The Rise of the Service Sector in China

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Abstract

This paper analyzes the underlying mechanisms that explain the rise of the service sector in China. Along with China's unprecedented growth, the rapid expansion of its service sector is one of the fastest among emerging countries. However, the literature has yet to offer a clear understanding of such expansion. We show that distribution services first grow with the manufacturing sector, followed by personal services as per capita income rises. Motivated by this growth pattern, this paper provides a theory that describes 1) the complementarity between distribution services and the manufacturing sector, and 2) the substitution between personal services and home production. Quantitative results show that the personal service sector is the key to account for the early and rapid rise of the service sector in China. High productivity growth and high capital intensity in the personal service sector, and labor market frictions are the most important channels. By revealing the growth pattern of the service sector in the early stages of development, the paper thereby contributes to the growing literature on the rising importance of the service economy.

Keywords: structural change; service economy; Chinese economy

JEL Classification: J21; O11; O14

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. Historical data shows that

when an economy grows, resources flow from the agricultural sector to the manufacturing sector, eventually shifting to the service sector. Such Transition calls for a natural question: why do some countries experience earlier and faster growth in the service sector?

Over the past three decades China has grown rapidly into the second largest economy in the world. Along with such unprecedented growth, it also experienced a fast expansion of its service sector, with an expansion rate that is among the top of emerging countries. Understanding the sources of such expansion is important, since it can help elucidate the growth potential of other developing countries.

We first show that China has distinguished itself from other emerging economies with a higher growth of value added share or employment share in the service sector at the early development stages. However this feature is difficult to explain at the aggregate level because 1) evidence suggests that personal services, a sub-division of the service sector, are the key to explain its early rise; 2) traditional theories of structural change cannot explain the dynamic pattern of the service sector quantitatively when applied at the aggregate level. Other service components are not as important in explaining this rapid growth. Motivated by these facts, this paper departs from the existing literature by disaggregating services into distribution services and personal services, which enables a deeper examination of the different growth patterns of the two service components.

Disaggregation in this way reveals the heterogeneity in the service sector: different services have different growth patterns, and they require separate explanations. Distribution services accompany the manufacturing sector as its complements. They rise with industrialization and are commonly unaffected by per capita income changes. Personal services, on the other hand, are demanded by the households as substitutes for home production. As income increases, people who have comparative advantage with their work prefer to purchase personal services from the market rather than producing at home. As a consequence, the personal services expand, but at a later time than distribution services.

This paper provides a theory that highlights 1) the complementarity between distri-

bution services and the manufacturing sector, and 2) the substitution between personal services and home production. In order to fully study the structural change, the model incorporates both non-homothetic preferences and uneven sectoral productivity growth. It also incorporates physical capital and moving cost across sectors, which enables the study of the capital deepening effect and the role of labor market frictions.

The model establishes a link between labor productivity and the sectoral composition. We calibrate the model to fit the Chinese data. Given exogenous sectoral TFP trends, the model endogenously generates dynamic patterns of the sectoral labor allocation, that are consistent with the data. We then use this quantitative model to conduct counterfactual analyses to determine the relative importance of different channels of the structural change. There are several important channels which can affect labor reallocation across sectors, but only a few of them can account for the early and rapid rise of personal service sector. Our counterfactual results show that the most important channels are the high productivity growth and high capital intensity in personal services, and the labor market frictions.

This paper is related to a large existing literature on structural change, rise of service, home production and development of China. Traditional theories of structural change (for instance, see Kongsamut, Rebelo and Xie (2001); Ngai and Pissarides (2007); Acemoglu and Guerrieri (2008)), cannot provide a good quantitative match with the rise of the service sector.[1] This paper fills the gap by providing a candidate with disaggregated services and home production. It is also the first to document the growth of the service sector in China at a disaggregate level, as well as different growth patterns between distribution services and personal services at the early stages of development. For alternative treatment, see Buera and Kaboski (2012*a*,*b*) which features hierarchic type preferences. This paper also relates to a growing literature on the role of market versus home production. Similar to Gollin, Parente and Rogerson (2004); Rogerson (2008); Ngai and Pissarides

[1] See the discussion in Section 2.2.

(2008), we introduce a home production sector, which can explain a large and late income effect towards services. In our work we focus on the substitution between personal services and home production. Existing literature on China's economic growth and transformation 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 an alternative perspective to decompose the non-agricultural sector in China.

The rest of this paper is organized as follows. Section 2 provides the background and motivation for the service disaggregation. Section 3 formally states the model. Section 4 delivers the calibration and counterfactual results. Section 5 discusses the robustness of the model. Section 6 summarizes and concludes.

2 Why Disaggregating the Service Sector

The emerging service market in post-reform China provides a great opportunity to study the early stages of development in the service sector. Most existing literature focuses on the aggregate service sector. However, it is difficult to explain the growth features of the service sector in China from the aggregate level. By looking at the disaggregated level, we can identify that the rapid expansion of the personal service sector is the key to explain the rise of the service sector in China. We also show that the traditional structural change theories cannot fit the growth pattern of the service sector due to the heterogeneity of services, which calls for a higher level of disaggregation of the service sector.

2.1 The Rapid Rise of Service Sector in China

China has grown rapidly over the past three decades and has now become the second largest economy in the world. Along with this unprecedented growth, it also experienced

a quick expansion of the service sector. Table 1 lists a few emerging countries and regions. It shows the first year when these economies reached $2,000 per capita income (PPP adjusted, 2005 US dollars), annual growth rates of per capita GDP, annual growth of percentage points in service value added share and employment share.[2] We can see the growth of the service sector (in terms of growth of value added share or employment share) in China is one of the fastest among emerging economies. For example, Korea has comparable growth rate in per capita GDP, but a much slower growth in the service sector during early development stages.

[Table 1 here]

How has China distinguishes itself from other emerging economies? Figure 1 shows the macro trend of labor reallocation across sectors in China from 1978 to 2007. The red line with point markers, black line with squared markers, and the blue line with triangular markers stand for the employment shares of agriculture, manufacturing, and services respectively.[3] We can see that during the last 30 years, China has experienced a dramatic change in sectoral composition. The service employment share has increased from about 10 percent in 1978 to more than 30 percent in 2007. Also notice that the service employment share surpasses the manufacturing sector share before the manufacturing sector starts to decline. A structural break test shows that there is a break point in the year of 1993, which implies that the underlying structure of the service sector has changed.[4]

[Figure 1 here]

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.

[2]We only count the growth for the first ten years after the economies reached $2,000 per capita income level. Most of the economies experienced the highest growth speed for the first ten years. The threshold $2,000 is used to distinguish low-income countries and lower-middle-income countries. See Appendix A.2.

[3]The agricultural sector consists of farming, animal husbandry, forest and fishing. The manufacturing sector consists of mining, manufacturing, construction and public utility. The service sector consists of all the rest.

[4]See Appendix B.1.

Distribution services consist of wholesale, retailing, transportation and storage, which are mainly demanded by the manufacturing sector. Personal services consist of catering, lodging, and other community and personal services, such as babysitting, laundry, haircut, etc. These services are mainly demanded by the households as substitutes for home production. Table 2 summarizes this disaggregation of services.

[Table 2 here]

Figure 2 shows the employment shares of services after disaggregation. Lines marked with squares, triangles, and circles stand for the employment share (over total employment) of distribution services, personal services, and other services respectively. We can see that the employment share of distribution services grew steadily and it exhibited the same pattern as the employment share of the manufacturing sector in Figure 1. The employment share of personal services started with a slower growth, and then accelerated in the year of 1993, surpassing that of the distribution services. Other services kept a relatively constant share over time. From this disaggregation, we see the boom of the personal service sector causes of the growing aggregate employment share of the service sector, which also accounts for the rise of services when China started to take off.

[Figure 2 here]

If we disaggregate the service sector for other emerging countries such as Japan and Korea in the same way, we find similar growth patterns for distribution services, but a considerable delay in the surge of personal services. Figure 3 shows the growth patterns of sectoral employment shares for Japan and Korea. Lines with point markers, squared markers, and triangular markers stand for the employment shares of manufacturing, distribution services, and personal services, respectively. We can see that in both countries the employment share of the distribution service sector rose with the manufacturing sector from the very beginning. Personal services for both countries rose much later than the time when they reached $2,000 per capita income level (see Table 1). Hence the early rise

of the personal service sector in China is also the key to explain why China expanded its service sector more promptly than other emerging countries.

[Figure 3 here]

2.2 Can Traditional Theory of Structural Change Fit the Data?

There are two main theoretical perspectives regarding structural change. The first one starts with Baumol (1967), which emphasizes sectoral biased productivity growth and assumes non-unitary elasticity of substitution across sectoral goods.[5] The second one emphasizes non-homothetic preferences and different income elasticities across sectoral goods. Stone-Geary preference and its varieties are widely used in the literature of this category.[6]

Most existing literature focuses only on aggregate variables. Analyses show that neither of the theories can do reasonably well in fitting the structural change patterns in the data, especially for the service sector. Buera and Kaboski (2009) construct a quantitative model that combines both theories and they find that the model cannot fit the U.S. data from 1870–2000. It fails to match the later increase in the service sector or the sharper decline in the manufacturing sector. Explaining the pattern in the data requires a delayed income effect of demand for the service sector, which is impossible with the Stone-Geary preferences. With just the substitution effect, their model can only calibrate Leontieff preferences. Possible solutions to this issue include introducing hierarchic consumption, home production, and higher level of disaggregation.[7]

Duarte and Restuccia (2010) study productivity differences across countries using a model of structural transformation that also emphasizes both non-homothetic preferences and sectoral biased technological change. Their model is calibrated with the U.S. data and

[5] See Ngai and Pissarides (2007); Acemoglu and Guerrieri (2008).

[6] 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).

[7] See Murphy, Shleifer and Vishny (1989); Matsuyama (2002); Buera and Kaboski (2012*a*,*b*) for hierarchic consumption and disaggregation. See Gollin, Parente and Rogerson (2004); Ngai and Pissarides (2008); Rogerson (2008) for home production.

simulated with country-specific productivity time series for 29 countries. They find that the model generates a larger increase in service employment share than that observed in the data over the sample period.

None of the results are surprising, because services are heterogeneous. Different services exhibit different growth patterns and they relate to different explanations. The model with one aggregate service sector cannot fully capture the dynamics within the service sector. Based on the growth patterns of China, Japan and Korea, we find that personal services rise later than distribution services. Distribution services complements manufacturing. Input-Output Tables shows that about 12 percent intermediate input of manufacturing sector comes from distribution services while only a negligible 0.7 percent comes from personal services, which means the manufacturing sector depends heavily on distribution services.[8] Distribution services rise with industrialization, and they are commonly unaffected by per capita income changes.[9]

Personal services are substitutes for home production. As income increases, more households want to purchase the services from the market rather than producing them at home. As a consequence, the personal service sector starts to take off. Evidence from China shows an increasing expenditure share of personal services and a decreasing home production working time.

On the one hand, higher income increases the demand for personal services. We collect data of the expenditure share of dining out and household service from various issues of *China Statistical Yearbooks*. Although this time series only goes as far back as 1992, it features a structural break at 1994 which is in accordance with the rise of personal service employment. Figure 4 shows this change of consumer preferences.

[Figure 4 here]

On the other hand, higher income also accompanies lower home production work-

[8] Average data of Input-Output Tables, 1987-2002, KLEMS China.
[9] See Katouzian (1970); Eichengreen and Gupta (2011).

ing time. We construct micro data of major home production hours (cooking, childcare, laundry, and cleaning) from *China Health and Nutrition Survey* (CHNS) and it shows that Chinese people gradually decrease their time usage of home production (see Figure 5).[10]

[Figure 5 here]

The different growth patterns between distribution services and personal services are also common for developed countries. We 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 the United States based on the following regression:

$$Service\%_{it} = Constant + \sum \theta_i D_i + \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 y_{it}^3 + \mu_{it},$$

where D_i is the country dummy and y_i is log per capita GDP (PPP 2005 $) for country i. Figure 6 shows the results after removing the fixed effects.[11] We see that for both value added share and employment share, distribution services rise earlier than personal services.

[Figure 6 here]

Hence, the type of disaggregation we proposed in the paper can help explain different growth patterns of services across countries. By disaggregating the service sector, we can capture the early rise of distribution services after industrialization, and the delayed increase of personal services resulted from declining home production.

In sum, the disaggregated data show that there exists substantial heterogeneity in the service sector: different services have different growth patterns, and they require separate explanations. A theory with an aggregate service sector only is hence insufficient. In the next section, we introduce a model with multiple service divisions and home production, which better assesses the rapid rise of China's service sector.

[10] See Appendix A.1.2. See Wang (2014) for similar results.

