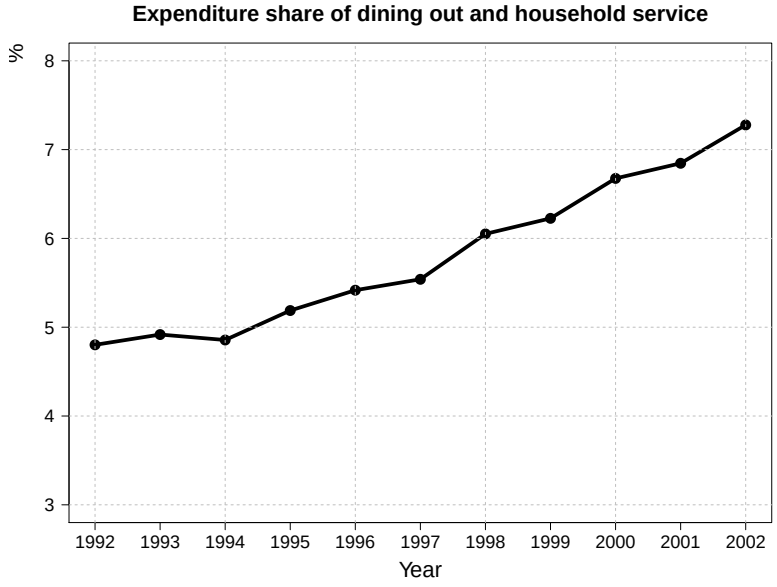

Figure 4: Change in Consumer Preference

then after several decades personal service employment share started to boom. So for different countries there might be different reasons for the personal sector to take off, but when we put all the evidence together, we cannot ignore the general pattern for the rise of the service sector.

One thing should be emphasized that the employment share of distribution service sectors rose earlier than that of personal service sectors. Cross-country evidence shows that this is also true for developed countries. I use KLEMS (1970-2004) panel data to estimate the value added share and employment share of distribution services and personal services for European Union 15 countries and United States based on the following regression:

$$Service\%_{it} = Constant + \sum \theta_i D_i + y + y^2 + y^3 + \mu_{it},$$

where D_i is the country dummy and y is log per capital GDP (PPP 2005 \$). Figure 6 shows the results after removing the fixed effects. We can see that for both value added share and employment share, distribution service sectors rose earlier than personal service sectors.

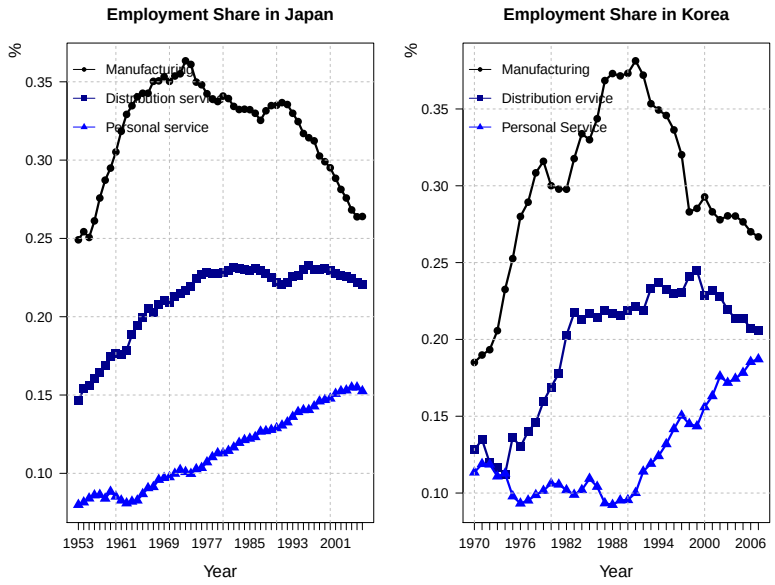

Figure 5: Rise of Service in Japan and Korea

To summarize, During China's past 30 years, the service sector has absorbed two thirds of labor allocation from the agricultural sector while the manufacturing sector are still growing. In this transition, distribution service employment has been harmonizing the movement of manufacturing employment and personal service employment shows a strong growth pattern which can be explained by income effects.

This is because distribution services are complement goods of manufacturing goods and are not related to per capita income (Katouzian (1970); Eichengreen and Gupta (2011)). On the contrary, personal services are related to per capita income and feature income effects (Eichengreen and Gupta (2011); Buera and Kaboski (2012*b*,*a*)). Cross-country evidence also shows that the distribution service sector rises first, then after income level increases, the personal service sector booms.

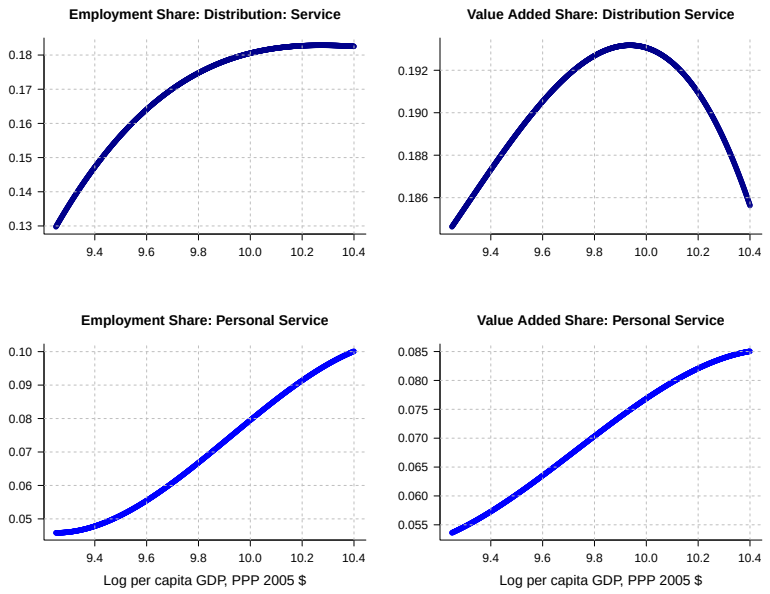

Figure 6: Estimated Distribution Services And Personal Services in EU15+U.S.

3 Simple Model

This section presents a simple model without capital to highlight the main components of the theory.[7] Without the dynamics of capital accumulation, analytical solutions can be achieved.

Here I consider a closed economy with five sectors: agriculture (a), manufacturing (m), distribution services (ds), personal services (ps), and a home production sector (h). Each sector produces corresponding commodities which are all used for consumption. The economy has an identical, infinitely lived household who is endowed with one unit of productive time each period. Time is discrete and starts from 0. The productivity growth rates are differential across sectors and are exogenous. Goods markets and labor markets are competitive.

In order to fully demonstrate the reasons for structural change, the model incorporate both non-homothetic preference and different TFP growth rate. The model emphasizes three channels to account for the rise of the service sector in China: 1) I use Stone-Geary type preference which features a subsistence level of agricultural

[7] A full-fledged quantitative model with capital and other features is presented in Section 4.

goods as in Gollin, Parente and Rogerson (2002) to capture the decline in the agricultural sector; 2) I also allow for uneven TFP grow rate across sectors as in Ngai and Pissarides (2007) to capture the complementarity between manufacturing and distribution services; 3) my model also incorporate a home production sector as in Gollin, Parente and Rogerson (2004) to capture the substitution between home goods and personal services.

The model establishes a link between labor productivity and the sectoral labor employment share. The model predicts that lower productivity growth in the distribution service sector and higher productivity growth in the personal service sector lead to higher service employment share.

3.1 Technology

For this simple model I assume linear technologies without capital in the production of agricultural goods Y_a and manufacturing goods Y_m:

$$\begin{aligned} Y_a(t) &= A_a(t)L_a(t), \\ Y_m(t) &= A_m(t)L_m(t), \end{aligned}$$

where A is labor productivity, L is labor input and subscripts denotes sectors.

I disaggregate the service sector into two components: distribution services and personal services. The distribution service sector provides complement services for the manufacturing production, and the personal service sector provides services which substitute for home production. Again I abstract from capital in the production of distribution services Y_{ds} and personal services Y_{ps}:

$$\begin{aligned} Y_{ds}(t) &= A_{ds}(t)L_{ds}(t), \\ Y_{ps}(t) &= A_{ps}(t)L_{ps}(t). \end{aligned}$$

Households consume a final good Y_f which are produced from two intermediates, i.e., distribution services Y_{ds} and manufacturing goods Y_m:

$$Y_f(t) = \left[\eta Y_{ds}(t)^{\frac{\epsilon-1}{\epsilon}} + (1-\eta)\, Y_m(t)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}}, \tag{1}$$

where$\eta \in (0,1)$, and $\epsilon > 0$ is the elasticity of substitution between manufacturing production and distribution services.

