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The rise of the service sector in China

Junmin Liao*

Center for Economic Development Research, Wuhan University, Wuhan, Hubei 430072, 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. Empirics show that the personal service sector is the key to account for the early and rapid rise of the service sector in China. Quantitatively, 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.

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 markets. 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. 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

* Corresponding author.
E-mail address: liaojunmin@whu.edu.cn.

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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 distribution 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 contributes to the literature in two aspects: Firstly, most research on the rise of the service economy, focuses on the growth of the service sector at a later stage following a high level of per capita income. This paper, on the other hand, looks at the growth of services at an earlier stage when per capita income is low. It is particularly meaningful to look at this early stage, because it is what many emerging economies are currently experiencing, so the study of China's case offers a useful and important lesson. Secondly, this paper departs from most literature by studying the service sector at the disaggregate level, instead of the aggregate level. Such disaggregation is necessary, because different service components show very different trends in their growth. This is why traditional structural change theories based on aggregate service data often fail: anyone is bound to get a poor fit if two distinctive series are mingled together. This paper shows that to study China's service sector we have to look at the disaggregate level.

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 (2012a, 2012b) 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 (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

[1] See the discussion in Section 2.2.

[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.

Table 1
The rise of the service sector in emerging markets.

Region	Year	GDP/Capita	Service/GDP	Service/GDP
		Growth %	VA% Growth	EMP% Growth
Taiwan, China	1962	7.41	0.12	0.55
Mainland 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

Source: Penn World Table 7.1 and GGDC 10-sector Productivity Database ver. 2007.

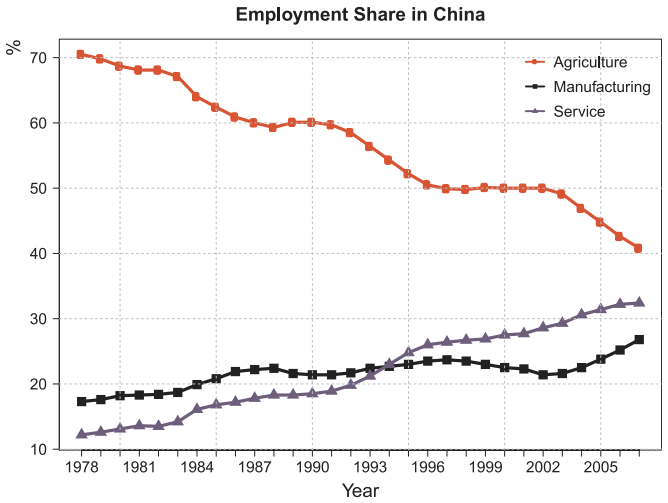

Fig. 1. Employment share by sector: 1978–2007.
Source: Various issues of *China Statistical Yearbook*. Necessary adjustment is made by the author. See Appendix A.1.

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.

Year: the first year when the country reached $2,000 per capita income level.

How has China distinguishes itself from other emerging economies? Fig. 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]

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. 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.

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

[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.

Table 2
Disaggregation of the service sector.

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

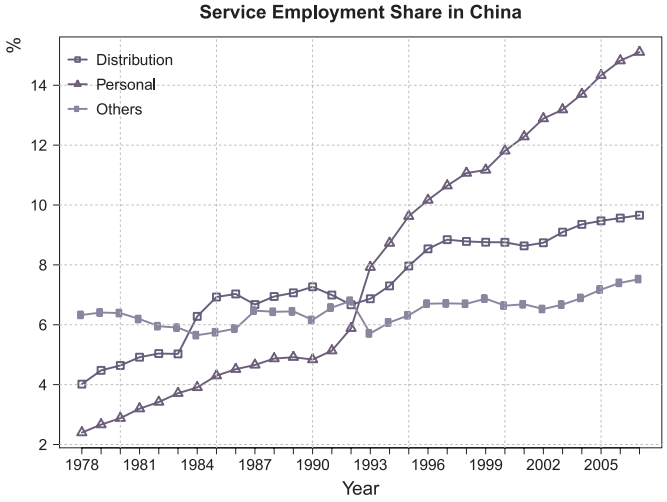

Fig. 2. Disaggregation of service employment share.