[11] The EU15 comprised the following 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

3 The Model

In order to fully demonstrate the reasons for structural change, the model incorporates both non-homothetic preferences and different TFP growth rates. We highlight three channels to account for the rise of China's service sector: 1) Stone-Geary preferences, which features a subsistence level of agricultural goods, to capture the decline in the agricultural sector; 2) uneven TFP growth rate across sectors to capture the complementarity between manufacturing and distribution services; 3) a home production sector to capture the substitution between home goods and personal services.

The model also features other supplemental channels which can affect the structural change. Growth accounting analysis shows that capital growth is an important factor in the growth of China, especially the non-agricultural sector.[12] In particular, Acemoglu and Guerrieri (2008) show that capital deepening can affect sectoral resource allocation. Meanwhile, 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.[13] Our model incorporates physical capital and moving cost across sectors, which enables the study of the capital deepening effect and the role of labor market frictions.

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) require physical capital as an input in production. The final goods Y_f can be used for both consumption and investment. Different sectors have different wage rates as a result of labor market frictions.

The model establishes a link between labor productivity and the sectoral composition. It predicts that both low productivity growth in the distribution service sector and high productivity growth in the personal service sector will lead to a high service employment share. At the end of this section, we present a simple model without capital accumulation

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

to highlight the main insight of the model.

3.1 Technologies

3.1.1 Market Production

The market production consists of four primary sectors: agriculture, manufacturing, distribution services and personal services, which are indexed with subscripts a, m, ds, ps, respectively. The production in sector $j \in \{a, m, ds, ps\}$ is

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

where θ_j is the physical capital income share in sector j, which can be different across sectors. $A_j(t)$, $K_j(t)$ and $L_j(t)$ are total factor productivity (TFP), capital inputs, and labor inputs.

The TFP parameter $A_j(t)$ is assumed to grow exogenously:

$$A_j(t) = A_j(1+\gamma_j)^t, \ j \in \{a, m, ds, ps\}, \tag{2}$$

where A_j is the initial labor productivity in sector j, and γ_j is the sector-specific TFP growth rate in sector j, which is constant over time but can be different across sectors.

The final goods Y_f are produced using two intermediate inputs: distribution services Y_{ds} and manufacturing goods Y_m:

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

with $\epsilon > 0$, $\eta \in (0, 1)$.

Y_f can be both consumed and invested. The aggregate capital stock satisfies:

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

where C_f is the final goods consumption, and $\delta \in [0,1]$ is the capital depreciation rate. The initial capital stock $K(0) > 0$ is given.

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

$$\max_{L_j(t), K_j(t) \geq 0} \{p_j(t) Y_j(t) - w_j(t) L_j(t) - r(t) K_j(t)\}. \tag{3}$$

The profit maximization problem for the final good sector is

$$\max_{Y_m(t), Y_{ds}(t) \geq 0} \{Y_f(t) - p_m(t) Y_m(t) - p_{ds}(t) Y_{ds}(t)\}. \tag{4}$$

Labor Market Frictions The wage rate w_j is not equalized across sectors. Here we assume labor is homogeneous, and consider the frictions of labor market as the source of wage gaps.[14] These frictions can be a result of rural-urban migration cost or other labor market distortions.[15]

The wage gaps across sectors have been identified as important to structural change by the literature, since they are implicit barriers of labor reallocation. By including them we can quantitatively evaluate and compare the importance of each channel of structural change in a unified framework.[16] We use $\mu_{j \in \{a,ds,ps\}}$ to denote the wage gaps, which are

[14] See Section 5.2 for another explanation of heterogenous labor.

[15] In China, there are many institutional and policy constraints that distort wages across sectors and labor reallocation. For example, there were severe labor movement from agriculture to non-agriculture; the level of wage in the state owned enterprises was set by the government not by the market. See Brandt and Zhu (2010); Dekle and Vandenbroucke (2012); Cao and Birchenall (2013).

[16] The wage differentials are also necessary to explain the differences between sectoral employment shares and value added shares in the data. If we assume the same capital intensity across sectors, and there are no intersectoral wedges, the model predicts the same value added share and employment share for each sector.

defined as the wage ratio between sector $j \in \{a, ds, ps\}$ and the manufacturing sector:

$$w_a(t) = \mu_a(t) w_m(t), \tag{5}$$

$$w_{ds}(t) = \mu_{ds}(t) w_m(t), \tag{6}$$

$$w_{ps}(t) = \mu_{ps}(t) w_m(t), \tag{7}$$

We can view $1-\mu_j$ as the cost of moving across sectors: if one wants to move from sector j to the manufacturing sector, he must pay a fraction of $1-\mu_j(t)$ of his marginal product of labor in the manufacturing sector as a movement cost (or entry cost) in each period. Workers will therefore be indifferent between working in sector j and the manufacturing sector. An increase in μ_j has two opposite effects: 1) it raises the relative wage rate in sector j and helps increase the employment in sector j; 2) it increases the overall income hence an increase in both consumption and labor demand in other sectors. Which effect will dominate depends on the elasticity of sbustitution of different sectoral goods.

3.1.2 Home Production

We assume that the production of home goods is linear in home work time:

$$Y_h(t) = A_h L_h(t), \tag{8}$$

where A_h is the labor productivity of home production and it is assumed to be constant over time. The labor input in home work is evaluated at the wage from the market of personal services $(w_{ps}(t))$, which are substitutes to home production.[17]

Given the fact that the capital intensity differences in the data is not large, the wedges are quantitatively important to cover the differences in the data. See Buera and Kaboski (2009); Święcki (2013).

[17]This market cost method is one of the standard way in the literature to evaluate home production; see Hawrylyshyn (1976) for a survey.

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 in each period. The period utility is a function of agricultural goods C_a, goods produced by the final goods sector C_f, and composite consumption C_{hps}:

$$U\left\{C_a\left(t\right), C_f\left(t\right), C_{hps}\left(t\right)\right\} = \begin{cases} C_a\left(t\right), & \text{if } C_a\left(t\right) < \bar{a} \\ \bar{a} + \ln\left[\left(1-\phi\right) C_f\left(t\right)^{\frac{\rho-1}{\rho}} + \phi C_{hps}\left(t\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} & \text{if } C_a\left(t\right) \geq \bar{a} \end{cases}, \tag{9}$$

where the composite consumption C_{hps} is an aggregate consumption of personal services C_{ps} and home goods C_h:

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

and $\phi, \nu \in (0,1)$, $\rho, \zeta > 0$. When agricultural productivity is such low that $C_a\left(t\right) < \bar{a}$, the representative household can only consume the agricultural good C_a; when agricultural output is above the subsistence level, namely $C_a\left(t\right) \geq \bar{a}$, the household starts to gain utility from the consumption of C_f and C_{hps}.[18] The agricultural productivity is assumed to be high enough 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 subsistence requirement, the income elasticity of demand for agricultural goods is less than one, which is consistent with Engel's law. 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 across C_f and C_{hps}.

The lifetime utility maximization problem for the representative household is as fol-

[18] This utility function is a simplified specification of Stone-Geary utility function; see John Laitner (2000); Douglas Gollin, Stephen Parente and Richard Rogerson (2002). This simplification has no significant differences from the more general Stone-Geary utility and makes the analysis much more tractable.

lows:

$$\max_{C_a, C_f, C_{ps}, C_h, X} \sum_{t=0}^{\infty} \beta^t U \left\{ C_a(t), C_f(t), C_{ps}(t), C_h(t) \right\}, \tag{10}$$

subject to

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

where $X(t)$ is the household saving for capital investment, $\beta \in (0,1)$ is the discount factor, and p_f is the price of the final good Y_f.

3.3 Equilibrium

The following market clearing conditions hold in each period t:

- Goods market

$$\begin{aligned} C_a(t) &= Y_a(t), \; C_f(t) + X(t) = Y_f(t), \\ C_{ps}(t) &= Y_{ps}(t), \; C_h(t) = Y_h(t); \end{aligned} \tag{11}$$

- Capital market

$$\begin{aligned} K_a(t) + K_m(t) + K_{ds}(t) + K_{ps}(t) &= K(t), \\ K(t+1) - (1-\delta) K(t) &= X(t); \end{aligned} \tag{12}$$

- Labor market

$$L_a(t) + L_m(t) + L_{ds}(t) + L_{ps}(t) = 1 - L_h(t). \tag{13}$$

The competitive equilibrium of this economy is defined 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 $\{w_j(t), r(t)\}_{t=0}^{+\infty}$, 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)–(4) and the representative household's maximization problem (10), and satisfy the market clearing conditions (11)-(13).

3.3.1 The Static Equilibrium

This model has a unique competitive equilibrium. The equilibrium can be characterized by a static part and a dynamic part. Let's first describe the static part. Given the capital stock $K(t)$, sectoral TFP $A_j(t)$, $j \in \{a, m, ds, ps, h\}$, and prices, we can solve the allocation of factors as well as consumption across sectors. Profit maximization and competitive market imply that

$$w_j(t) = (1-\theta_j) p_j(t) A_j(t) \left[\frac{K_j(t)}{L_j(t)}\right]^{\theta_j}, \ j \in \{a, m, ds, ps\} \tag{14}$$

$$r(t) = \theta_j p_j(t) A_j(t) \left[\frac{K_j(t)}{L_j(t)}\right]^{\theta_j - 1}, \ j \in \{a, m, ds, ps\} \tag{15}$$

$$p_f(t) = \left[\eta^{\epsilon} p_{ds}(t)^{1-\epsilon} + (1-\eta)^{\epsilon} p_m(t)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \tag{16}$$

$$p_m(t) = (1-\eta) p_f(t) \left[\frac{Y_m(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}, \tag{17}$$

$$p_{ds}(t) = \eta p_f(t) \left[\frac{Y_{ds}(t)}{Y_f(t)}\right]^{-\frac{1}{\epsilon}}. \tag{18}$$

The marginal rate of technical substitution satisfies:

$$\frac{1-\theta_a}{\theta_a}\frac{K_a(t)}{\mu_a(t) L_a(t)} = \frac{1-\theta_m}{\theta_m}\frac{K_m(t)}{L_m(t)} = \frac{1-\theta_{ds}}{\theta_{ds}}\frac{K_{ds}(t)}{\mu_{ds}(t) L_{ds}(t)} = \frac{1-\theta_{ps}}{\theta_{ps}}\frac{K_{ps}(t)}{\mu_{ps}(t) L_{ps}(t)}. \tag{19}$$

Labor reallocation between the manufacturing sector and the distribution service sector follows

$$\frac{L_m(t)}{L_{ds}(t)} = \left(\mu_{ds}(t)\frac{1-\eta}{\eta}\frac{1-\theta_m}{1-\theta_{ds}}\right)^{\epsilon} \left[\frac{A_{ds}(t)\left(K_{ds}(t)/L_{ds}(t)\right)^{\theta_{ds}}}{A_m(t)\left(K_m(t)/L_m(t)\right)^{\theta_m}}\right]^{1-\epsilon}. \tag{20}$$

From (20) we can see if ϵ is less than one, which means that distribution services

and manufacturing are complements, then labor will move from the sector with higher TFP growth rate to the sector with lower TFP growth rate. This quantitative model also features a capital deepening effect (Acemoglu and Guerrieri, 2008). If ϵ is less than one, and capital intensities are different across sectors (for example, $\theta_m \neq \theta_{ds}$), then capital per worker of the capital intensive sector will accumulate faster than that of the labor intensive sector, which results in a labor shift from the capital intensive sector to the labor intensive sector.

For agricultural consumption, since we assume that the agricultural production has passed the subsistence level, agricultural consumption are constant:

$$C_a(t) = \bar{a}. \tag{21}$$

Recall that the labor cost of home production is w_{ps}, then the optimal consumption among final goods C_f, and the composite consumption C_{hps} must satisfy

$$\frac{C_{hps}(t)}{C_f(t)} = \left\{ \frac{1-\phi}{\phi} \frac{\left[\nu^{\zeta} p_{ps}(t)^{1-\zeta} + (1-\nu)^{\zeta} \left(\frac{w_{ps}(t)}{A_h} \right)^{1-\zeta} \right]^{\frac{1}{1-\zeta}}}{p_f(t)} \right\}^{-\rho}. \tag{22}$$

Utility maximization also implies

$$\frac{C_{ps}(t)}{C_h(t)} = \left(\frac{1-\nu}{\nu} \frac{p_{ps}(t)}{\frac{w_{ps}(t)}{A_h}} \right)^{-\zeta}. \tag{23}$$

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

$$\frac{L_{ps}(t)}{L_h(t)} = \left[\frac{\nu}{1-\nu} (1-\theta_{ps}) \right]^{\zeta} \left[\frac{A_{ps}(t)}{A_h} \left(\frac{K_{ps}(t)}{\mu_{ps} L_{ps}(t)} \right)^{\theta_{ps}} \right]^{\zeta-1}. \tag{24}$$

Equations (14)-(24) together determine the static allocation.