I also assume the labor productivity $A_j(t)$ grows exogenously at a constant rate:

$$A_j(t) = A_j(1+\gamma_j)^t,\ j \in \{a, m, ds, ps\},$$

where A_j is the initial labor productivity in sector j, γ_j is the sector-specific productivity growth rate in sector j.

I assume labor can move freely across sectors. Therefore the wage rate is the same for all sectors. At each date t, given the price of good Y_j, $j \in \{a, m, is, hs\}$, and wage rate $w(t)$, the profit maximization problem for a representative firm in sector j is

$$\max_{L_j(t)\geq 0} p_j(t)Y_j(t) - w(t)L_j(t) \tag{2}$$

The profit maximization problem for the final good sector is

$$\max_{Y_m(t),Y_{ds}(t)\geq 0} \left\{Y_f(t) - p_m(t)\,Y_m(t) - p_{ds}(t)\,Y_{ds}(t)\right\}. \tag{3}$$

I also assume there is a hidden sector (people can work at home) which produces home goods with constant labor productivity over time:

$$Y_h(t) = A_h L_h(t).$$

3.2 Preferences

The economy has an infinitely lived representative household who is endowed with one unit of time each period. Labor is supplied inelastically hence the total labor supply is equal to one each period. The household's utility is based on the consumption of agricultural good C_a, final good C_f, and composite good of personal services and home products C_{hps}. When agricultural productivity is such low that $C_a(t) < \bar{a}$, the representative household can only consume the agricultural good C_a; when agricultural output is above the subsistence level, namely $C_a(t) \geq \bar{a}$, the household could gain

utility from the consumption of C_f and C_{hps}.[8] The period utility function is given by

$$U\left\{C_a\left(t\right), C_f\left(t\right), C_{ps}\left(t\right)\right\} = \begin{cases} C_a\left(t\right), & \text{if } C_a\left(t\right) < \bar{a} \\ \bar{a} + \left(1-\phi\right)\ln C_f\left(t\right) + \phi \ln C_{hps}\left(t\right), & \text{if } C_a\left(t\right) \geq \bar{a} \end{cases}, \tag{4}$$

where $\phi \in (0,1)$ is a utility weight, and $\bar{a} > 0$ is the subsistence parameter of agricultural consumption. The composite consumption good C_{hps} is defined as

$$C_{hps}\left(t\right) = \left[\nu C_{ps}\left(t\right)^{\frac{\zeta-1}{\zeta}} + \left(1-\nu\right) C_h\left(t\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}},$$

where $\nu \in (0,1)$, and $\zeta > 0$ is the elasticity of substitution between personal services C_{ps} and home products.

I assume that the agricultural productivity is high enough $\left(A_a\left(0\right) \geq \bar{a}\right)$ to make the economy operate above the subsistence level $\left(C_a\left(t\right) \geq \bar{a}\right)$. Then as a result of the introduction of the subsistence level, the income elasticity of demand for agricultural goods is less than one, which is consistent with the evidence described by Engel's law.[9] The utility function requires that the representative household consume $\bar{a}$ units of agricultural good in the first place and then allocate the rest of resources optimally to C_f and C_{hps} based on the weight a.

The lifetime utility maximization problem for the representative household is as follows:

$$\max_{C_a, C_f, C_{ps}, C_h} \sum_{t=0}^{\infty} \beta^t U\left\{C_a\left(t\right), C_f\left(t\right), C_{ps}\left(t\right), C_h\left(t\right)\right\}, \tag{5}$$

subject to

$$p_a\left(t\right) C_a\left(t\right) + p_f\left(t\right) C_f\left(t\right) + p_{ps}\left(t\right) C_{ps}\left(t\right) = w\left(t\right)\left(1 - L_h\left(t\right)\right),$$

[8] This simplified specification of utility function for agricultural goods can be seen in John Laitner (2000); Douglas Gollin, Stephen Parente and Richard Rogerson (2002). This simplification makes the analysis much more tractable. In Section 5 it is shown that this type of utility function captures the decline of agricultural employment observed in the data remarkably well.

[9] The utility function is non-homothetic. But the marginal propensity to consume, is independent of total wealth (if $C_a \geq \bar{a}$). This feature allows for aggregation across households and hence I can talk about representative household. This type of utility function has long been used in the literature on structural change such as Douglas Gollin, Stephen Parente and Richard Rogerson (2002).

where$0 < \beta < 1$ is the discount factor and p_f is the price of the final good Y_f. From the budget constraint we can see that the opportunity cost of working at home is the wage rate.

3.3 Equilibrium

The following market clearing conditions hold in each period t:

- Goods market

$$\begin{aligned} C_a(t) &= Y_a(t), \; C_f(t) = Y_f(t), \\ C_{ps}(t) &= Y_{ps}(t), \; C_h(t) = Y_h(t). \end{aligned} \tag{6}$$

- Labor market

$$L_a(t) + L_m(t) + L_{ds}(t) + L_{ps}(t) = 1 - L_h(t). \tag{7}$$

The competitive equilibrium of this economy is defined on TFP parameters$\{A_{j\in\{a,m,ds,ps,h\}}$, $\gamma_{j\in\{a,m,ds,ps\}}\}$ and structural parameters $\{\eta, \epsilon, \nu, \zeta, \phi, \delta, \beta, \bar{a}\}$ as follows.

Definition 1. A competitive equilibrium is a sequence of goods prices $\{p_a(t), p_m(t), p_{ds}(t), p_f(t), p_{ps}(t)\}_{t=0}^{+\infty}$, factor prices $\{w(t)\}_{t=0}^{+\infty}$, and labor and goods allocations $\{L_a(t), L_m(t), L_{ds}(t), L_{ps}(t), L_h(t), C_a(t), C_f(t), C_{ps}(t), C_h(t), Y_a(t), Y_m(t), Y_{ds}(t), Y_f(t), Y_{ps}(t), Y_h(t)\}_{t=0}^{+\infty}$, such that given prices, the allocations solve the representative firm's maximization problem (2) and 3, the representative household's maximization problem (5), and satisfy the market clearing conditions (6), and (7).

This model has a unique competitive equilibrium. Without capital there are no intertemporal decisions thus we only have to solve static problems in each period. I start to characterize the model with the relative prices and consumption, and focus on the sectoral allocation of employment.

3.3.1 Relative prices and consumption

At every t, the profit maximization and competitive market implies that

$$\begin{aligned} p_j(t) &= \frac{w(t)}{A_j(t)},\ j \in \{a, m, ds, ps\}, \\ p_f(t) &= \left[\eta^{\epsilon} p_{ds}(t)^{1-\epsilon} + (1-\eta)^{\epsilon} p_m(t)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \\ p_m(t) &= (1-\eta) p_f(t) \left[\frac{Y_m(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}, \\ p_{ds}(t) &= \eta p_f(t) \left[\frac{Y_{ds}(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}. \end{aligned} \tag{8}$$

Since I assume the agricultural production has already passed the subsistence level, then agricultural consumption are constant:

$$C_a(t) = \bar{a}. \tag{9}$$

Remember that the opportunity cost of home production is $w(t)$, then the optimal consumption among final goods C_f, and the composite consumption of personal services and home goods C_{hps} should satisfy

$$\begin{aligned} C_{hps}(t) &= \left[\nu C_{ps}(t)^{\frac{\zeta-1}{\zeta}} + (1-\nu) C_h(t)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}} \\ &= \frac{\phi}{1-\phi} \frac{p_f(t) C_f(t)}{\left[\nu^{\zeta} p_{ps}(t)^{1-\zeta} + (1-\nu)^{\zeta} \left(\frac{w(t)}{A_h}\right)^{1-\zeta}\right]^{\frac{1}{1-\zeta}}}. \end{aligned} \tag{10}$$

3.3.2 Labor allocation

Since the technologies are constant return to scale and there are no other distortions, the sectoral expenditure shares are the same as the sectoral employment share. Hence here I only focus on the employment share. Goods Market clearing conditions give the

labor allocation result:

$$
\begin{aligned}
L_a(t) &= \frac{\bar{a}}{A_a(t)}, && (11)\\
\frac{L_m(t)}{L_{ds}(t)} &= \left(\frac{1-\eta}{\eta}\right)^{\epsilon}\left[\frac{A_{ds}(t)}{A_m(t)}\right]^{1-\epsilon}, && (12)\\
\frac{L_{ps}(t)}{L_h(t)} &= \left(\frac{\nu}{1-\nu}\right)^{\zeta}\left[\frac{A_h}{A_{ps}(t)}\right]^{1-\zeta}. && (13)
\end{aligned}
$$

The above equations link sectoral TFP growth to sectoral labor allocations. In this system, TFP changes in one sector will have an impact on the labor allocation of another sector. From (11) we can see $\frac{\partial L_a}{\partial A_a} < 0$. The increase of agricultural productivity pushes labor out of the agricultural sector.