Fig. 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 Fig. 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.

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. Fig. 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.

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,

[5] See Ngai and Pissarides (2007); Acemoglu and Guerrieri (2080).
[6] See Matsuyama (1992), Echevarria (1997), Laitner (2000), Kongsamut et al. (2001), Caselli and Coleman II (2001), Gollin et al. (2002), and Wang and Xie (2004).

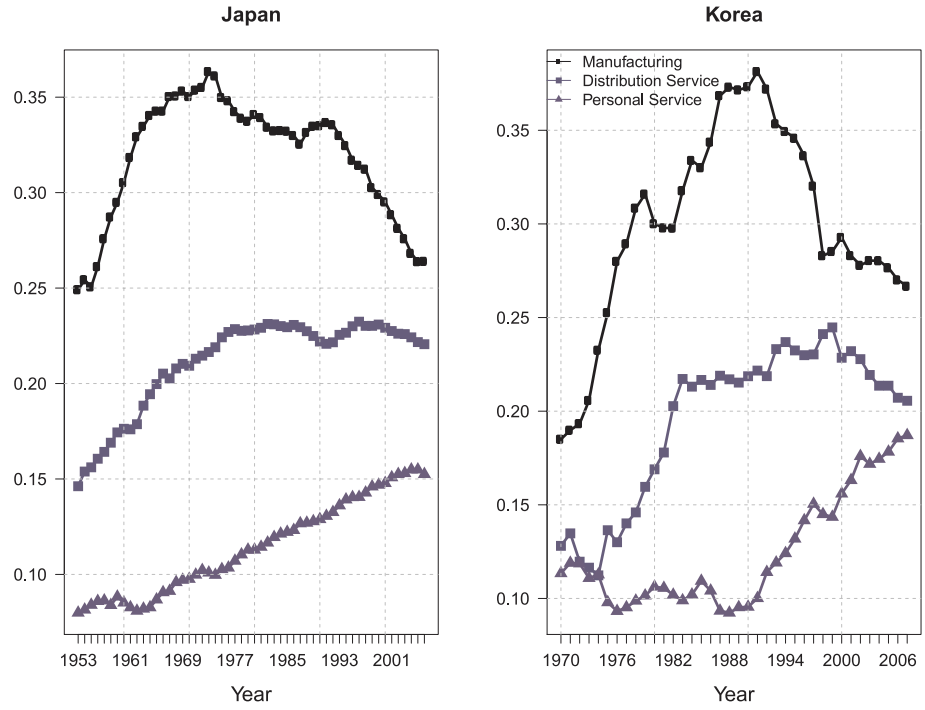

Fig. 3. Rise of service in Japan and Korea.

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 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. Fig. 4 shows this change of consumer preferences.

On the other hand, higher income also accompanies lower home production working 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 Fig. 5).[10]

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:

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

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

[9] See Katouzian (1970); Eichengreen and Gupta (2013).

[10] See Wang (forthcoming) for similar results.

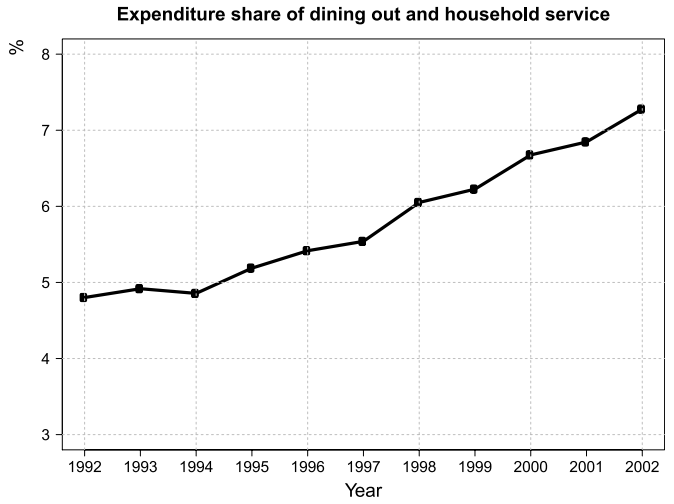

Fig. 4. Change in consumer preference.
Source: various issues of *China Statistical Yearbooks*.