3.3.2 The Dynamic Equilibrium

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

$$\frac{p_f(t+1)\lambda(t+1)}{p_f(t)\lambda(t)} = \frac{\beta}{1+g}\left[\frac{r(t+1)}{p_f(t+1)} + (1-\delta)\right], \tag{25}$$

where

$$\begin{aligned}\lambda(t) &= \left\{(1-\phi)^{\rho} + \phi^{\rho}\left[\nu^{\zeta} p_{ps}(t)^{1-\zeta} + (1-\nu)^{\zeta}\left(\frac{w_{ps}(t)}{A_h}\right)^{1-\zeta}\right]^{\frac{1-\rho}{1-\zeta}}\right\}^{\frac{1}{1-\rho}} \\ &\cdot\left[(1-\phi)\, c_f(t)^{\frac{\rho-1}{\rho}} + \phi c_{hps}(t)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}},\end{aligned}$$

and g is the employment growth rate.

3.4 An Analytical Illustration

This section presents a simple model to highlight the main components of the quantitative model. We consider a special case with $\theta_{j\in\{a,m,ds,ps\}} = 0$, $\mu_{j\in\{a,ds,ps\}} = 1$, $\rho = 1$. By setting the capital intensity of all market sectors as zero, we abstract from capital accumulation and the technologies become linear. We also assume the absence of labor market frictions. The period utility function (9) becomes

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

Since there is no more investment, all final goods Y_f are consumed: $C_f(t) = Y_f(t)$.

Without capital accumulation, an analytical solution can be derived. Since the technologies have constant return to scale and there are no other distortions, the sectoral value added shares are the same as the sectoral employment share. Hence we only focus

on the employment share.

With the same labor market clearing condition (13) L_a, L_m, L_{ds}, L_{ps} and L_h are solved:

$$\begin{aligned}
L_a(t) &= \frac{\bar{a}}{A_a(t)}, \\
L_{ds}(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\eta}{\eta}\right)^{\epsilon}\left[\frac{A_{ds}(t)}{A_m(t)}\right]^{1-\epsilon}}, \\
L_m(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\eta}{1-\eta}\right)^{\epsilon}\left[\frac{A_m(t)}{A_{ds}(t)}\right]^{1-\epsilon}}, \\
L_{ps}(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\nu}{\nu}\right)^{\zeta}\left[\frac{A_{ps}(t)}{A_h}\right]^{1-\zeta}}, \\
L_h(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\nu}{1-\nu}\right)^{\zeta}\left[\frac{A_h}{A_{ps}(t)}\right]^{1-\zeta}}.
\end{aligned} \tag{26}$$

Equation (26) characterizes the labor allocation in the personal service sector. Since $A_{ps}(t)$ grows exponentially, it is a special form of the 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 more important than manufacturing goods, more labor will be allocated to the personal service sector. ζ controls the growth rate of the employment share. When $\zeta > 1$, personal services are substitutes for home goods. A larger ζ means a faster demand shift from home goods to personal services. ν affects the timing of the maximum growth rate. $\frac{\nu}{1-\nu}$ measures the expenditure share ratio between personal services and home goods. With a smaller ν, the employment share of the personal service sector will rise later. Therefore this equation has enough degrees of freedom to capture the later rise (structural break) in the personal service sector.

Proposition 1 summarizes the pattern of the 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.

Proposition 1. *Labor Reallocation across Sectors*

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* $\zeta > 1$,
$$\frac{\partial L_{ps} / \partial L_h}{\partial A_{ps}} > 0.$$

4 Quantitative Analysis

In this section, we first introduce the calibration strategy, and then show the results that suggest a good description of the dynamics of labor reallocation. Based on the calibration we conduct several counterfactual analyses to examine the relative importance of several structural change channels and discuss the implications.

4.1 Calibration

Each period in the model is assumed to be one year. The parameters that need to be calibrated are $\{\bar{a},\ A_{j\in\{a,m,ds,ps,h\}},\ \gamma_{j\in\{a,m,ds,ps\}},\ \theta_{j\in\{a,m,ds,ps\}},\ \eta,\ \epsilon,\ \phi,\ \rho,\ \nu,\ \zeta,\ \beta,\ \delta,\ g\}$, the initial capital per worker $k\left(0\right) = \frac{K(0)}{L(0)}$ and wage gaps $\mu_{j\in\{a,ds,ps\}}\left(t\right)$. This dynamic model is simulated using forward shooting to determine optimal consumption path. The calibration

strategy is to restrict the parameter values so that they match the main structural change features of China. The calibration is done by steps and the sample period of data we use for calibration is 1978-2007.

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.[19] The capital income share is one minus labor income share. The results are summarized in Table 3. $\theta_m = 0.596 > \theta_{ds} = 0.531$, which means the manufacturing sector is more capital intensive than the distribution service sector (but the difference is not large).

Given $\theta_{j\in\{a,m,ds,ps\}}$ and (1), we use real value added, capital and employment for each sector to pin down TFP growth rate $\gamma_{j\in\{a,m,ds,ps\}}$ with growth accounting. Note that the initial TFP parameters $A_{j\in\{a,m,ds,ps,h\}}$ only reflect a choice of units, so they can be set to unity.

We use first order condition to back out labor market distortions.[20] Wage gaps $\mu_{j\in\{a,ds,ps\}}$ are calibrated based on (5)–(7) and (14). According to the first order condition (14), the wage ratio is proportional to the ratio of average labor productivity (nominal output per worker):

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

Figure 7 shows the patterns of μ_j across time. Although there are fluctuations, all of them exhibit a downward trend, which implies that the average labor productivity in the manufacturing sector increases faster than any other sector. If we focus on the mean value (denoted by $\bar{\mu}_j$), we can see that on the one hand, the wage level is nearly the same between the manufacturing sector and the distribution service sector ($\bar{\mu}_{ds} = 1.00$), which means labor can move almost freely between these two sectors; on the other hand, the wage gap

[19] 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.

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

between the manufacturing sector and both of the agricultural sector ($\bar{\mu}_a = 0.38$) and the personal service sector ($\bar{\mu}_{ps} = 0.23$) is large, which means that it is relatively easier for rural surplus labor to find jobs in the urban personal service sector. These facts also confirm that distribution services and personal services in China have different characteristics. Given such large gap, labor market frictions are not negligible.

[Figure (7) here]

Given $\frac{L_m(t)}{L_{ds}(t)}$, $\frac{L_{ps}(t)}{L_h(t)}$ $\frac{K_{ds}(t)}{L_{ds}(t)}$, $\frac{K_m}{L_m}$, $\frac{K_{ps}(t)}{L_{ps}(t)}$ from data, and calibrated $\theta_{j\in\{m,ds\}}$, $\mu_{j\in\{m,ds\}}$, $A_{j\in\{m,ds\}}$, $\gamma_{j\in\{m,ds\}}$, we can calibrate ϵ, η, ζ and ν using the two first order equations: (20) and (24).[21] ϵ and η are calibrated to match the slope and mean of $\frac{L_m(t)}{L_{ds}(t)}$; ζ and ν are calibrated to match the slope and mean of $\frac{L_{ps}(t)}{L_h(t)}$. Intuitively, the elasticity parameters (ϵ and ζ) are disciplined by the slope and the share parameters (η and ν) are disciplined by the mean. On the one hand, $\epsilon = 0.61 < 1$ confirms that there is complementarity between the manufacturing sector and the distribution service sector. On the other hand, $\zeta = 2.43 > 1$ indicates that personal services are substitutes for home production.

At last we jointly calibrate ϕ, ρ, $\bar{a}$ and $k(0)$ to match the mean value of personal service employment share, the slope of personal service employment share, the initial value of agricultural employment share, the slope of agricultural employment share, respectively. $\rho = 1.635$ shows that there exists a substitution effect between the composite consumption C_{hps} and the final goods C_f.[22] $\bar{a} = 0.779$, which is about 30 percent of initial output per capita. $k(0) = 566.3$, which results in a capital-output ratio of about 2.5. We follow the literature and choose $\beta = 0.95$, $\delta = 0.05$ for the entire quantitative analysis.[23] The annual growth rate of labor employment is 1 percent, so $g = 0.01$. Table 3 summarizes all the parameter values.

[Table 3 here]

[21] The employment ratio between personal services and home production are calculated from the working hours information in *China Health and Nutrition Survey*.

[22] We also follow Rupert, Rogerson and Wright (1995) to estimate the elasticity using *China Health and Nutrition Survey* and get a result close to 1.5, which is similar to the calibration result.

[23] Varying β and δ in a reasonable interval does not change the quantitative results significantly.

This calibration strategy targets agricultural employment share to pin down $\bar{a}$ and $k(0)$, and it targets personal service employment share to pin down ϕ and ρ. The rest employment share are allocated between the manufacturing sector, the distribution service sector, and the home production sector, which is based on parameters η,ϵ, ν and ζ. Figure 8 shows the employment share results generated by the model based on the above calibration. Blue dash lines are the original data and red solid lines are estimates generated by the model. The dynamic patterns of the employment share are captured well by the quantitative model. Employment share of the agricultural sector keeps decreasing, while that of the manufacturing sector shows a increasing trend. At the same period, distribution service and personal service employment shares keep increasing, with personal services featuring a later start. For the manufacturing sector and the distribution service sector, the data and the model deviate from each other after the year of 2002. Since the calibration strategy is to capture the trend, it could be a result of a TFP shock at that time (we only calibrate the average TFP growth rate), or a change of elasticity due to open economy.[24]

[Figure 8 here]

Although we only calibrate the TFP trend, the employment shares fluctuate over time due to ever-changing intersectoral wage gaps. Given the wage gaps, the model solves different capital labor ratios for each sector over time. To see the trend more clearly, we also calibrate the model parameters using only the mean value of $\mu_j(t)$ (see Figure 9).

[Figure 9 here]

We test the calibration by comparing the valued added shares generated by the model with the data. See Figure 10 for the results. The model generated results (red solid lines) can capture the value added share of each sector from data (blue dash lines). The trends of value added shares are similar to that of the employment shares.

[24]Starting from 2002 China has joined WTO and become the world factory, which breaks the domestic equilibrium between demand and supply for manufacturing goods. Since distribution services are not as tradable as the manufacturing goods, the elasticity of substitution between them could change.

[Figure 10 here]

We also check the capital dynamics, which are not the target of our calibration. Figure 11 shows the dynamic patterns of investment output ratio (I/Y) and capital output ratio (K/Y). Blue dash lines come from the data and red solid lines are from the model. Our calibration results show an increasing pattern for I/Y and a decreasing pattern for K/Y; both model and data have similar mean values. After 1985 the model generates a relatively stable K/Y ratio which indicates a relatively stable real capital return. This is consistent with the empirical evidence in the literature.[25]

[Figure 11 here]

4.2 Counterfactual Analysis

This model features multiple channels for the structural change, especially the rise of the service sector. These channels are:

1. Subsistence requirement for agricultural goods (*income effect*);
2. Complementarity between manufacturing goods and 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. Substitution between personal services and home production:
   (a) TFP growth in the personal service sector and the home production sector (*sector-biased productivity growth*);
   (b) Capital accumulation in the personal service sector (*capital deepening*);

[25] See Bai, Hsieh and Qian (2006); Song, Storesletten and Zilibotti (2011).

4. Substitution between the composite consumption C_{hps} and the final good C_f;

5. Changes of intersectoral wage gap.

These channels interplay with each other, we hence cannot simply differentiate them from the data only. In this subsection we conduct several counterfactual analyses to determine the quantitative importance of these channels. Since the calibration results show that the trends of sectoral value added shares are similar to that of the sectoral employment shares (see Figure 8 and Figure 10), and the changes in sectoral employment shares are the most notable aspect of this transition, we will focus on the changes in sectoral employment shares. We assess the quantitative importance of each channel by comparing the changes of labor reallocation they can generate with the benchmark model.

No Income Effect The first channel is very important because it guides the surplus labor in the agricultural sector to the non-agricultural sector. If there is no labor productivity growth in the agricultural sector, labor will be restricted in the agricultural sector. To shutdown this channel, we calibrate different $\bar{a}$ over time to generate a steady expenditure share of agricultural goods. After shutting down this channel, only wage gaps $\mu_j(t)$ can reallocate labor from the agricultural sector to the non-agricultural sector. Figure 12 shows the simulation result. In the table we show the change of percentage points of sectoral employment share for the benchmark model and the counterfactuals. The values in parentheses show the relative percentage changes comparing to the benchmark model. We can see the agricultural employment share is relatively constant over time because the overall changes of μ_j are small. When there is no income effect, labor is kept in the agricultural sector, and all employment shares in non-agricultural sectors decrease significantly (comparing with the data).