From (12) and (13) we can see that if the elasticity of substitutions are all equal to one, then there will be no structural change within the non-agricultural sector. If distribution services and manufacturing complement each other ($\epsilon < 1$), then labor will move from the sector with higher TFP growth rate to the sector with lower TFP growth rate. Similarly, if personal services and home production substitute each other ($\zeta > 1$), then households will do less housework and purchase personal services from the market.

With labor market clearing condition (7) L_m, L_{ds}, L_{ps} and L_h can be solved:

$$
\begin{aligned}
L_{ds}(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\eta}{\eta}\right)^{\epsilon}\left[\frac{A_{ds}(t)}{A_m(t)}\right]^{1-\epsilon}},\\
L_m(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\eta}{1-\eta}\right)^{\epsilon}\left[\frac{A_m(t)}{A_{ds}(t)}\right]^{1-\epsilon}},\\
L_{ps}(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\nu}{\nu}\right)^{\zeta}\left[\frac{A_{ps}(t)}{A_h}\right]^{1-\zeta}}, && (14)\\
L_h(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\nu}{1-\nu}\right)^{\zeta}\left[\frac{A_h}{A_{ps}(t)}\right]^{1-\zeta}}.
\end{aligned}
$$

Equation (14) gives the labor allocation in the personal service sector. Since $A_{ps}(t)$ grows exponentially, it is a special form of logistic function when $\zeta > 1$. ϕ is a scale parameter which controls the upper asymptote (carrying capacity). When ϕ is larger, which means personal service consumption is relatively more important than manufacturing goods, more labor will be allocated to the personal service sector. ζ controls the growth rate of the employment share. If $\zeta > 1$, it means personal services substitute home goods. Then larger ζ means demand shifts faster from home goods to personal services. ν affects when the maximum growth rate occurs. $\frac{\nu}{1-\nu}$ measures the expenditure share ratio between personal services and home goods. The employment share of the personal service sector will rise later if ν is smaller. Therefore this equation has enough degrees of freedom to capture the later rise (structural break) in the personal service sector.

Proposition 1. *Structural change in labor allocation*

1. $\frac{\partial L_a}{\partial A_a} < 0$;
2. $\frac{\partial L_j}{\partial A_a} > 0$, $j \in \{m, ds, ps, h\}$;
3. *If* $\epsilon < 1$,
$$\frac{\partial L_m / L_{ds}}{\partial A_m / A_{ds}} < 0;$$
4. *If* $\zeta > 1$,
$$\frac{\partial L_{ps} / \partial L_h}{\partial A_{ps}} > 0.$$

Proof. See the discussion above. □

Proposition 1 summarizes the pattern of structural change. First, the productivity growth in the agricultural sector pushes rural surplus labor out from the agricultural sector to the non-agricultural sector. Second, if manufacturing production and distribution services are complements (with the elasticity of substitution less than one), then the manufacturing sector (which grows faster) will shrink and the distribution service sector (which grows slower) will expand in terms of employment share. Third, if personal services and home goods are substitutes (with the elasticity of substitution larger than one), then the personal services will expand as its productivity grows.

4 Quantitative Model

In Section 3, the model gives a sequence of static allocation which cannot fully capture the dynamics of capital accumulation. However, growth accounting analysis shows that capital growth is an important factor to explain the growth of China, especially the non-agricultural sector.[10] In particular, Acemoglu and Guerrieri (2008) shows that capital deepening could also affect sectoral resource allocation. By ignoring physical capital, the role of TFP in structural change could be overestimated. Meanwhile, the assumption that labor can move freely across sectors (or homogeneous labor) is not realistic either. Empirical studies show that the wage rate is not equalized across sectors and labor market frictions such as regulations on labor movement cannot be ignored.[11] What's more, the simple model also ignore the complementarity between between personal services, home production and market goods consumption. Some market goods can also be used in home production and personal services from the demand side. For example, washing machines and kitchenware. Therefore the change of the expenditure share of personal services and home production could also affect the demand for some of the market goods. In this section, I extend the model in Section 3 to incorporate physcial capital. This model also takes into account labor market frictions and non-unit elasticity of substitution between market goods and the composite consumption of personal services and home production, which is better suited to assessing the quantitative implications.

Here we consider a closed economy with five sectors: agriculture (a), manufacturing (m), distribution services (ds), personal services (ps), and a home production sector (h). All market sectors (a, m, ds, ps) need physical capital as an input in production. The final goods Y_f can be used for both consumption and investment. Different sectors have different skill requirements which are used to capture labor market frictions. The final good consumption C_f and composite consumption C_{hps} are aggregated by CES utility function.

By incorporating capital, it is possible to study the capital deepening effect in the structural change model. The model predicts that the more capital intensive sector will accumulate capital faster and push labor to the less capital intensive sector. The model

[10] For example, see Bosworth and Collins (2008); Brandt and Zhu (2010); Wu (2011); Zhu (2012).
[11] See Brandt and Zhu (2010); Brandt, Tombe and Zhu (2013); Cao and Birchenall (2013).

also predicts that different skill requirement (or different labor market friction level) allocate more labor to the service sector instead of the manufacturing sector. In the rest of the section, I will only highlight the differences of this quantitative model from the simple model in Section 3.

4.1 Technologies

I use Cobb-Douglas production function to include physical and human capital across sectors. The production in sector $j \in \{a, m, ds, ps\}$ is

$$Y_j(t) = A_j(t) K_j(t)^{\theta_j} H_j(t)^{1-\theta_j},$$

where $\theta_{j\in\{a,m,ds,ps\}}$ is physical capital income share and it can be different across sectors. $H_{j\in\{a,m,ds,ps\}}$ is defined as effective labor unit: $H_j(t) = \mu_j L_j(t)$, where μ_j is used to denote the different human capital or skill levels reqired by different sectors and $L_j(t)$ is the raw labor unit.[12] For simplicity, the skill level in the manufacturing sector is normalized to be one, i.e., $\mu_m = 1$. Therefore the production function can be written as

$$Y_j(t) = A_j(t) K_j(t)^{\theta_j} (\mu_j L_j(t))^{1-\theta_j}, \; j \in \{a, m, ds, ps\}. \tag{15}$$

I assume firms make the labor demand decisions and households are assigned to each sector by random draw. Once a unit of labor is allocated to sector j, he is also given ability μ_j. Due to different skill requirement, labor cannot move freely across sectors.

We also assume the TFP parameter $A_j(t)$ grows exogenously at a constant rate:

$$A_j(t) = A_j(1+\gamma_j)^t, \; j \in \{a, m, ds, ps\}, \tag{16}$$

where A_j is the initial labor productivity in sector j, γ_j is the sector-specific TFP growth

[12] Generally speaking, the manufacturing sector and the distribution service sector require higher skill level than the agricultural and personal service sector. According to the *National Population Cencus 2010*, the proportion of employment without college degree in each sector is 99% (agriculture), 90% (manufacturing), 88% (distribution services), 94% (personal services).

rate in sector j.

I assume the production of home goods needs zero physical capital and without loss of generality, the same skill level as the personal service sector:

$$Y_h(t) = A_h(\mu_{ps} L_h(t)), \tag{17}$$

where A_h is the labor productivity of home production and it is constant over time. Therefore the opportunity cost of working at home is the same as the marginal product of labor in the personal service sector.

The final goods production Y_f is the same as (1). Different from the simple model, here Y_f can be both consumed and invested. The evolution of capital stock and the aggregate capital stock satisfy:

$$\begin{aligned} K_a(t) + K_m(t) + K_{ds}(t) + K_{ps}(t) &= K(t), \\ K(t+1) - (1-\delta) K(t) + C_f(t) &\leq Y_f(t), \end{aligned}$$

where $K(0) > 0$ is given, and $\delta > 0$ is the capital depreciation rate.

At each date t, given the price p_j, $j \in \{a, m, ds, ps\}$, wage rate $w_j(t)$ and capital rental rate $r(t)$, the profit maximization problem for a representative firm in sector j is

$$\max_{L_j(t), K_j(t) \geq 0} \{p_j(t) Y_j(t) - w_j(t) L_j(t) - r(t) K_j(t)\}. \tag{18}$$

The profit maximization problem for the final good sector is the same as (3).