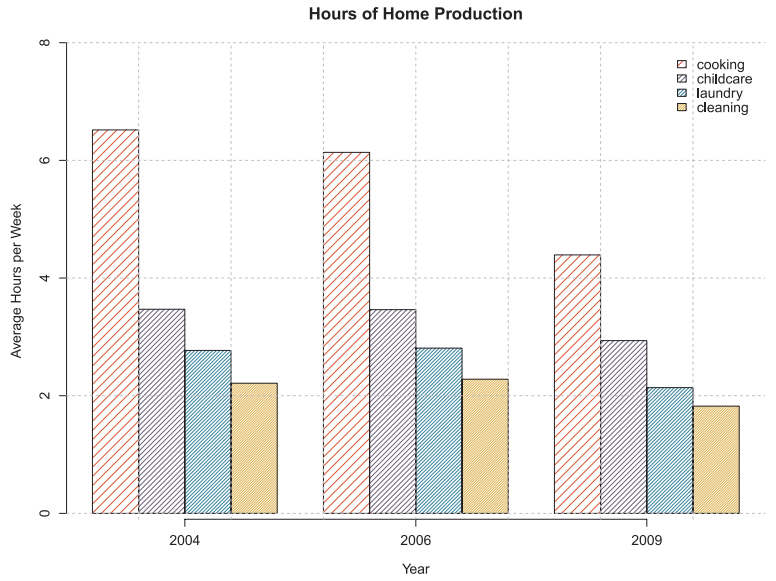

Fig. 5. Change in hours of home production.
Source: China Health and Nutrition Survey.

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

where D_i is the country dummy and y_i is log per capita GDP (PPP 2005 $) for country i. Fig. 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.

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.