[Figure 12 here]

Unitary Elasticity of Substitution between Manufacturing and Distribution Services The elasticity of substitution between the manufacturing goods and distribution services are set to be 1 ($\epsilon = 1$) to disable the labor reallocation between these two sectors. From Figure 13 we can see the level of the manufacturing employment share shifts up and the overall change of percentage points increases. On the contrary, the level of the distribution service employment share shifts down and the overall changes of percentage points decreases. The change of agricultural and personal service employment shares are not noticeable.

[Figure 13 here]

Unitary Elasticity of Substitution between Personal Services and Home Production In this counterfactual analysis we let the elasticity of substitution between personal services and home production be zero. Figure 14 shows the results of the employment share. The most noticeable change happens in the personal service sector. Due to unitary elasticity, both the level and the change of percentage points of personal services drops almost to zero. The employment shares in all other three sectors increase due to labor reallocation.

[Figure 14 here]

Unitary Elasticity of Substitution between C_{hps} and C_f From Figure 15 we can see if the elasticity of substitution between the composite consumption C_{hps} and the final goods C_f is one, then the model underestimates the employment shares in the manufacturing and distribution service sectors; on the other hand, employment shares in the agricultural and personal service sectors are overestimated.

[Figure 15 here]

Table 4 summarizes the changes of sectoral employment share generated by the above four counterfactual analyses and compare them with that of the benchmark model. The

first column lists the change of percentage points resulted from the benchmark model for the four market sectors (agriculture $\triangle L_a$, manufacturing $\triangle L_m$, distribution services $\triangle L_{ds}$, personal services $\triangle L_{ps}$) and the aggregate service sector $\triangle L_s = \triangle L_{ds} + \triangle L_{ps}$. The following four columns shows the results of above four counterfactual analyses.

[Table 4 here]

Sector-biased Productivity Growth and Capital Deepening Given non-unitary elasticity of substitution, different TFP growth and capital accumulation can result in the changes of relative prices, and labor reallocation across sectors. Here we conduct 4 counterfactual analyses to quantitatively evaluate their roles:

1. we set $\gamma_{ds} = \gamma_m$ to equalize different TFP growth rates between the manufacturing sector and the distribution service sector;

2. we set $\theta_{ds} = \theta_m$ to shut down the capital deepening effect between the manufacturing sector and the distribution service sector;

3. we set $\gamma_{ps} = 0$ to turn off TFP growth in the personal service sector;

4. we set $\theta_{ps} = 0$ to eliminate the capital deepening effect in the personal service sector.

[Table 5 here]

Table 5 summarizes the counterfactual results. When the manufacturing sector and the distribution service sector have the same TFP growth rate ($\gamma_{ds} = \gamma_m$), the distribution services drops 32 percent comparing to the benchmark model. When equalizing the capital intensity between the two sectors, L_{ds} drops only 18 percent. This is because the discrepancy between TFP growth rate is much larger than that of the capital intensity. In both cases, the manufacturing employment share increases significantly due to less complementarity. The personal service sector is barely affected ($\pm 5\%$). The rest two simulations show

that both TFP growth and capital accumulation are important for the rise of the personal service sector, and have a much larger impact on the aggregate service employment share. See Figure 16–19 for the above counterfactual results.

[Figure 16–19 here]

Intersectoral Wage Gaps Last but not the least we conduct several counterfactual analyses to evaluate the role of intersectoral wage gaps in the structural change. To eliminate the effects of ever-changing wage gaps on labor reallocation we keep them at the initial value: $\mu_j(t) = \mu_j(0)$, for $j \in \{a, ds, ps\}$. Table 6 summarizes the results.

[Table 6 here]

From the table we can see that the first counterfactual ($\mu_a(t) = \mu_a(0)$) only has a negligible effect on labor reallocation. This is because the overall changes of μ_a is small. The second and the third counterfactuals have similar effects on employment shares. When we keep $\mu_{j\in\{ds,ps\}}$ constant, in equilibrium less labor is reallocated to sector j. Both $\mu_{j\in\{ds,ps\}}$ decline over time (see Figure 7). If we keep the wage gaps at their initial values, it means we increase μ_j comparing to the real cases. In other words, we alleviate the frictions of labor movement so that labor moves out of sector j. See Figure 20–22 for the graphic illustration of the above counterfactual results.

[Figure 20–22 here]

4.3 Key factors Driving the Early and Rapid Growth of Personal Services

Which factors led to the early and rapid growth of personal services in China? The above counterfactuals identify three important channels: high TFP growth rate in the personal service sector (high γ_{ps}), capital deepening in the service sector (high θ_{ps}), and high labor

market frictions (low μ_{ps}). Both high TFP growth rate and high capital accumulation lead to high labor productivity growth in the personal service sector, which has a strong price effect on the expansion of personal service expenditure. The wage gap μ_{ps} is an implicit measure of labor market frictions regarding the personal service sector. Low μ_{ps} suppresses the return to labor in personal services relative to manufacturing, which also provides market personal services a price advantage.

We also compare the above three channels with Japan and Korea. Table 7 lists the annual growth rate of labor productivity Y_{ps}/L_{ps} and TFP γ_{ps}, capital intensity θ_{ps} in the personal service sector, wage rate of personal services relative to the manufacturing, for China, Korea, and Japan. We can see that China has the highest TFP growth rate and capital intensity, and the lowest relative wage rate among the three countries. The result is robust with respect to a shorter sample period of Korea and Japan. Hence all three factors can explain the early and rapid growth of personal services in China.

[Table 7 here]

5 Model Discussion

5.1 Simulation Results from Alternative Data

This paper mainly uses 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.

We follow the method 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, but they barely change the final quantitative results, because the calibration target the labor employment data and labor allocation does not change.

5.2 The Role of Human Capital

This paper tries to establish a link connecting labor allocation, TFP growth and capital accumulation. The model abstracts from human capital because sectoral time series data for human capital are not available, especially in the service sector. But from empirical facts in Section 2.1 we can see the main contributors to the growth of the service sector in China are distribution services and personal services, which are categorized as traditional service sectors and are not considered as skill-labor intensive. Those modern service sectors that require high-skill labor, such as financial services, health and education, keep a relatively constant employment share. In this subsection, we argue that the abstraction of human capital is not restrictive for the quantitative results from both statistical and theoretical aspects.

5.2.1 Statistical Evidence

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 cannot be high. According to the fifth *National Population Census* in 2000, About 70 percent of workers in wholesale, retailing, and catering services have not gone to high school. Only 5 percent of workers have a college degree (see Table 8). Therefore, human capital accumulation in the service sector itself cannot be an important reason for the past growth of the service sector in China.

[Table 8 here]

Buera and Kaboski (2012*b*) argue that growth in services can benefit 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.

5.2.2 Theory of Heterogenous Labor

The wage gap μ_j can also cover the change of skill components across sectors. We 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 which can be different across sectors. $H_{j\in\{a,m,ds,ps\}}$ is defined as effective labor unit: $H_j(t) = \mu_j(t) L_j(t)$, where $\mu_j(t)$ is used to denote the relative human capital or skill level required by sector j at time t, and $L_j(t)$ is the raw labor unit.[26] Without loss of generality, the skill level in the manufacturing sector is normalized to one, i.e., $\mu_m = 1$. Therefore the production function can be written as

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

We assume the goods and factor markets are competitive and capital is perfectly mobile. Due to different skill requirements across sectors, labor is imperfectly mobile in the

[26] 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 Census 2010*, the proportion of employment without college degree in each sector is 99% (agriculture), 90% (manufacturing), 88% (distribution services), 94% (personal services).

sense that the marginal product of effective labor (H) is the same across sectors, but there are gaps between the marginal product of raw labor (L) across sectors. Hence the profit maximization implies

$$\begin{aligned} w_a(t) &= \mu_a(t) w_m(t), \\ w_{ds}(t) &= \mu_{ds}(t) w_m(t), \\ w_{ps}(t) &= \mu_{ps}(t) w_m(t), \end{aligned}$$

From the above equations we can see $\mu_{j\in\{a,ds,ps\}}$ capture the gaps of wage rates between sectors. Therefore, based on the same calibration strategy of μ in Section 4.1, μ_j can also reflect the change of sectoral skill components. The role of μ_j has been discussed in Section 4.2.

5.3 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 the domestic market; on the other hand, it can have an impact on domestic productivity via resource reallocation. 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 contributes 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 the calibration targets are mainly from data that contain the influence of trade. We also calibrate the model based on a shorter time frame 1978–2002 (before China joined the WTO). The quantitative results

are not significantly different. Hence, the assumption of closed economy is not restrictive for the quantitative results.

6 Conclusion

This paper shows that it is important to study the service sector from a disaggregated level if we want to explain the rise of services at the early development stages. We show that distribution services first grow with the manufacturing sector, followed by personal services as per capita income rises. This paper provides a theory that highlights the complementarity between distribution services and the manufacturing sector, and the substitution between personal services and home production. We calibrate the model to fit Chinese data, and the quantitative analysis shows that the personal service sector is the key to the earlier and faster rise of the service sector in China. High productivity growth and high capital intensity in the personal service sector, and the labor market frictions are the most important channels.

The rise of the service sector has been proven to have a strong relationship with aggregate productivity, an essence in development economics (Duarte and Restuccia, 2010). The service sector, especially the personal service sector, absorbs a substantial portion of rural surplus labor, and hence plays an important role in urbanization and development. This paper provides the underlying mechanisms of the early and rapid rise in the personal service sector in China, which sheds lights on the potential of structural transformation in other developing countries.

It is of our interests to continue the research on personal services. One extension is to evaluate the role of the drivers of personal services in a multi-country comparison. We intend to simulate the model with country-specific productivity series from Korea and Japan, and quantitatively assess the the channels that account for the gap with China. Another extension involves finding the micro source of productivity growth in the personal service

sector. China has a higher female labor participation rate than other Asian countries. Since female workers have a relatively higher productivity in the urban personal service sector than in the agricultural sector, the flow of rural female labor to personal services could be a potential source of high labor productivity growth in the personal service sector of China.

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7 Tables and Figures

Country	Year	GDP/Capita Growth %	Service/GDP VA% Growth	Service/GDP EMP% Growth
Taiwan	1962	7.41	0.12	0.55
China	1993	6.78	0.86	0.85
India	1996	6.64	0.18	0.27
Japan	1950	6.47	0.41	0.64
Korea	1966	6.47	0.15	0.20
Brazil	1955	4.00	0.08	0.53
Thailand	1977	3.98	0.40	0.42
Indonesia	1989	3.18	-0.05	0.87
Colombia	1950	1.00	0.00	0.36

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

Source: *Penn World Table 7.1* and *GGDC 10-sector Productivity Database ver. 2007*.
Year: the first year when the country reached $2,000 per capita income level.