4.2 Preferences

The economy has an infinitely lived representative household who is endowed with one unit of time each period. Labor is supplied inelastically hence the total labor supply is equal to one each period. The period utility function now includes the elasticity of substituion between final goods consumption C_f and the composite goods of personal

services and home production C_{hps}:

$$U\left\{C_a\left(t\right),C_f\left(t\right),C_{ps}\left(t\right)\right\}=\begin{cases}C_a\left(t\right), & \text{if } C_a\left(t\right)<\bar{a}\\ \bar{a}+\left[\left(1-\phi\right)C_f\left(t\right)^{\frac{\rho-1}{\rho}}+\phi C_{hps}\left(t\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} & \text{if } C_a\left(t\right)\geq\bar{a}\end{cases}, \tag{19}$$

where C_{hps} is a composite good of personal services and home production:

$$C_{hps}\left(t\right)=\left[\nu C_{ps}\left(t\right)^{\frac{\zeta-1}{\zeta}}+\left(1-\nu\right)C_h\left(t\right)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}},$$

and $\phi,\nu\in\left(0,1\right)$, $\rho,\zeta>0$.

The lifetime utility maximization problem for the representative household is as follows:

$$\max_{C_a,C_f,C_{ps},C_h,X}\sum_{t=0}^{\infty}\beta^t U\left\{C_a\left(t\right),C_f\left(t\right),C_{ps}\left(t\right),C_h\left(t\right)\right\}, \tag{20}$$

subject to

$$p_a\left(t\right)C_a\left(t\right)+p_f\left(C_f\left(t\right)+X\left(t\right)\right)+p_{ps}\left(t\right)C_{ps}\left(t\right)=\sum_{j=a,m,ds,ps}\left(w_j\left(t\right)L_j\left(t\right)+r\left(t\right)K_j\left(t\right)\right),$$

where $X\left(t\right)=K\left(t+1\right)-\left(1-\delta\right)K\left(t\right)$ is the capital investment.

4.3 Equilibrium

The following market clearing conditions hold in each period t:

- Goods market

$$\begin{aligned}C_a\left(t\right) &= Y_a\left(t\right),\ C_f\left(t\right)+X\left(t\right)=Y_f\left(t\right), \\ C_{ps}\left(t\right) &= Y_{ps}\left(t\right),\ C_h\left(t\right)=Y_h\left(t\right);\end{aligned} \tag{21}$$

- Capital market

$$\begin{aligned}K_a\left(t\right)+K_m\left(t\right)+K_{ds}\left(t\right)+K_{ps}\left(t\right) &= K\left(t\right), \\ K\left(t+1\right)-\left(1-\delta\right)K\left(t\right) &= X\left(t\right);\end{aligned} \tag{22}$$

- Labor market

$$L_a(t) + L_m(t) + L_{ds}(t) + L_{ps}(t) = 1 - L_h(t). \tag{23}$$

The competitive equilibrium of this economy is defined on TFP parameters $\{A_{j\in\{a,m,ds,ps,h\}}$, $\gamma_{j\in\{a,m,ds,ps\}}\}$ and structural parameters $\{\theta_{j\in\{a,m,ds,ps\}}$, $\mu_{j\in\{a,m,ds,ps\}}$ η, ϵ, ν, ζ, ϕ, ρ, δ, β, $\bar{a}\}$ as follows.

Definition 2. A competitive equilibrium is a sequence of goods prices $\{p_a(t), p_m(t), p_{ds}(t), p_f(t), p_{ps}(t)\}_{t=0}^{+\infty}$, factor prices $\{w_j(t), r(t)\}_{t=0}^{+\infty}$, and labor and goods allocations $\{L_a(t), L_m(t), L_{ds}(t), L_{ps}(t), L_h(t), C_a(t), C_f(t), C_{ps}(t), C_h(t), Y_a(t), Y_m(t), Y_{ds}(t), Y_f(t), Y_{ps}(t), Y_h(t)\}_{t=0}^{+\infty}$, such that given prices and $K(0) > 0$, the allocations solve the representative firm's maximization problem (3) and (18), the representative household's maximization problem (20), and satisfy the market clearing conditions (21)-(23).

4.3.1 The Static Equilibrium

This model has a unique competitive equilibrium. The equilibrium can be characterized by two parts: the static part and the dynamic part. I first describe the static part. Given the state variables aggregate capital stock $K(t)$, sectoral TFP $A_j(t)$, $j \in \{a, m, ds, ps\}$, we can solve the allocation of factors as well as consumption across sectors. The profit maximization and competitive market imply that

$$w_j(t) = (1-\theta_j)\mu_j p_j(t) A_j(t) \left[\frac{K_j(t)}{\mu_j L_j(t)}\right]^{\theta_j}, \ j \in \{a, m, ds, ps\} \tag{24}$$

$$r(t) = \theta_j p_j(t) A_j(t) \left[\frac{K_j(t)}{\mu_j L_j(t)}\right]^{\theta_j - 1}, \ j \in \{a, m, ds, ps\} \tag{25}$$

$$p_f = \left[\eta^{\epsilon} p_{ds}(t)^{1-\epsilon} + (1-\eta)^{\epsilon} p_m(t)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \tag{26}$$

$$p_m(t) = (1-\eta) p_f \left[\frac{Y_m(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}, \tag{27}$$

$$p_{ds}(t) = \eta p_f \left[\frac{Y_{ds}(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}. \tag{28}$$

We assume the goods and factor markets are competitive and capital is perfectly mobile. Due to different skill requirement across sectors, labor is imperfectly mobile in the sense that the marginal product of effective labor (H) is the same across sectors, while there are gaps between the marginal product of raw labor (L) across sectors. Hence according to (24) and the fact $\mu_m = 1$, the wage rate satisfies

$$w_a(t) = \mu_a w_m(t), \tag{29}$$

$$w_{ds}(t) = \mu_{ds} w_m(t), \tag{30}$$

$$w_{ps}(t) = \mu_{ps} w_m(t), \tag{31}$$

From the above equations (29)-(31) we can see $\mu_{j\in\{a,ds,ps\}}$ capture the wedge of wage rate between sectors, which are also measures of labor market frictions.[13] From this point of view, we can consider $1-\mu$ as a cost of moving across sectors. If one wants to move from sector j to the manufacturing sector, he must pay a fraction of $1-\mu_j$ of his marginal product of labor in the manufacturing sector as a movement cost (or entry cost). Then workers will be indifferent between working in sector j and the manufacturing sector. An increase in μ_j reduces the moving cost and raises the wage rate in sector j and results in a labor flow to the manufacturing sector. So we use the level of μ to indicate the level of labor market frictions.

In section 5.1 I use (29)-(31) to calibrate μ_j and use it as a proxy of labor market frictions in China to conduct quantitative analysis.

The marginal rate of technical substitution should satisfy:

$$\frac{1-\theta_a}{\theta_a}\frac{K_a}{\mu_a L_a} = \frac{1-\theta_m}{\theta_m}\frac{K_m}{L_m} = \frac{1-\theta_{ds}}{\theta_{ds}}\frac{K_{ds}}{\mu_{ds} L_{ds}} = \frac{1-\theta_{ps}}{\theta_{ps}}\frac{K_{ps}}{\mu_{ps} L_{ps}}. \tag{32}$$

Employment share between these two sectors follows

$$\frac{L_m(t)}{L_{ds}(t)} = \mu_{ds}\left(\frac{1-\eta}{\eta}\frac{1-\theta_m}{1-\theta_{ds}}\right)^{\epsilon}\left(\frac{A_{ds}(t)}{A_m(t)}\right)^{1-\epsilon}\left[\frac{\left(K_{ds}(t)/\left(\mu_{ds}L_{ds}(t)\right)\right)^{\theta_{ds}}}{\left(K_m(t)/L_m(t)\right)^{\theta_m}}\right]^{1-\epsilon}. \tag{33}$$

[13] This wage gap can capture frictions in the labor market, see Restuccia, Yang and Zhu (2008). In China, there are many institutional and policy constraints that distort wage and price or restrict movement of labor, see Brandt and Zhu (2010); Dekle and Vandenbroucke (2012); Cao and Birchenall (2013).

From (33) we can see this quantitative model also features a capital deepening effect (Acemoglu and Guerrieri, 2008). If $\epsilon < 1$, and the manufacturing sector is more capital intensive than the distribution service sector ($\theta_m > \theta_{ds}$), then capital per worker of the manufacturing sector will increase faster than that of the distribution service sector, which will result in a labor movement from the manufacturing sector to the distribution service sector.