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

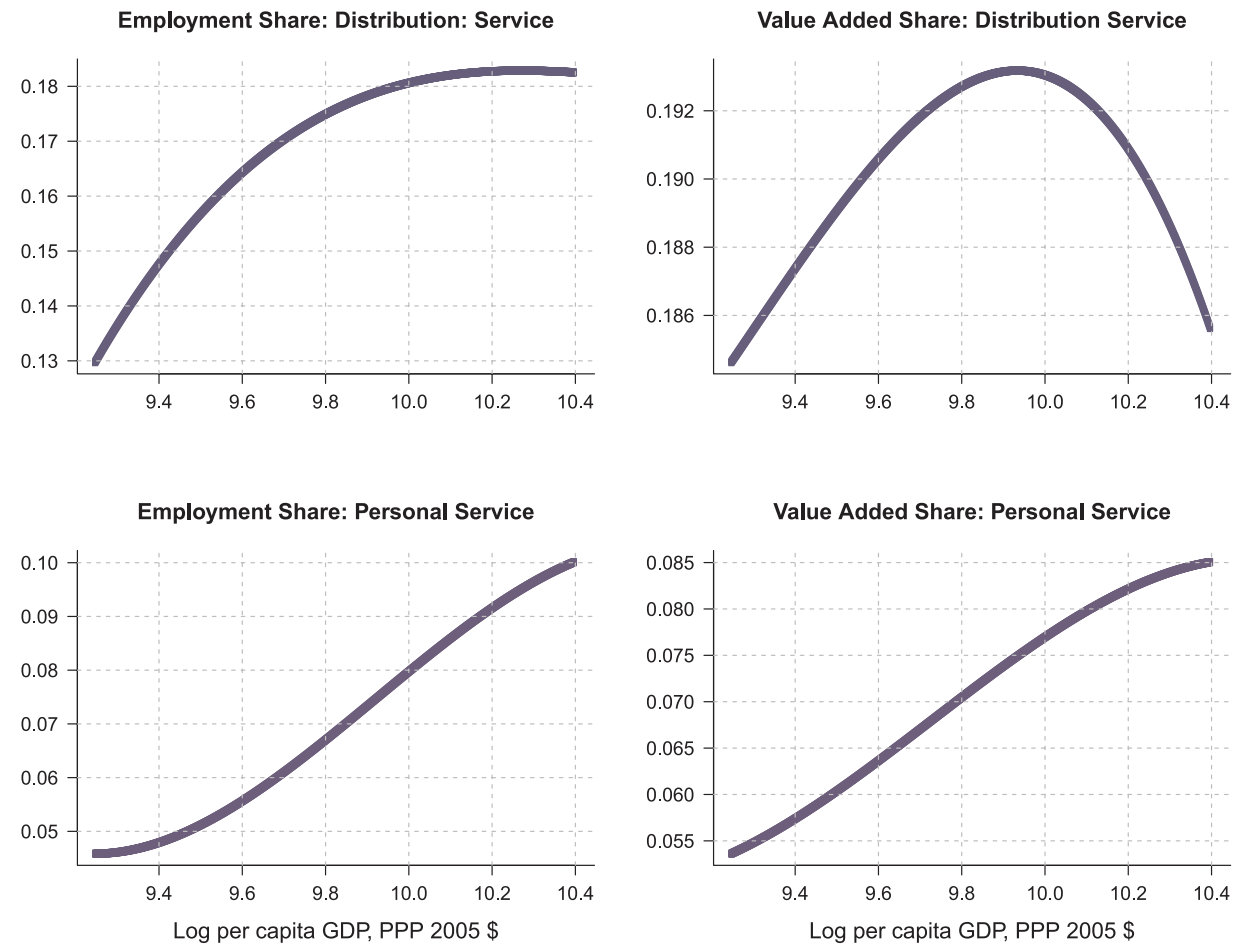

Fig. 6. Estimated distribution services and personal services in EU15 + U.S.

3. The model

3.1. An analytical illustration

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

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). 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) we use Stone-Geary type preference which features a subsistence level of agricultural goods as in Gollin, Parente, and Rogerson (2002) to capture the decline in the agricultural sector; 2) we 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 et al. (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.

3.1.1. Technology

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

$$Y_a(t) = A_a(t)L_a(t),$$

$$Y_m(t) = A_m(t)L_m(t),$$

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

The service sector is disaggregated into two subsectors: 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. The production functions of distribution services Y_{ds} and personal services Y_{ps} are

$$Y_{ds}(t) = A_{ds}(t)L_{ds}(t),$$

$$Y_{ps}(t) = A_{ps}(t)L_{ps}(t).$$

We also assume there is a non-market sector (people can work at home) which produces home goods with constant labor productivity over time:

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

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

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

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

Households also consume a composite service Y_s which are produced from personal services Y_{ps} and home production Y_h:

$$Y_s(t) = \left[\nu Y_{ps}(t)^{\frac{\zeta-1}{\zeta}} + (1-\nu)Y_h(t)^{\frac{\zeta-1}{\zeta}}\right]^{\frac{\zeta}{\zeta-1}},$$

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

The sector-specific labor productivity $A_j(t)$ for the market sectors $\{a,m,ds,ps\}$ grows exogenously at a constant rate:

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

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

Labor can move freely across sectors. Therefore the wage rate is the same for all sectors. At each date t, given p_j (the price of good Y_j, $j \in \{a,m,ds,ps,h\}$), 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 problems for the final goods and services are

$$\max_{Y_m(t),Y_{ds}(t)\geq 0} \{Y_g(t) - p_m(t)Y_m(t) - p_{ds}(t)Y_{ds}(t)\}, \tag{3}$$

$$\max_{Y_{ps}(t),Y_h(t)\geq 0} \{Y_s(t) - p_{ps}(t)Y_{ps}(t) - p_h(t)Y_h(t)\}. \tag{4}$$

3.1.2. 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_g, and composite services C_s. 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_g and C_s.[12] The period utility function is given by

$$U\{C_a(t), C_g(t), C_s(t)\} = \begin{cases} C_a(t), & \text{if } C_a(t) < \bar{a} \\ \bar{a} + (1-\phi)\ln C_g(t) + \phi \ln C_s(t), & \text{if } C_a(t) \geq \bar{a} \end{cases}, \tag{5}$$

where $\phi \in (0,1)$ is a utility weight, and $\bar{a} > 0$ is the subsistence parameter of agricultural consumption. We assume that the agricultural productivity is high enough ($A_a(0) \geq \bar{a}$) to make the economy operate above the subsistence level ($C_a(t) \geq \bar{a}$). Then as a result of the introduction of the subsistence level, the agricultural expenditure share decreases as income increases, which is consistent with the evidence described by Engel's law.