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

Parameter	Target
$\theta_a = 0.148$, $\theta_m = 0.596$, $\theta_{ds} = 0.531$, $\theta_{ps} = 0.576$	Average sectoral capital share
$\gamma_a = 0.001$, $\gamma_m = 0.056$, $\gamma_{ds} = 0.001$, $\gamma_{ps} = 0.036$	Average sectoral TFP growth rate
$\mu_a = 0.376$, $\mu_{ds} = 0.998$, $\mu_{ps} = 0.231$	Average labor productivity ratio
$g = 0.01$	Employment growth rate
$\bar{a} = 0.779$	Initial agricultural employment share
$k(0) = 566.3$	Slope of agricultural employment share
$\eta = 0.105$	Mean of L_m/L_{ds}
$\epsilon = 0.610$	Slope of L_m/L_{ds}
$\nu = 0.019$	Mean of L_{ps}/L_h
$\zeta = 2.432$	Slope of L_{ps}/L_h
$\phi = 0.761$	Mean of personal service employment share
$\rho = 1.635$	Slope of personal service employment share

Table 3: Parameter Values

	Change of percentage points				
	Benchmark	No Income Effect	$\epsilon = 1$	$\zeta = 1$	$\rho = 1$
$\triangle L_s$	0.221	0.101 (-54%)	0.168 (-24%)	0.112 (-49%)	0.295 (33%)
$\triangle L_{ds}$	0.091	0.034 (-63%)	0.035 (-62%)	0.112 (23%)	0.024 (-74%)
$\triangle L_{ps}$	0.130	0.067 (-48%)	0.132 (2%)	0.001 (-99%)	0.272 (109%)
$\triangle L_m$	0.063	-0.052 (-183%)	0.142 (125%)	0.103 (63%)	0.005 (-92%)
$\triangle L_a$	0.284	0.049 (-83%)	0.31 (9%)	0.215 (-24%)	0.301 (6%)

Table 4: Counterfactual: Income Effect and Elasticity of Substitution

	Change of percentage points				
	Benchmark	$\gamma_{ds} = \gamma_m$	$\theta_{ds} = \theta_m$	$\gamma_{ps} = 0$	$\theta_{ps} = 0$
$\triangle L_s$	0.221	0.186 (-16%)	0.210 (-5%)	0.154 (-30%)	0.115 (-48%)
$\triangle L_{ds}$	0.091	0.062 (-32%)	0.075 (-18%)	0.104 (14%)	0.112 (23%)
$\triangle L_{ps}$	0.130	0.124 (-5%)	0.136 (5%)	0.050 (-62%)	0.003 (-98%)
$\triangle L_m$	0.063	0.136 (116%)	0.099 (57%)	0.090 (43%)	0.104 (65%)
$\triangle L_a$	0.284	0.322 (13%)	0.310 (9%)	0.244 (-14%)	0.219 (-23%)

Table 5: Counterfactual: Sector-biased Productivity Growth and Capital Deepening

	Change of percentage points			
	Benchmark	$\mu_a(t) = \mu_a(0)$	$\mu_{ds}(t) = \mu_{ds}(0)$	$\mu_{ps}(t) = \mu_{ps}(0)$
$\triangle L_s$	0.221	0.223 (1%)	0.197 (-11%)	0.185 (-16%)
$\triangle L_{ds}$	0.091	0.092 (1%)	0.054 (-41%)	0.129 (42%)
$\triangle L_{ps}$	0.130	0.130 (0%)	0.142 (9%)	0.056 (-57%)
$\triangle L_m$	0.063	0.068 (8%)	0.071 (13%)	0.141 (124%)
$\triangle L_a$	0.284	0.29 (2%)	0.268 (-6%)	0.326 (15%)

Table 6: Counterfactual: Intersectoral Wage Gaps

	Annual Growth Rate		θ_{ps}	μ_{ps}	Sample Period
	Y_{ps}/L_{ps}	γ_{ps}			
China	0.029	0.03	0.576	0.24	1978–2007
Korea	0.025	-0.02	0.362	0.34	1970–2007
Japan	0.004	-0.001	0.411	0.43	1955-2007

Table 7: Personal Service Comparison for China, Japan, and Korea

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 8: Education Level of Employee in the Service Sector in Year 2000

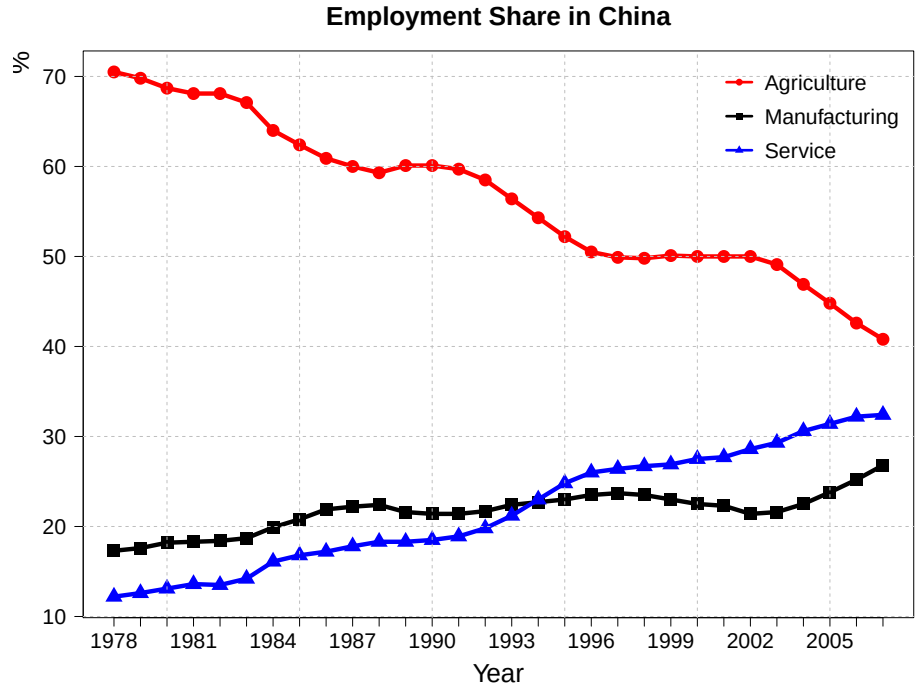

Figure 1: Employment Share by Sector: 1978-2007

Source: Various issues of *China Statistical Yearbook*. Necessary adjustment is made by the author. See Appendix A.1.

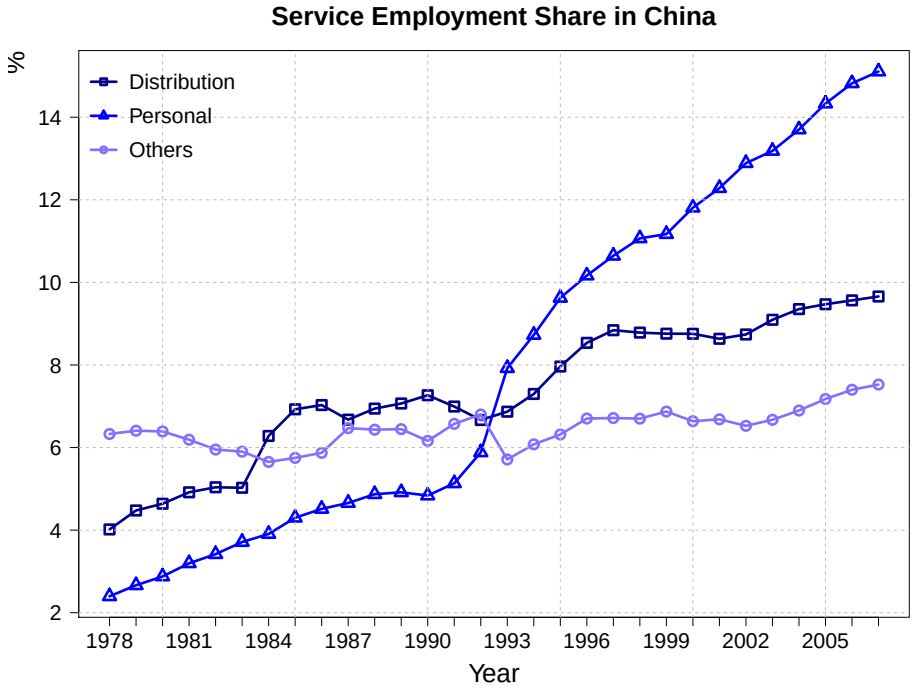

Figure 2: Disaggregation of Service Employment Share

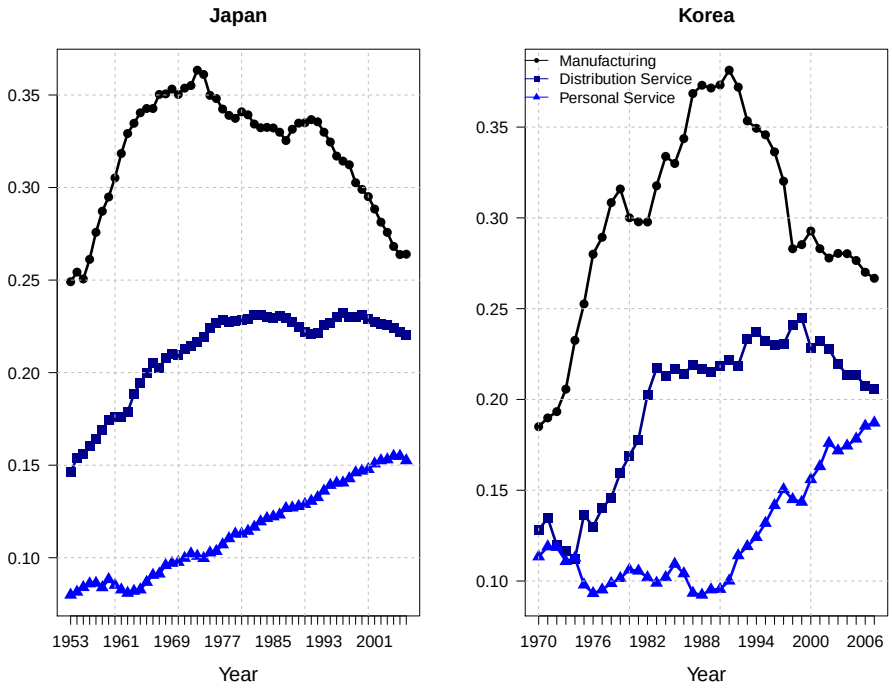

Figure 3: Rise of Service in Japan and Korea

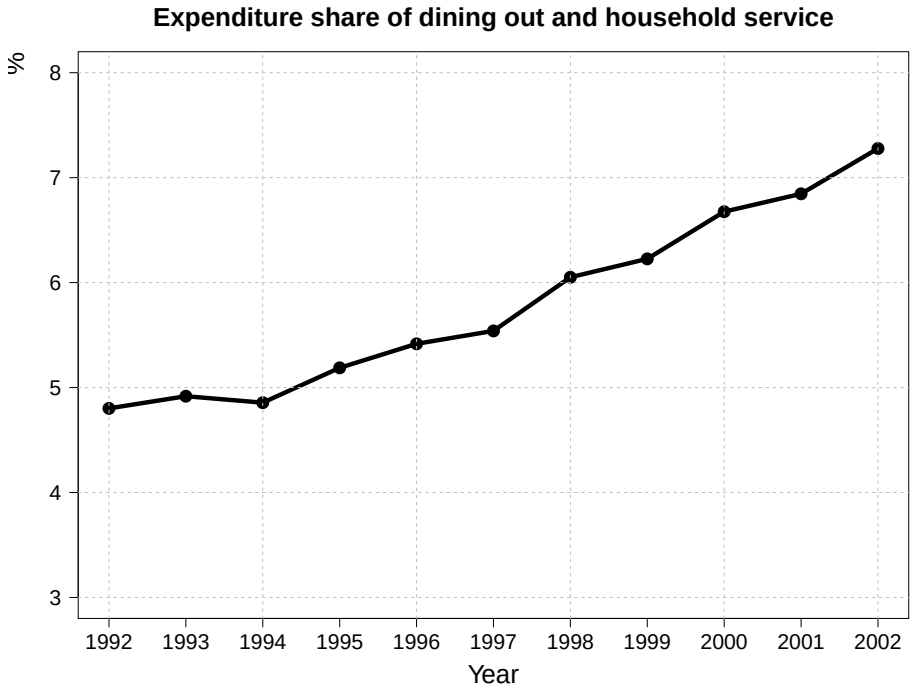

Figure 4: Change in Consumer Preference

Source: various issues of *China Statistical Yearbooks.*

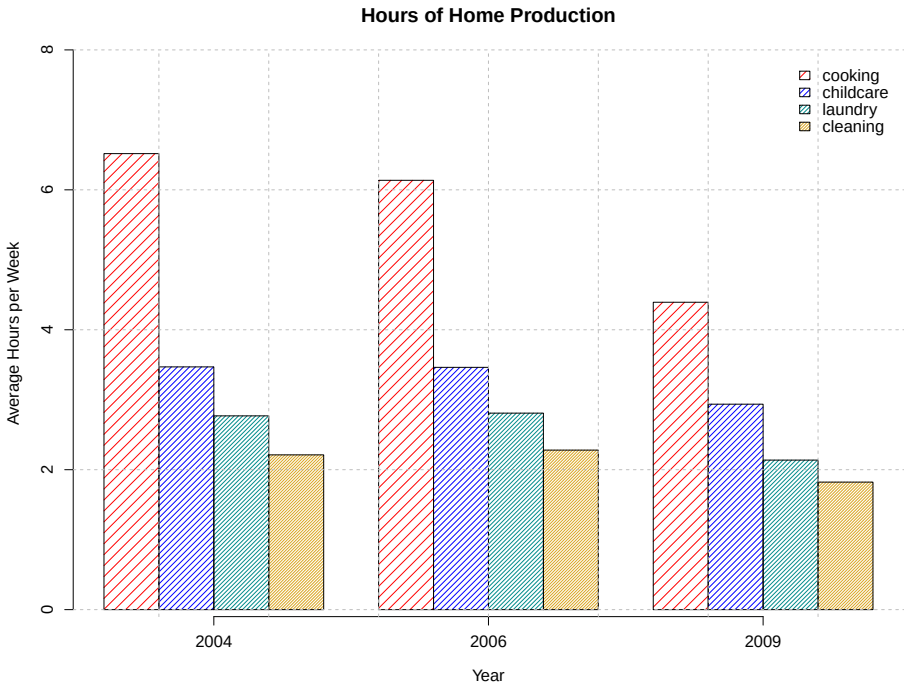

Figure 5: Change in Hours of Home Production

Source: China Health and Nutrition Survey.