For agricultural consumption, (9) still holds here. Given (17) then the opportunity cost of home production is w_{ps} therefore (10) is changed to

$$\frac{C_{hps}(t)}{C_f(t)} = \left\{ \frac{1-\phi}{\phi} \frac{\left[\nu^{\zeta} p_{ps}(t)^{1-\zeta} + (1-\nu)^{\zeta} \left(\frac{w_m(t)}{A_h} \right)^{1-\zeta} \right]^{\frac{1}{1-\zeta}}}{p_f(t)} \right\}^{-\rho}. \tag{34}$$

Employment between personal services L_{ps} and home production L_h is determined by the following condition

$$\frac{L_{ps}(t)}{L_h(t)} = \left[\frac{\nu}{1-\nu} (1-\theta_{ps}) \right]^{\zeta} \left[\frac{A_{ps}(t)}{A_h} \left(\frac{K_{ps}(t)}{\mu_{ps} L_{ps}(t)} \right)^{\theta_{ps}} \right]^{\zeta-1}. \tag{35}$$

Hence (9), (21)-(35) determine the static allocation.

4.3.2 The Dynamic Equilibrium

The optimal consumption rule of C_f is determined by the standard Euler Equation:

$$\frac{C_f(t+1)}{C_f(t)} = \beta \left[r(t+1) + (1-\delta) \right]. \tag{36}$$

Now we finish charactering the model. Comparing to the seimple model in Section 3, here we add dynamic part and allow for capital deepening effect. This richful model can allow labor movement across the final good sector and the composite sector of personal services and home production. We should also notice that unlike the simple model, here the sectoral expenditure shares are no longer the same as the sectoral employment share due to the labor market friction μ, which means μ can also affect

resource allocation across sectors.[14] The next section will assess the consequences of differences in TFP or barriers to labor movement for differences in the rise of the service sector.

5 Quantitative Analysis

In this section, first the calibration strategy is introduced. Based on the calibration strategy, the model can capture the dynamics of labor reallocation substantially. Then I use this quantitative model to conduct several counterfactual analyses to determine the relative importance of several structural change channels and discuss the implications. At last the robustness of the results is discussed.

5.1 Calibration

The model period is assumed to be one year. There are ?? parameters that need to be calibrated and they are $\{\bar{a}, A_{j\in\{a,m,ds,ps,h\}}, \gamma_{j\in\{a,m,ds,ps\}}, \theta_{j\in\{a,m,ds,ps\}}, \mu_{j\in\{a,ds,ps\}}, \eta, \epsilon, \phi, \rho, \nu, \zeta, \beta, \delta\}$. Given all the parameters, and the initial capital per worker $k(0) = \frac{K(0)}{L(0)}$, this dynamic model is simulated using forward shooting to determine optimal consumption path. The calibration strategy is to restrict the parameters values to match the main growth and structural change features of China. The calibration is done by steps and the sample period of data we use for calibration is 1984-2007.[15]

First the sectoral capital income shares $\theta_{j\in\{a,m,ds,ps\}}$ is computed from the average data of input-output table issued by various yearbooks. The labor income share is calculated as labor compensation divided by value added net of production tax.[16] Then the capital income share is one minus labor income share. $\theta_m = 0.596$ and $\theta_{ds} = 0.531$ hence we have $\theta_m > \theta_{ds}$, which means the manufacturing sector is more capital intensive than the distribution service sector (but the difference is not large).

Second,

[14] Different capital intensity across sectors can also result in a gap between the expenditure share and employment share. But it can only capture a very small fraction.

[15] I start from 1984 to avoid the jumps happened during the initial period of reform in China.

[16] It is argued that agricultural labor income share calculated from input-output table is very high because it includes land income share (see Cao and Birchenall, 2013). In this paper, the agricultural production function does not contain land input.

Since in the model the agricultural employment share is determined independently of other sectors, I the subsistence level separately. Given θ_a, (**??**), and (9), $\bar{a}$ and γ_a are estimated to minimize the sum of squared errors between data and model generated results based on the following equation:

$$L_a = \frac{\bar{a}}{A_a \left(1+\gamma_a\right)^t k_a\left(t\right)},$$

where L_a is agricultural employment share from data, $k_a = K_a/L_a$ is agricultural capital per worker from data, and A_a is normalized as one.[17]

Given $\theta_{j\in\{a,m,ds,ps\}}$ and (**??**)-(16), I use real value added, capital and employment for each sector to do growth accounting exercises to pin down $A_{j\in\{m,ds,ps\}}$ and $\gamma_{j\in\{a,m,ds,ps\}}$. The initial TFP parameter of the agricultural sector A_a and home production A_h are normalized as 1.

I use first order condition to back out labor market distortions.[18] Wage gaps $\mu_{j\in\{a,ds,ps\}}$ are calibrated based on (29)-(31) and (24). According to the first order condition (24), the wage ratio is proportional to the ratio of average labor productivity (nominal output per worker):

$$\mu_{j\in\{a,ds,m\}}\left(t\right) = \frac{w_j\left(t\right)}{w_m\left(t\right)} = \frac{\frac{(1-\theta_j)p_j(t)Y_j(t)}{L_j(t)}}{\frac{(1-\theta_m)p_m(t)Y_m(t)}{L_m(t)}},$$

and μ_j is the mean of $\mu_j\left(t\right)$ across time.[19] From Table 3 we can see that on the one hand, the wage level is almost the same between the manufacturing sector and the distribution service sector ($\mu_{ds} = 1.00$) which means labor can move freely between these two sectors; on the other hand, the wage gap between the manufacturing sector and both of the agricultural sector ($\mu_a = 0.38$) and the personal service sector ($\mu_{ps} = 0.23$) are large, which means it is easy for rural surplus labor to find a job in the urban personal service sector. Given this large gap, labor market frictions are not negligible.

ϵ and η capture the relationship between the manufacturing sector and the distribu-

[17] Employment-to-population ratios do not differ systematically across time. Since I assume agricultural consumption is constant here, γ_a is not comparable to other literature on growth accounting.

[18] See Restuccia, Yang and Zhu (2008); Brandt and Zhu (2010).

[19] Here I only capture the mean because the economic foundation of μ in my model is different skill requirement across sectors, which is quite constant over time.

tion service sector employment. Based on (33), given $\frac{L_m(t)}{L_{ds}(t)}$, $\frac{K_{ds}(t)}{L_{ds}(t)}$, $\frac{K_m}{L_m}$ from data, and calibrated $\theta_{j\in\{m,ds\}}$, $\mu_{j\in\{m,ds\}}$, $A_{j\in\{m,ds\}}$, $\gamma_{j\in\{m,ds\}}$, ϵ and η are estimated to minimize the sum of squared error between the employment ratio (left hand side) and the result generated by the right hand side of the equation. $\epsilon = 0.71 < 1$ confirms that there is complementarity between the manufacturing sector and the distribution service sector.

ϕ, ν and ζ capture the dynamics of personal service employment share. In Subsection (3.3.2) of the simple model case, there is analytical solution for personal service employment share:

$$L_{ps}(t) = \frac{\phi\left[1 - \frac{\bar{a}}{A_a(t)}\right]}{1 + \left(\frac{1-\nu}{\nu}\right)^{\zeta}\left[\frac{A_{ps}(t)}{A_h}\right]^{1-\zeta}}.$$

Since $A_{ps}(t)$ grows exponentially, it is a special form of logistic function when $\zeta > 1$. ϕ is a scale parameter which controls the upper asymptote (carrying capacity). ζ controls the growth rate of the employment share. ν affects when the maximum growth rate occurs. In the quantitative model there is no analytical solution for personal service employment share, but the idea is the same. So I simulated the model and choose these three parameters to minimize the sum of squared errors between personal service employment share data and model generated results.[20] $\zeta = 4.05 > 1$ confirms that personal services substitute home production goods.

I follow the literature and pick $\beta = 0.95$, $\delta = 0.05$ for the whole quantitative analysis. Table 3 summarizes all the parameter values.

This calibration strategy target agricultural employment share to pin down $\bar{a}$, and it target personal service employment share to pin down ϕ, ν, and ζ. Then the rest employment share are allocated between the manufacturing sector and the distribution service sector, which is based on parameters η and ϵ. Figure 7 shows the quantitative results generated by the model based on above calibration. Points are data and lines are from the model. The dynamic patterns of the employment share data are captured well by the quantitative model. Employment share in the manufacturing sector increases over time after the reform period, and there is no sign of decline. At the same period, distribution service and personal service employment shares keep increasing,

[20]The labor market clearing condition is $L_a + L_m + L_{ds} + L_{ps} + L_h = 1$. Since there are no employment data for home production, the personal service employment share generated by the model is scaled to match the data, i.e., $L^*_{ps} = L_{ps}/(L_a + L_m + L_{ds} + L_{ps})$.