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

[12] This simplified specification of utility function for agricultural goods can be seen in Gollin, Stephen Parente and Richard Rogerson (2002). See Appendix C.1 for more details.

$$\max_{C_a,C_g,C_s} \sum_{t=0}^{\infty} \beta^t U\{C_a(t), C_g(t), C_s(t)\}, \tag{6}$$

subject to

$$p_a(t)C_a(t) + p_g(t)C_g(t) + p_s(t)C_s(t) = w(t)L(t),$$

where $0 < \beta < 1$ is the discount factor and p_g is the price of the final good Y_g.

This model has a unique competitive equilibrium.[13] Without capital there are no intertemporal decisions thus we only have to solve static problems in each period. We start to characterize the model with the relative prices and consumption, and focus on the sectoral allocation of employment.

3.1.3. 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 we only focus on the employment share. Goods Market clearing conditions give the labor allocation result:

$$L_a(t) = \frac{\bar{a}}{A_a(t)}, \tag{7}$$

$$\frac{L_m(t)}{L_{ds}(t)} = \left(\frac{1-\eta}{\eta}\right)^{\varepsilon} \left[\frac{A_{ds}(t)}{A_m(t)}\right]^{1-\varepsilon}, \tag{8}$$

$$\frac{L_{ps}(t)}{L_h(t)} = \left(\frac{\nu}{1-\nu}\right)^{\zeta} \left[\frac{A_h}{A_{ps}(t)}\right]^{1-\zeta}. \tag{9}$$

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 (7) we can see $\frac{\partial L_a}{\partial A_a} < 0$. The increase of agricultural productivity pushes labor out of the agricultural sector.

From (8) and (9) we can see that if the elasticity of substitutions (ε and ζ) 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 ($\varepsilon < 1$), 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 more personal services from the market.

With labor market clearing conditions, L_m, L_{ds}, L_{ps} and L_h can be solved:

$$\begin{aligned}
L_{ds}(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\eta}{\eta}\right)^{\varepsilon}\left[\frac{A_{ds}(t)}{A_m(t)}\right]^{1-\varepsilon}}, \\
L_m(t) &= \frac{(1-\phi)\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\eta}{1-\eta}\right)^{\varepsilon}\left[\frac{A_m(t)}{A_{ds}(t)}\right]^{1-\varepsilon}}, \\
L_{ps}(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{1-\nu}{\nu}\right)^{\zeta}\left[\frac{A_{ps}(t)}{A_h}\right]^{1-\zeta}}, \\
L_h(t) &= \frac{\phi\left[1-\frac{\bar{a}}{A_a(t)}\right]}{1+\left(\frac{\nu}{1-\nu}\right)^{\zeta}\left[\frac{A_h}{A_{ps}(t)}\right]^{1-\zeta}}.
\end{aligned} \tag{10}$$

In Section 2 we have shown that personal services usually take off later (see Figs. 2, 3 and 6 for the evidence from China, Japan, Korea and OECD countries). Traditional structural change model cannot quantitatively match the data because 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. By incorporate the substitution between market services and home production, this model can account for a large and late rise of services. Specifically, Equation (10) 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 $\zeta > 1$. Mathematically, ν regulates the timing when the personal services take off (maximum growth rate). 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. *Structural change in labor allocation*

[13] See Appendix C.2 for the equilibrium details.

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. When $\varepsilon < 1$, $\frac{\partial L_m / L_{ds}}{\partial A_m / A_{ds}} < 0$.
When $\zeta > 1$, $\frac{\partial L_{ps}}{\partial A_{ps}} > 0$.

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 (Engel's law). Second, if manufacturing goods (Y_m) and distribution services (Y_{ds}) are complements (with the elasticity of substitution ε less than one), then the manufacturing sector will shrink in terms of employment share (since its TFP grows faster than that of the distribution services), and the distribution service sector will expand. Third, if personal services (Y_{ps}) and home goods (Y_h) are substitutes (with the elasticity of substitution ζ larger than one), then the personal services will expand as its productivity grows.