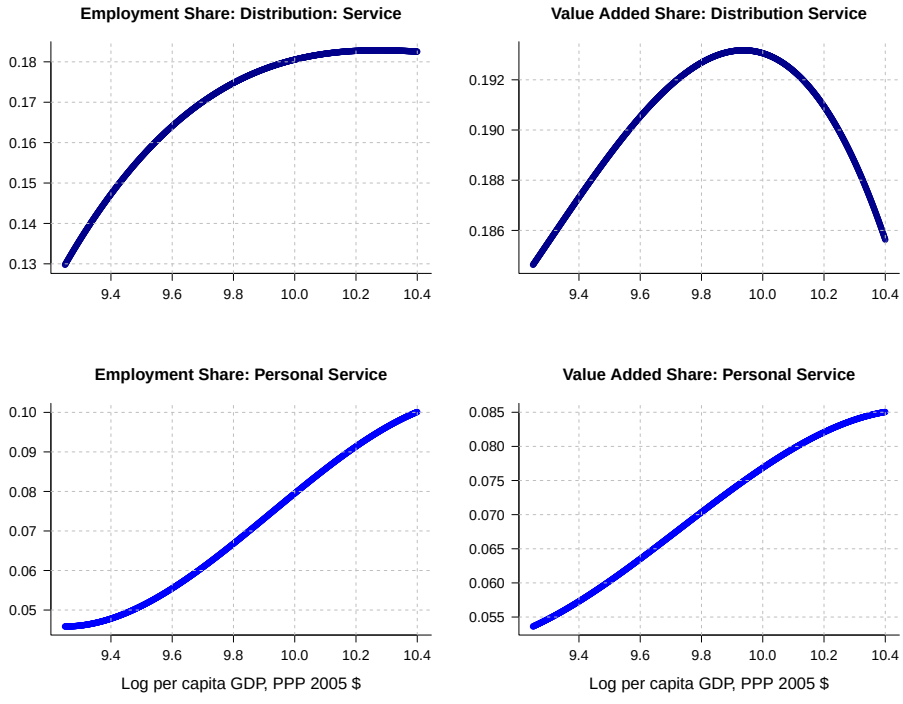

Figure 6: Estimated Distribution Services And Personal Services in EU15+U.S.