Parameter	Description
$\theta_a = 0.148, \theta_m = 0.596, \theta_{ds} = 0.531, \theta_{ps} = 0.576$	Sectoral capital income share
$A_a = 1, A_m = 11.38, A_{ds} = 40.81, A_{ps} = 8.59, A_h = 1$	Initial TFP parameter
$\gamma_a = 0.001, \gamma_m = 0.056, \gamma_{ds} = 0.001, \gamma_{ps} = 0.036$	Constant exogenous TFP growth rate
$\mu_a = 0.376, \mu_{ds} = 0.998, \mu_{ps} = 0.231$	Relative wage gap
$\eta = 0.147$	Input share of distribution service
$\epsilon = 0.709$	Elasticity of substitution between manufacturing goods and distribution service
$\phi = 0.163$	Expenditure share of personal service and home production
$\nu = 0.009$	Input share of personal service
$\zeta = 4.054$	Elasticity of substitution between personal services and home production
$\beta = 0.95$	Utility discount factor
$\delta = 0.05$	Capital depreciation rate

Table 3: Parameter Values

and personal service features a later start.

The percentage change of employment share can also be captured very well (see Figure 8). I test the calibration by comparing the valued added shares generated by the model with the data. See Figure 9 for the results. The model generated results (lines) can capture the average value added share of each sector from data (dots), while the variation seems large. But the basic trend can still be captured. This is because value added data usually involve with price distortion. In my model I only emphasize average wage gap.

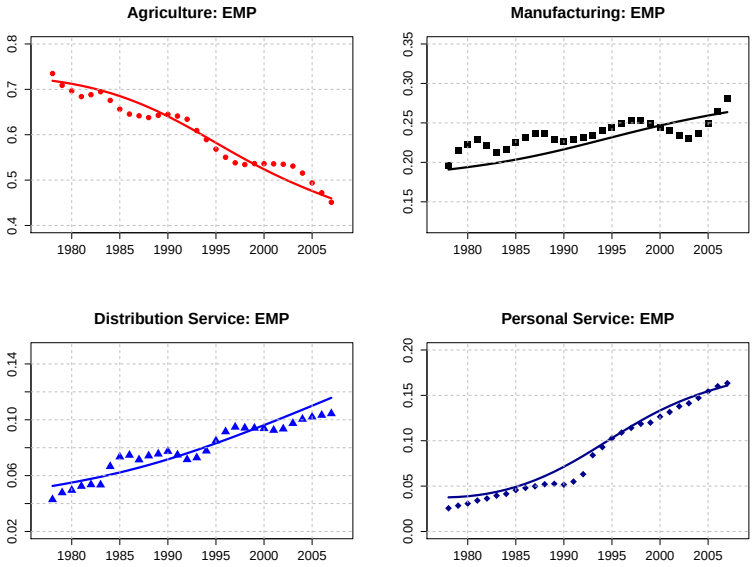

Figure 7: Employment Share of China

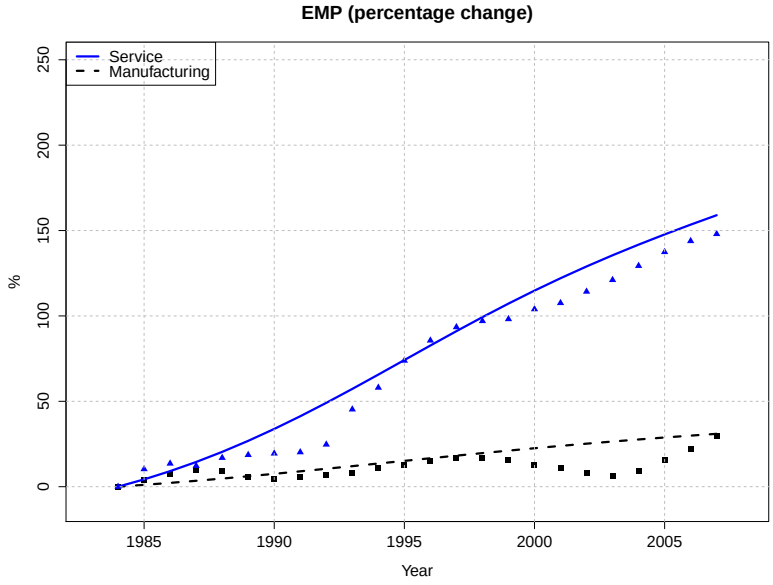

Figure 8: Employment Share (Percentage Change)

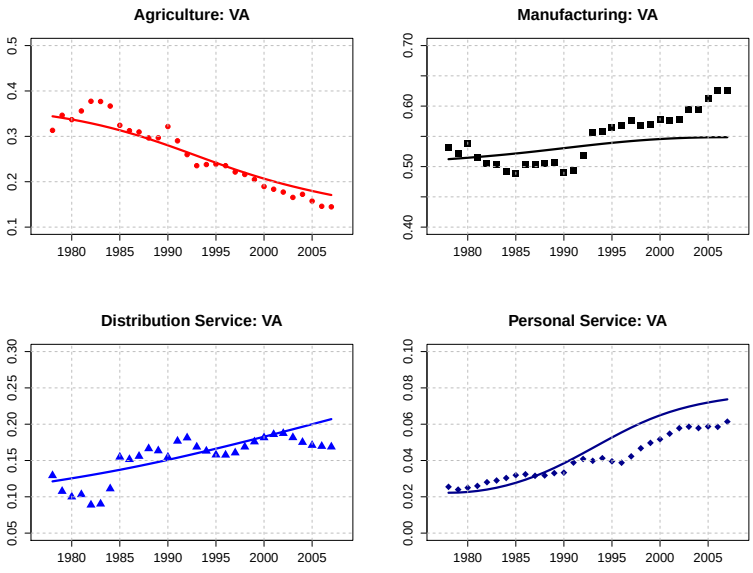

Figure 9: Value Added Share of China

5.2 Counterfactual Analysis

In this subsection I focus on the change of employment share and conduct several counterfactual analysis to determine the source of growth quantitatively. From Proposition 1 and Equation (33) we can see that there are four channels that can affect structural change patterns:

1. labor productivity growth in the agricultural sector (*non-homothetic preference*);
2. demand for distribution services
   (a) TFP growth in the manufacturing sector and the distribution service sector (*sector-biased productivity growth*);
   (b) capital accumulation in the manufacturing sector and the distribution service sector (*capital deepening*);
3. demand for personal services (*income effect*).

The first channel is very important because if there is no labor productivity growth in the agricultural sector, labor will be restricted in the agricultural sector. Then because of the subsistence requirement there will be no structural change. So given this channel, I will evaluate the quantitative effects of the rest three channels using model simulation. Because there are interactions between channels, I use two ways to measure the quantitative effects for each channels. First I will shutdown only one of the channels at one time to see how much the service employment share would drop. Second, I will keep only one of the channels at one time to see how much the service employment share would be generated.

To shutdown the distribution service sector (personal services only), I set the input share of distribution services to be zero, i.e., $\eta = 0$. To switch off sector-biased productivity growth, I let the distribution service sector have the same TFP growth rate as the manufacturing sector, i.e., $\gamma_{ds} = \gamma_m$. To turn off capital deepening effect, I let the distribution service sector have the same capital income share as the manufacturing sector, i.e., $\theta_{ds} = \theta_m$. To shutdown the personal service sector (distribution services only), I set the input share of personal services to be zero, i.e., $\nu = 0$.

	Benchmark	no (2a)	no (2b)	no (3)	(2a) only	(2b) only	(3) only
$L_s = L_{ds} + L_{ps}$	27.67%	25.75%	26.24%	11.24%	9.12%	8.79%	18.55%
L_{ds}	11.58%	8.9%	9.29%	11.24%	9.12%	8.79%	0%
L_{ps}	16.09%	16.85%	16.95%	0%	0%	0%	18.55%
L_m	26.36%	31.40%	29.99%	25.54%	29.43%	30.95%	43.66%
L_a	45.97%	42.85%	43.77%	63.22%	61.45%	60.26%	37.79%

(2a): *sector-biased productivity growth*

(2b): *capital deepening*

(3): *income effect*

Table 4: Employment Share: Counterfactual Analyses

Table 4 shows the results of counterfactual analyses. The benchmark model (with all 4 channels) shows that in 2007 the service employment share is 27.67%. If there is only the distribution service sector (no (3)), then service employment share would drop by 59.38%. If there is only the personal service sector ((3) only), then service employment share would drop by 32.96%. Given no personal service sector if we further switch off sector-biased productivity growth ((2b) only) or capital deepening ((2a) only), service employment share would drop by 8.85% and 7.66%, respectively.

Generally speaking, the income effect contributes most to the growth of service employment can explain 59.38% of the total growth of service employment. sector-biased productivity growth and capital deepening together (growth of distribution services) can explain 32.69%. It is not surprising that sector-biased productivity growth is quantitatively more important than capital deepening in explaining the rise of service, because there are only slightly differences in capital income share between the manufacturing sector and the distribution service sector. In the next subsection, the implications of the quantitative results are discussed.

5.3 Implication

From Table 4 we can see that the personal service sector is the main sector to absorb agricultural surplus labor. When the personal service sector is shutting down (no (3)), agricultural employment share (L_a) increases by 37.52%. And when there is only the personal service sector ((3) only), agricultural employment share decreases by 17.79%.

This is because it is easier for rural surplus labor to find a job in the personal service sector than in other urban sectors. Comparing to the manufacturing sector and the distribution service sector, the personal service sector mainly requires non-skilled labor. From the calibration results (Table 3) we can see that the marginal labor income in the personal service sector is much lower than that in the manufacturing sector ($\mu_{ps} = 0.231$). If we remove this wage gap ($\mu_{ps} = 1$), then the total service employment share would drop by 26.92% and personal service employment share would drop by 68.61% (see Table 5). So in simple words, the personal service sector grows at a fast speed also benefited from cheap labor from the agricultural sector. From Table 5 we can also see if removing wage distortion in the agricultural sector ($\mu_a = 1$), more labor would be pushed out from the agricultural sector and the service sector would increase.

	Benchmark	$\mu_{ps} = 1$	$\mu_a = 1$	$\mu_{ps}\&\mu_a = 1$
$L_s = L_{ds} + L_{ps}$	27.67%	20.22%	30.46%	22.38%
L_{ds}	11.58%	15.17%	13.03%	16.91%
L_{ps}	16.09%	5.05%	17.42%	5.47%
L_m	26.36%	34.51%	29.69%	3.85%
L_a	45.97%	45.28%	39.86%	39.16%

Table 5: Employment Share: Removing Wage Gap

5.4 Discussion

5.4.1 Simulation Results from Alternative Data

This paper mainly uses some of the official data with necessary adjustment (see Appendix A.1) to conduct quantitative analyses. However, there are debts on the biasness of official data. Ruoen Ren (1997), Alwyn Young (2003), Carsten Holz (2006), and Angus Maddison (2007) criticized that the official GDP deflators underestimate inflation and hence overestimate real output growth. Gregory C Chow (1993, 2004), however, argued that official data are reliable and new estimates may introduce new bias. This paper is not going to judge these arguments on the reliability of the official data.

I follow the way introduced by Alwyn Young (2003) to construct alternative real GDP data and conduct the growth accounting analyses again. The resulting TFP growth rates are slightly lower than original estimation, and they can barely change the final quantitative results because the calibration target the labor employment data and labor allocation do not change.

5.4.2 The Role of Human Capital

This paper tries to establish a link between labor allocation and TFP growth and capital deepening. The model abstract from human capital because sectoral time series data for human capital are not available, especially in the service sector. But from empirical facts in Subsection 2.2 we can see the main contributors to the growth of the service sector in China are distribution service and personal services, which are categorized as traditional service sectors and are not considered as skill-labor intensive. Those modern service sectors which require high skill labor, such as financial services, health and education, keep a constant employment share.

Based on the calibration result in Table 3, we can see the wage ratio between the personal service sector and the manufacturing sector is very large, which potentially means that the skill premium in the personal service sector can not be high. According to the fifth *National Population Census* in 2000, About 70% of workers in wholesale, retailing, and catering services have not went to high school. Only 5% of workers have a college degree (see Table 6). Therefore, human capital accumulation in the service sector itself cannot be an important reason for the past growth of the service sector in

China.

Education level	Wholesale, retailing, and catering
Elementary school and below	20%
Middle school	50%
High school	25%
College and above	5%

Age group of employment ranges from 15-64.

Table 6: Education Level of Employee in the Service Sector in Year 2000

Buera and Kaboski (2012*b*) argues that growth in services can be benefited from high-skilled labor in other sectors, because human capital accumulation can amplify income effect. This is possible because market demand for skilled labor does increase over time and skill premium was increasing after the reform period (Zhang et al., 2005). But according to several aggregate level growth accounting analyses (Bosworth and Collins, 2008; Wu, 2011), the contribution of education to output is very small between 1978-2005. TFP growth and physical capital accumulation are the main source of growth.

5.4.3 Open Economy

This paper studies the structural change pattern of China in a closed economy setup. It is interesting to discuss how the quantitative results would change if the economy opens to trade. On the one hand, international trade breaks the equilibrium between demand and supply in domestic market; on the other hand, it can have an impact on domestic productivity by reallocating resources. Hence international trade can affect structural change patterns (Matsuyama, 2009; Uy, Yi and Zhang, 2013). Święcki (2013) conducted a study on the determinants of structural change for 45 countries which includes China. He concluded that during the period 1978-2005, Trade is the least important factor and contribute a very small share to labor reallocation.

Based on the calibration strategy in this paper, the effects of openness on productivity are already captured by the calibration results because it is taken as given. Since the calibration also target the employment share from data which contains the influ-

ence of trade, the assumption of closed economy is not restrictive for the quantitative results.

6 Conclusion

This paper shows that it is important to differentiate the two kinds of services if we want to study the rise of the service sector. We observe that in early development stage, employment share in the distribution service sector rises first, then after income level increases, the personal service sector booms.

This paper quantitatively analyzes the source of rise in the service sector and structural change in China by disaggregating services into distribution services and personal services. The quantitative results show that the income effect is the main contributor and it can explain more than half of the growth of the service sector. The role for sector-biased technological progress and capital deepening are modest. Intersectoral wage gaps are also very important in explaining the rise of the service sector.

Structural change phenomena are proven to have a strong relationship with aggregate productivity, which is the essence in development economics (Duarte and Restuccia, 2010). Since productivity of the manufacturing sector is higher than that of agriculture and service in China, moving labor out of the agricultural sector to would raise aggregate productivity, while moving labor to the service sector would decrease aggregate productivity. This may be both good and bad for aggregate productivity. The results of this paper will help in the future study of this development.

References

Acemoglu, Daron, and Veronica Guerrieri. 2008. "Capital Deepening and Nonbalanced Economic Growth." *Journal of Political Economy*, 116(3): 467–498.

Baumol, William. 1967. "Macroeconomics of Unbalanced Growth: The Anatomy of Urban Crisis." *The American Economic Review*, 57(3): 415–426.

Bosworth, Barry, and Susan M Collins. 2008. "Accounting for Growth: Comparing China and India." *Journal of Economic Perspectives*, 22(1): 45–66.

Brandt, Loren, and Xiaodong Zhu. 2010. "Accounting for China's Growth." *IZA Discussion Paper*.

Brandt, Loren, Trevor Tombe, and Xiaodong Zhu. 2013. "Factor Market Distortions across Time, Space and Sectors in China." *Review of Economic Dynamics*, 16(1): 39–58.

Buera, Francisco, and Joseph Kaboski. 2009. "Can Traditional Theories of Structural Change Fit The Data?" *Journal of the European Economic Association*, 7(2-3): 469–477.

Buera, Francisco, and Joseph Kaboski. 2012*a*. "Scale and the Origins of Structural Change." *Journal of Economic Theory*, 147: 684–712.

Buera, Francisco, and Joseph Kaboski. 2012*b*. "The Rise of the Service Economy." *The American Economic Review*, 102: 2540–2569.

Cao, Kang H. Cao, Kang H., and Javier a. Birchenall. 2013. "Agricultural Productivity, Structural Change, and Economic Growth in Post-Reform China." *Journal of Development Economics*, 104: 165–180.

Caselli, Francesco, and Wilbur Coleman II. 2001. "The US Structural Transformation and Regional Convergence: A Reinterpretation." *Journal of Political Economy*, 109(3): 584–616.

Chow, Gregory C. 1993. "Capital Formation and Economic Growth in China." *The Quarterly Journal of Economics*, 108(3): 809–842.