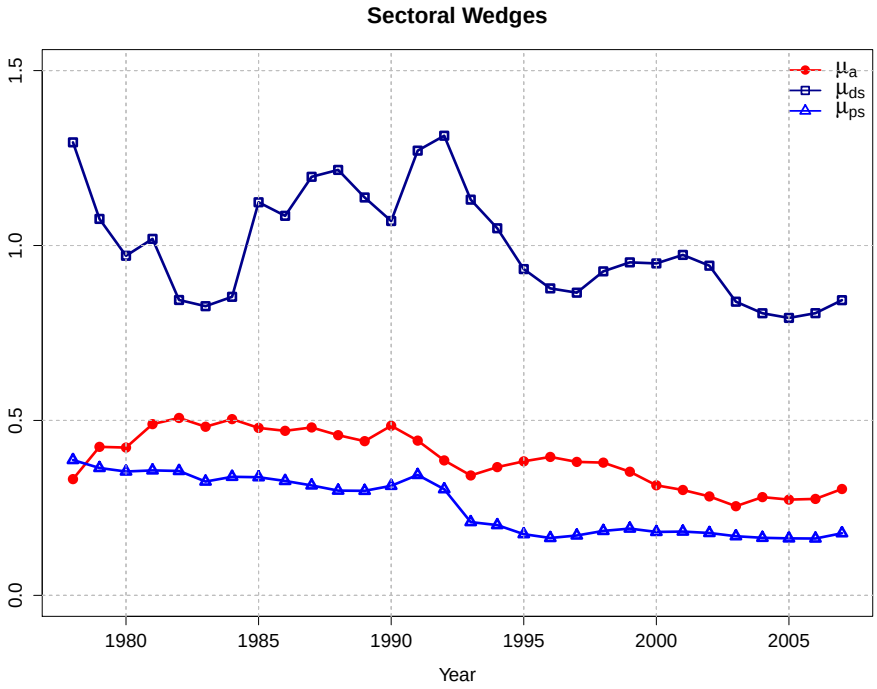

Figure 7: Wedges across Sectors in China

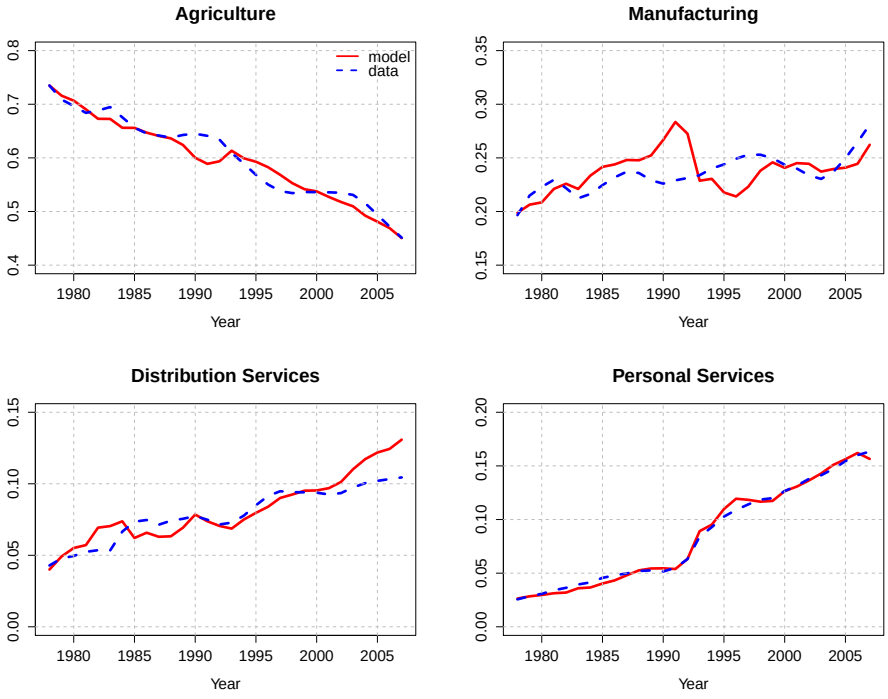

Figure 8: Sectoral Employment Share of China

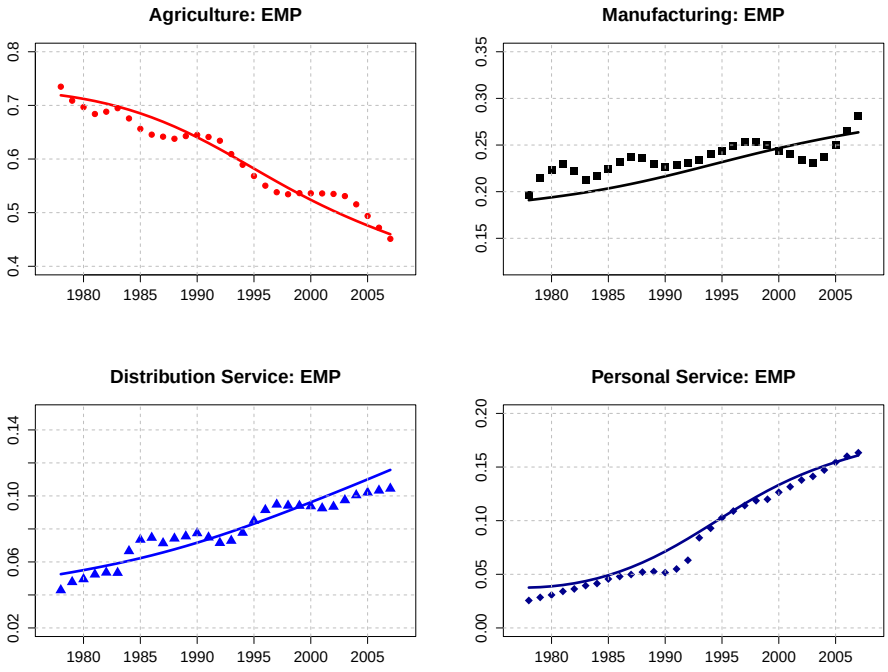

Figure 9: Sectoral Employment Share of China: Constant μ_j

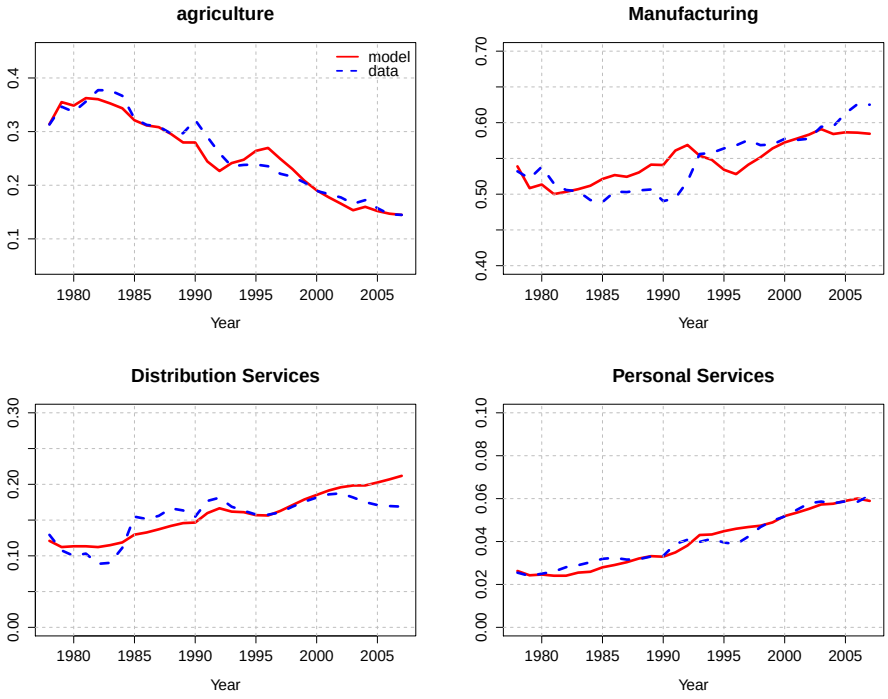

Figure 10: Sectoral Value Added Share of China

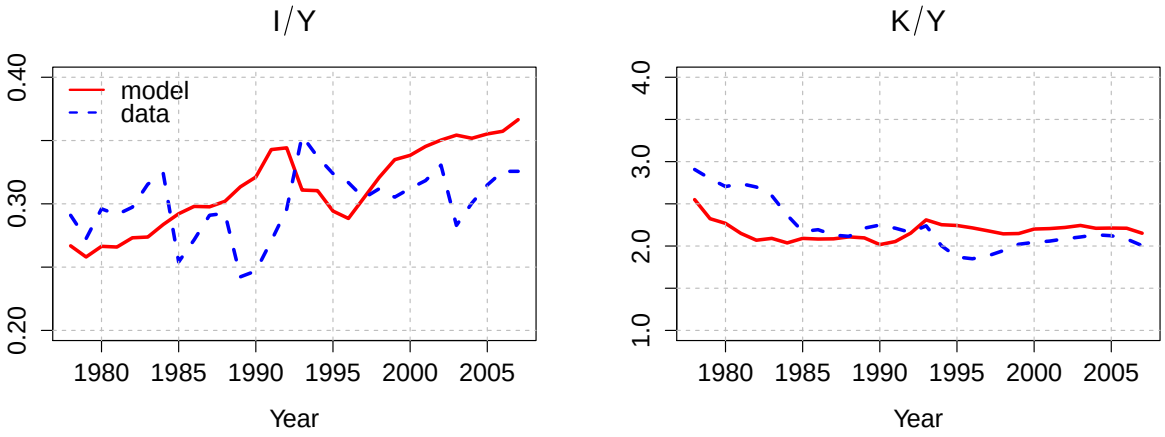

Figure 11: Capital Dynamics

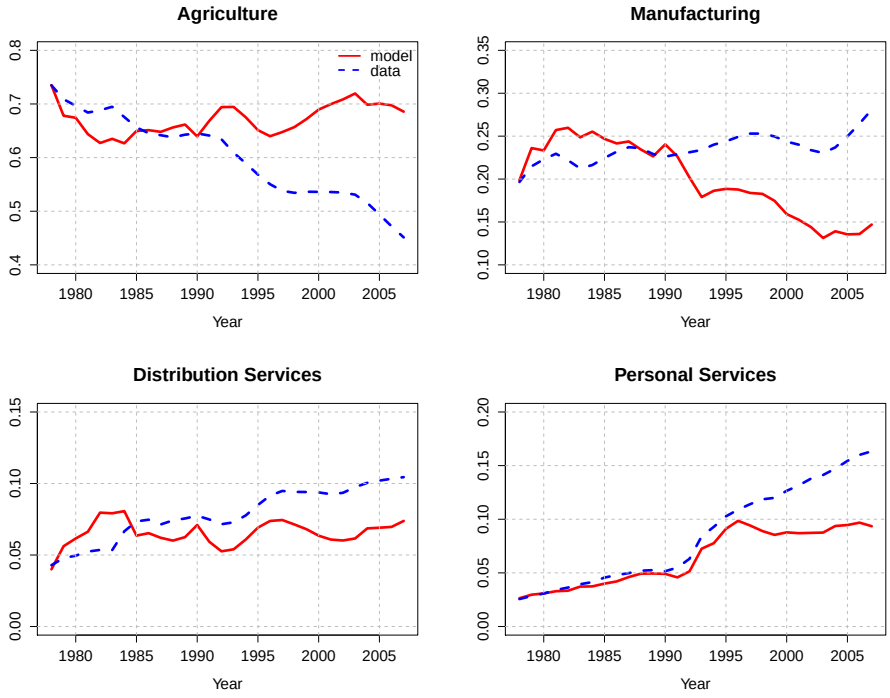

Figure 12: Counterfactual: Constant Expenditure Share of Agricultural Goods

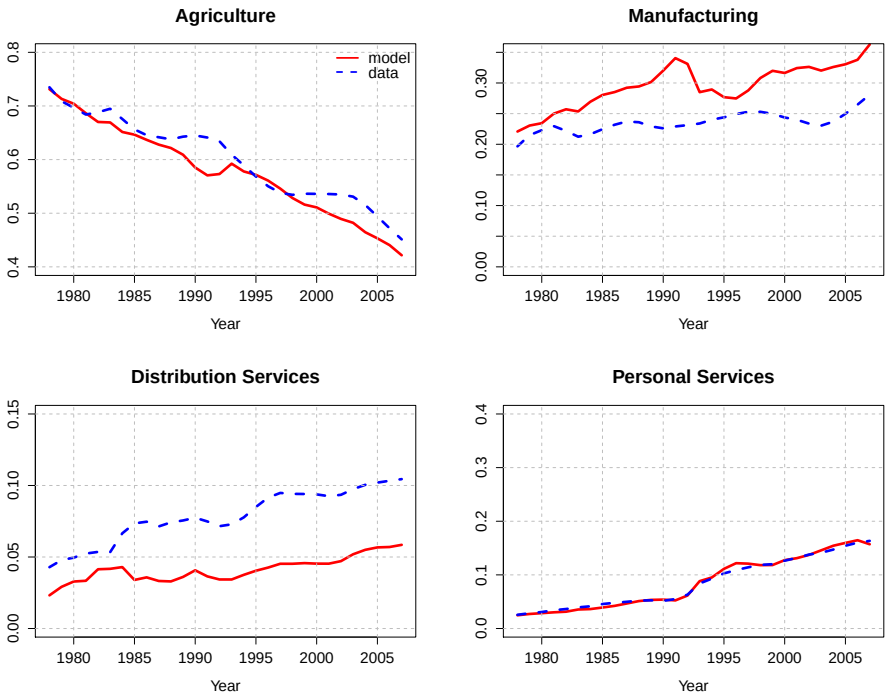

Figure 13: Counterfactual: $\epsilon = 1$

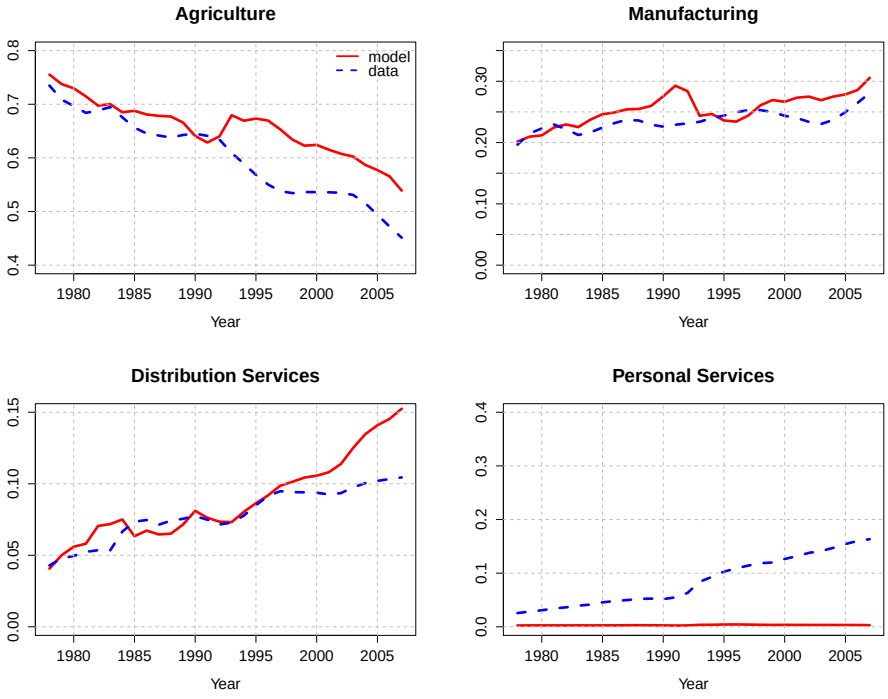

Figure 14: Counterfactual: $\zeta = 1$

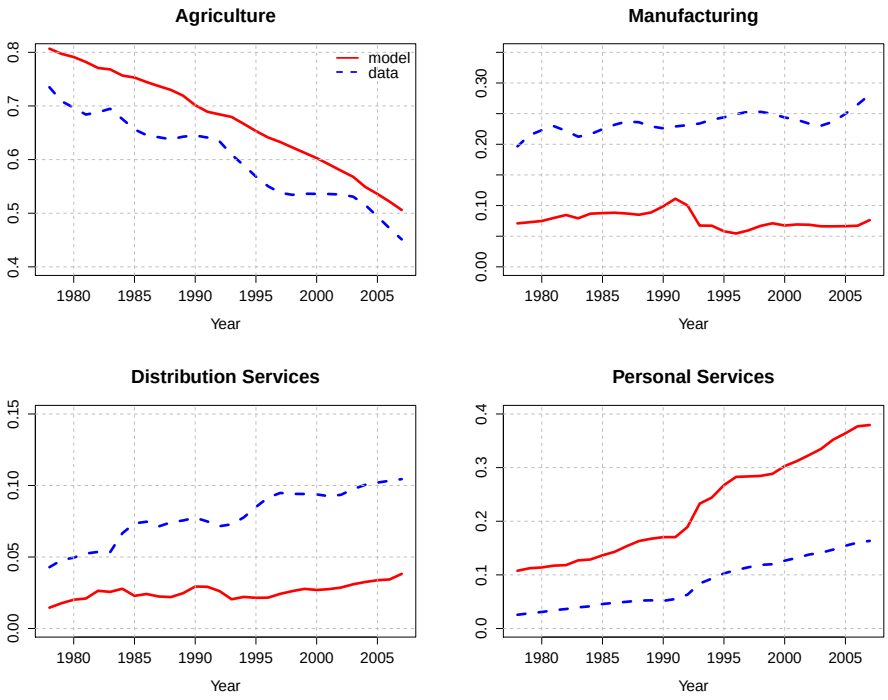

Figure 15: Counterfactual: $\rho = 1$

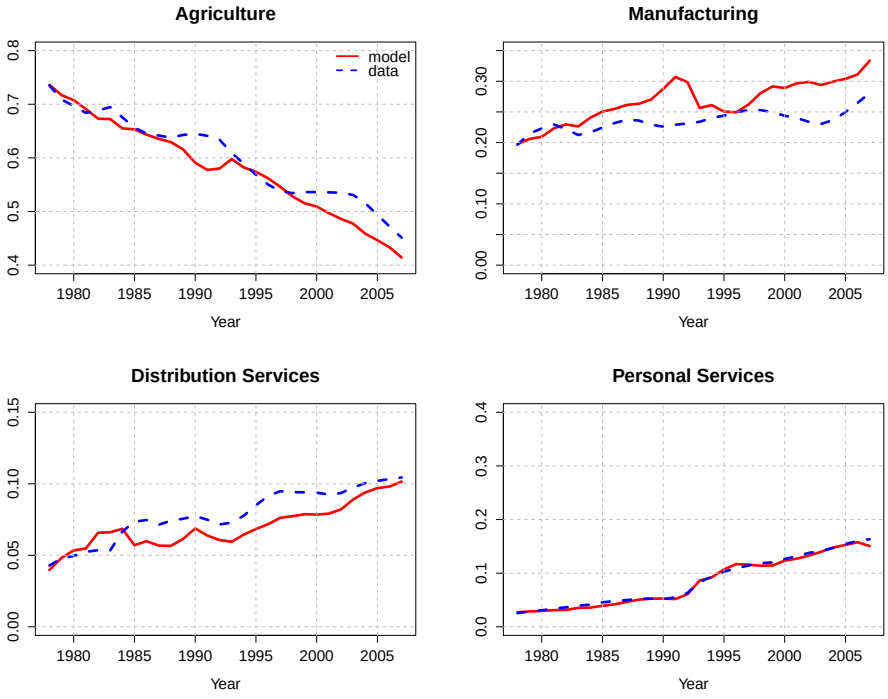

Figure 16: Counterfactual: $\gamma_{ds} = \gamma_m$

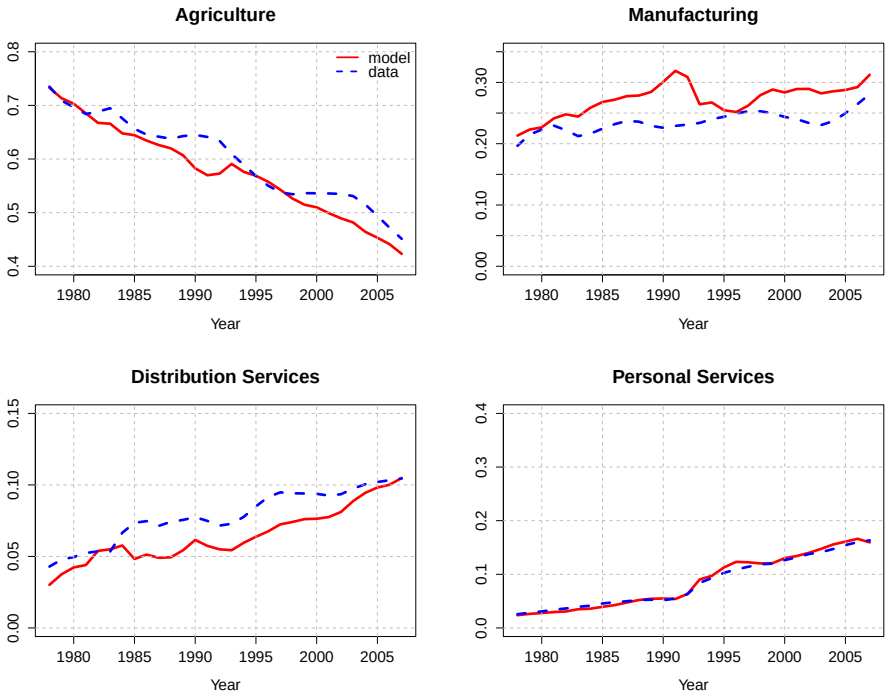

Figure 17: Counterfactual: $\theta_{ds} = \theta_m$

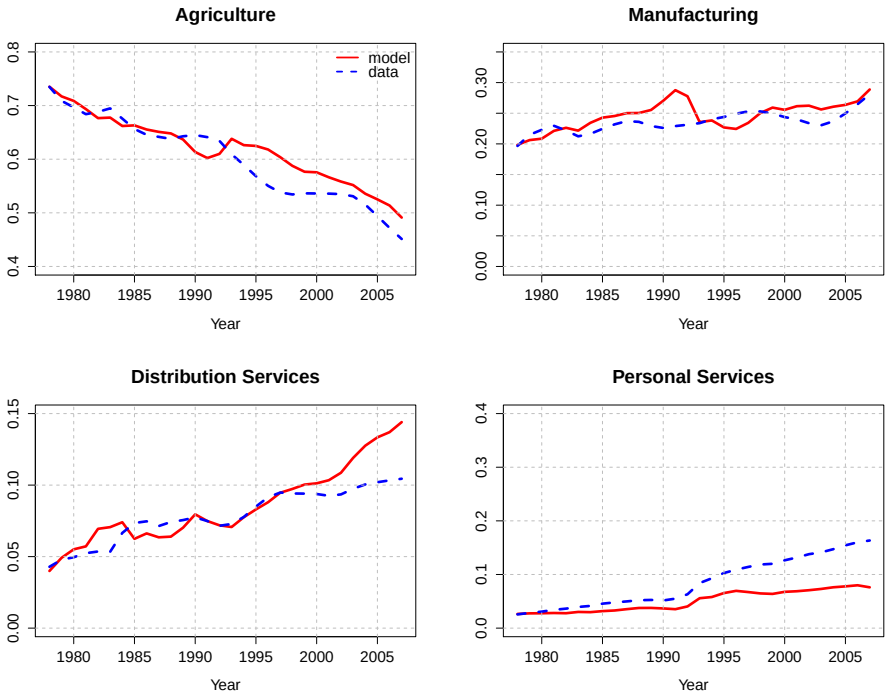

Figure 18: Counterfactual: $\gamma_{ps} = 0$

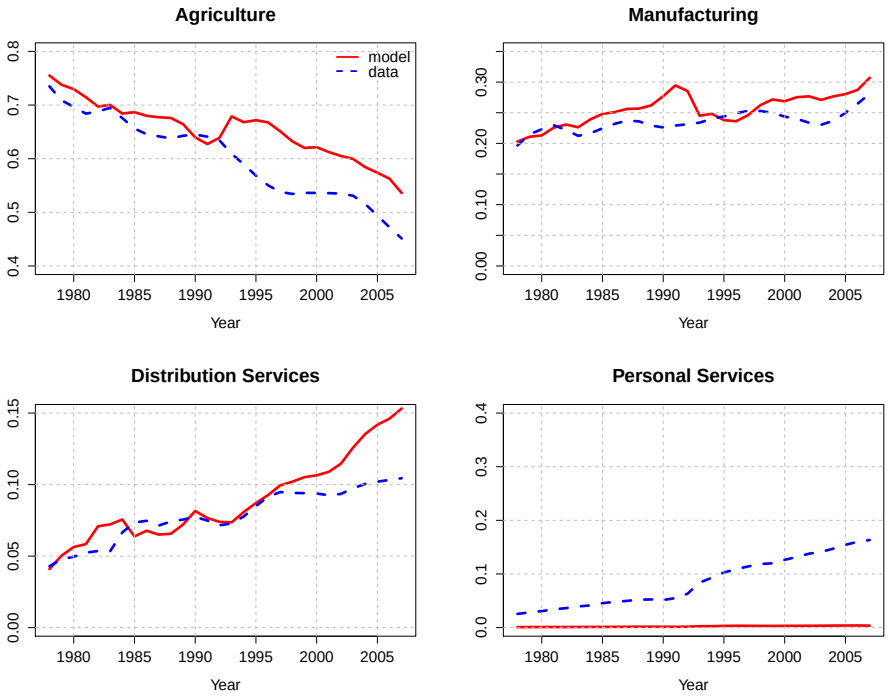

Figure 19: Counterfactual: $\theta_{ps} = 0$

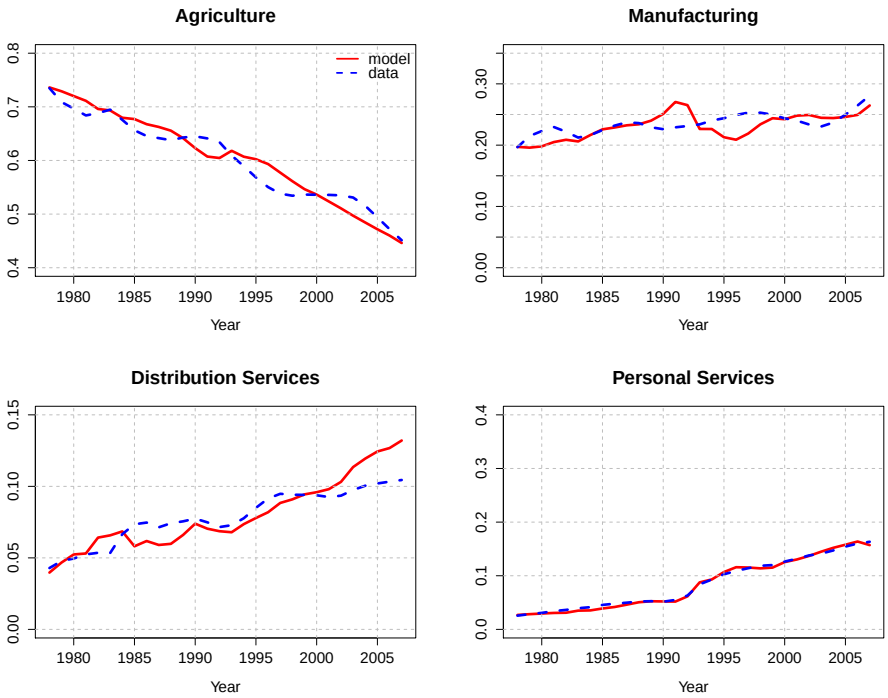

Figure 20: Counterfactual: $\mu_a(t) = \mu_a(0)$

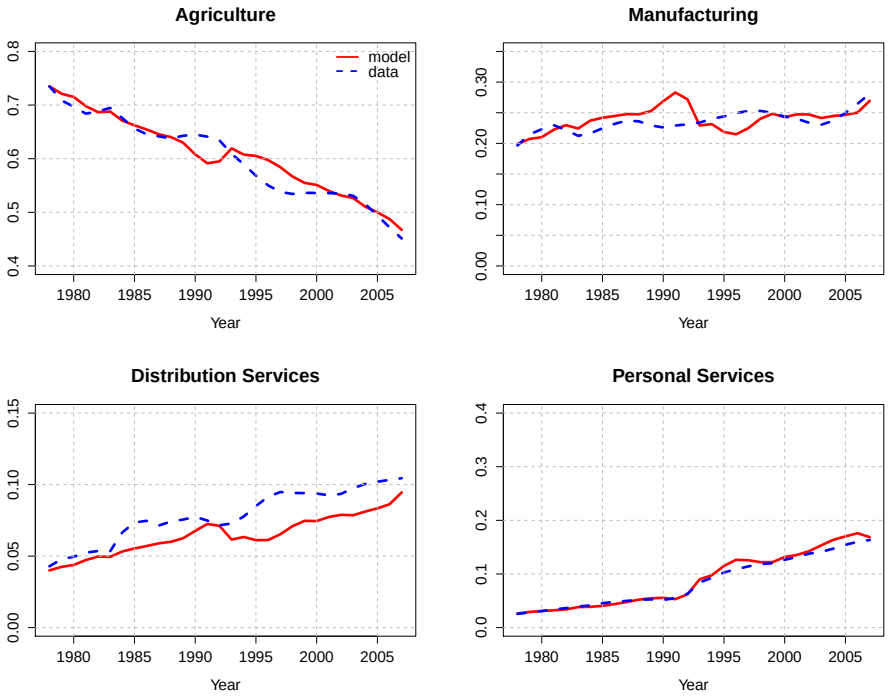

Figure 21: Counterfactual: $\mu_{ds}(t) = \mu_{ds}(0)$

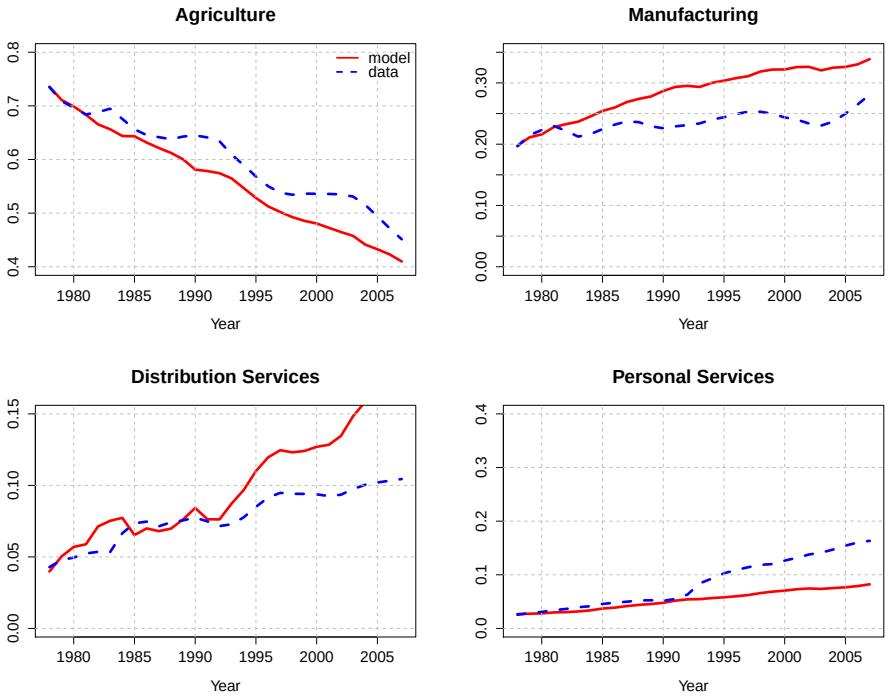

Figure 22: Counterfactual: $\mu_{ps}(t) = \mu_{ps}(0)$

A Data Description

A.1 China

A.1.1 Macro Data

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.[27] 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.[28] 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).[29] 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.[30] Then the constant-price value added data are calculated based on