Chow, Gregory C. 2004. "Another Look at the Growth of Output in China." *mimeo*.

Dekle, Robert, and Guillaume Vandenbroucke. 2012. "A Quantitative Analysis of China's SStructural Transformation." *Journal of Economic Dynamics and Control*, 36(1): 119–135.

Duarte, Margarida, and Diego Restuccia. 2010. "The Role of the Structural Transformation in Aggregate Productivity." *The Quarterly Journal of Economics*, 125(1): 129–173.

Echevarria, Cristina. 1997. "Changes in Sectoral Composition Associated with Economic Growth." *International Economic Review*, 38: 431–452.

Eichengreen, Barry, and Poonam Gupta. 2011. "The Two Waves of Service-sector Growth." *Oxford Economic Papers*.

Gollin, Douglas, Stephen L. Parente, and Richard Rogerson. 2004. "Farm Work, Home Work and International Productivity Differences." *Review of Economic Dynamics*, 7(4): 827–850.

Gollin, Douglas, Stephen Parente, and Richard Rogerson. 2002. "The Role of Agriculture in Development." *The American Economic Review*, 92(2): 160–164.

Greenfield, Harry. 1966. *Manpower and the Growth of Producer Services*. Columbia University Press.

Hansen, Gary, and Edward Prescott. 2002. "Malthus to Solow." *The American Economic Review*, 92(4): 1205–1217.

Holz, Carsten. 2006. "Measuring Chinese Productivity Growth: 1952-2005." *Mimeo*.

Kapur, Basant. 2012. "Progressive Services, Asymptotically Stagnant Services, and Manufacturing: Growth and Structural Change." *Journal of Economic Dynamics and Control*, 36: 1322–1339.

Katouzian, M. A. 1970. "The Development of the service sector: a new approach." *Oxford Economic Papers*, 22(3): 362–382.

Kongsamut, Piyabha, Sergio Rebelo, and Danyang Xie. 2001. "Beyond Balanced Growth." *The Review of Economic Studies*, 68(4): 869–882.

Laitner, John. 2000. "Structural Change and Economic Growth." *Review of Economic Studies*, 67(3): 545–561.

Maddison, Angus. 2007. *Development Centre Studies*. Organisation for Economic Co-Operation and Development.

Matsuyama, Kiminori. 1992. "Agricultural Productivity, Comparative Advantage, and Economic Growth." *Journal of Economic Theory*, 58(2): 317–334.

Matsuyama, Kiminori. 2002. "The Rise of Mass Consumption Societies." *Journal of Political Economy*, 110(5): 1035–1070.

Matsuyama, Kiminori. 2009. "Structural Change in an Interdependent World: A Global View of Manufacturing Decline." *Journal of the European Economic Association*, 7(2-3): 478–486.

Murphy, Kevin, Andrei Shleifer, and Robert Vishny. 1989. "Income Distribution, Market Size, and Industrialization." *The Quarterly Journal of Economics*, 104(3): 537–564.

Ngai, Rachel, and Christopher Pissarides. 2007. "Structural Change in a Multisector Model of Growth." *The American Economic Review*, 110: 681–712.

Ngai, Rachel, and Christopher Pissarides. 2008. "Trends in Hours and Economic Growth." *Review of Economic Dynamics*, 11(2): 239–256.

OMahony, Mary, and Marcel Timmer. 2009. "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database." *The Economic Journal*, 119(538): F374–F403.

Ren, Ruoen. 1997. *China's Economic Performance in an International Perspective*. Paris : OECD.

Restuccia, Diego, Dennis Tao Yang, and Xiaodong Zhu. 2008. "Agriculture and Aggregate Productivity: A Quantitative Cross-country Analysis." *Journal of Monetary Economics*, 55(2): 234–250.

Rogerson, Richard. 2008. "Structural Transformation and The Deterioration of European Labor Market Outcomes." *The Journal of Political Economy*, 116: 235–259.

Song, Zheng, Kjetil Storesletten, and Fabrizio Zilibotti. 2011. "Growing Like China." *American Economic Review*, 101(1): 196–233.

Święcki, Tomasz. 2013. "Determinants of Structural Change." *Working Paper*.

Uy, Timothy, Kei-Mu Yi, and Jing Zhang. 2013. "Structural Change in an Open Economy." *Working Paper*.

Wang, Ping, and Danyang Xie. 2004. "Activation of a Modern Industry." *Journal of Development Economics*, 74(2): 393–410.

Wolff, Edward. 2002. "How Stagnant are Services?" In *Productivity, Innovation and Knowledge in Services: New Economic and Socio-Economic Approaches.* , ed. Jean Gadrey and Faiz Gallouj. Edward Elgar Publishing.

Wu, Harry X. 2011. "Accounting for China's Growth in 1952-2008: China's growth performance debate revisited with a newly constructed data set." *RIETI Discussing Papers*.

Young, Alwyn. 2003. "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period." *Journal of Political Economy*, 111(6): 1220–1261.

Zhang, Junsen, Yaohui Zhao, Albert Park, and Xiaoqing Song. 2005. "Economic Returns to Schooling in Urban China, 1988 to 2001." *Journal of Comparative Economics*, 33(4): 730–752.

Zhu, Xiaodong. 2012. "Understanding China's Growth: Past, Present, and Future." *The Journal of Economic Perspectives*, 26(4): 103–124.

A Data Description

A.1 China

The aggregate economic time series, which include employment, value added, and capital by sector, are mainly collected from the official yearbooks published by National Bureau of Statistics of China (NBS). The data ranges from 1978 (the year China started to reform) to 2007 (before the global financial crisis).

Disaggregate level data of 4 sectors are needed. They are agriculture, manufacturing, distribution service and personal service. The agricultural sector consists of farming, animal husbandry, forest and fishing.[21] The manufacturing sector consists of mining, manufacturing, construction and public utility. The distribution service sector consists of wholesale, retailing, transportation and storage. The personal service sector consists of restaurant, hotel and other personal and community services.

The official employment data has a structural break in 1990 after NBS modified its estimation based on 1990 Population Census. Therefore this break is quite artificial and it has been discussed by a few papers.[22] To fix this jump, I followed the way used by Wu (2011) to adjust the data prior to 1990. To break down employment of the service sector, I use the data of sectoral employment share from China Industrial Productivity Database (CIP).[23] The CIP database contains detailed sectoral level data as far back as 1987. For the detailed service employment data before 1987, I construct my own data from the official yearbook.

Nominal sectoral value added data and implicit sectoral deflators are collected from official yearbooks.[24] Then the constant-price value added data are calculated based on the price of the year 1990. Value added data for personal and community services comes from CIP (1987-2007). From this data we can see the relative shares among nominal value added data of public administration, health, education, and personal and community services are very stable before 2002. So the data before 1987 are estimated with the assumption that the relative shares keep stable.

[21] The data contains agricultural service after 2002.

[22] See Holz (2006), Brandt and Zhu (2010) and Wu (2011).

[23] See RIETI CIP2011.

[24] Historical data have been adjusted and updated by NBS after several national economic census.

Nominal aggregate gross fixed capital formation data and implicit deflators are collected from official yearbooks. The more detailed fixed investment expernditure data are used to estimated sectoral gross fixed capital formation and they are scaled to be consistent with aggregate gross fixed capital formation. Then capital stock data for the 4 sectors are estimated using perpetual inventory method with the assumption that all sectors share the same capital depreciation rate $\delta = 0.5$:

$$K_j(t+1) = (1-\delta)K_j(t) + I_j(t),$$

where I_j is gross fixed capital formation. The capital stock data of the first year for each sector are estimated:

$$K_j(1978) = \frac{I_j(1978)}{\bar{g}+\delta},\ j \in \{a, m, ds, ps\},$$

where $\bar{g} = 0.1$ is the average output growth rate for 1978-1986.

A.2 Other Countries

GDP per capita data is collected from *PWT 7.1*.[25] The variable *rgdpl* is used. The value is PPP Converted and measured at 2005 constant prices. I exclude the countries with population less than one million. Philipphines is exclued because of stagnant growth after it reached $2000 per capita income level. I also exclude some emerging countries such as Banglasesh, Chile, Ecuador, Greece, Mexico, Nicaragua, Panama, Peru, Turkey, and Vietnam due to lack of data.

The value added share and employment share data are collected from the following sources:

- *GGDC 10-Sector Database*
- *World Development Indicators (World Bank)*
- *UN National Accounts*

[25] Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.1, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, Nov 2012.

- *EU KLEMS Database*[26]

[26]See Mary OMahony and Marcel Timmer (2009).