[27] The data contains agricultural service after 2002.
[28] See Holz (2006), Brandt and Zhu (2010) and Wu (2011).
[29] See RIETI CIP2011.
[30] Historical data have been adjusted and updated by NBS after several national economic census.

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.

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 $\delta = 0.05$:

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

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.1.2 Micro Data

To be continued.

A.2 Other Countries

GDP per capita data is collected from *PWT 7.1*.[31] 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, June 2007(Timmer and de Vries (2007))*
- *World Development Indicators (World Bank)*
- *UN National Accounts*
- *EU KLEMS Database (*Mary OMahony and Marcel Timmer (2009)*)*

B Additional Evidence

B.1 Structural Break Test of Service Employment Share

In this section we apply Quandt-Andrews structural break test (Andrews (1993)) to the service employment share of China. The test is based on the following regression:

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

Figure 23 shows the graph for Quandt-Andrews structural break test F statistics with 15% trimmed data. The test rejects the null hypothesis that there are no breakpoints in

[31] See Heston, Summers and Aten (Nov 2012).

the sample period at a 1 percent significant level. This result is also robust for linear regressions on service share with time t. We identify the year 1993 as the break point (if assuming single break point), which is consistent with the takeoff time of the personal services.

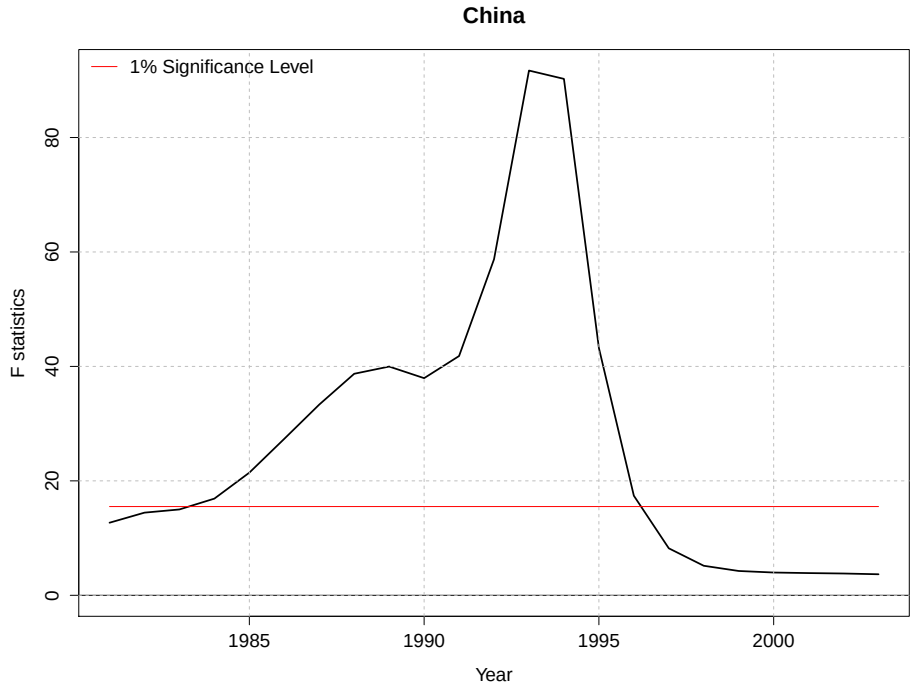

Figure 23: Quandt-Andrews Structural Break Test: LR F-Statistic, 15% Trimmed Data