3.2. The quantitative model

In Section 3.1, the model gives a sequence of static allocation which cannot fully capture the dynamics of capital accumulation. Meanwhile, the assumption that labor can move freely across sectors (same wage across sectors) is not realistic. This section builds a model with capital and wage gap across sectors which is better suited to assessing the quantitative implications. Moreover, this full-fledged model allows for non-unitary elasticity of substitution between the final goods C_g and composite services C_s. The differences from the simple model are emphasized below. If not mentioned, all other specifications of the model are the same as in Section 3.1.

3.2.1. Technologies

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

$$Y_j(t) = A_j(t) K_j(t)^{\theta_j} L_j(t)^{1-\theta_j}, \tag{11}$$

where θ_j is the physical capital income share in sector *j*, which can be different across sectors. $K_j(t)$ are capital inputs. Production of home goods Y_h is still assumed to be linear.

The final goods Y_g can be both consumed and invested. The aggregate capital stock satisfies:

$$K_a(t) + K_m(t) + K_{ds}(t) + K_{ps}(t) = K(t),$$
$$K(t+1) - (1-\delta)K(t) + C_g(t) \le Y_g(t),$$

where $\delta \in [0,1]$ 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

$$\max_{L_j(t), K_j(t) \ge 0} \{p_j(t) Y_j(t) - w_j(t) L_j(t) - r(t) K_j(t)\}. \tag{12}$$

3.2.2. Preferences

The period utility is a function of agricultural goods C_a, goods produced by the final goods sector C_g, and composite services C_s:

$$U\{C_a(t), C_g(t), C_s(t)\} = \begin{cases} C_a(t), & \text{if } C_a(t) < \bar{a} \\ \bar{a} + \ln\left[(1-\phi) C_g(t)^{\frac{\rho-1}{\rho}} + \phi C_s(t)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} & \text{if } C_a(t) \ge \bar{a} \end{cases}, \tag{13}$$

where $\rho > 0$ captures the elasticity of substitution between the final goods C_g and composite services C_s. $\phi \in (0,1)$.

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

$$\max_{C_a, C_g, C_s, X} \sum_{t=0}^{\infty} \beta^t U\{C_a(t), C_g(t), C_s(t)\}, \tag{14}$$

subject to

$$p_a(t) C_a(t) + p_g(t)(C_g(t) + X(t)) + p_s(t) C_s(t) = \sum_{j=a,m,ds,ps} (w_j(t) L_j(t) + r(t) K_j(t)) + w_h(t) L_h(t),$$

where $X(t)$ is the household saving for capital investment.

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

$$w_a(t) = \mu_a(t) w_m(t), \tag{15}$$

$$w_{ds}(t) = \mu_{ds}(t) w_m(t), \tag{16}$$

$$w_{ps}(t) = \mu_{ps}(t) w_m(t), \tag{17}$$

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 substitution of different sectoral goods. 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]

3.2.4. Labor allocation

This model has a unique competitive equilibrium.[18] Labor reallocation between the manufacturing sector and the distribution service sector follows

$$\frac{L_m(t)}{L_{ds}(t)} = \left(\mu_{ds}(t)\frac{1-\eta}{\eta}\frac{1-\theta_m}{1-\theta_{ds}}\right)^{\varepsilon}\left[\frac{A_{ds}(t)(K_{ds}(t)/L_{ds}(t))^{\theta_{ds}}}{A_m(t)(K_m(t)/L_m(t))^{\theta_m}}\right]^{1-\varepsilon}. \tag{18}$$

From (18) 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 & 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.

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

$$\frac{L_{ps}(t)}{L_h(t)} = \left[\frac{\nu}{1-\nu}(1-\theta_{ps})\right]^{\zeta}\left[\frac{A_{ps}(t)}{A_h}\left(\frac{K_{ps}(t)}{\mu_{ps}L_{ps}(t)}\right)^{\theta_{ps}}\right]^{\zeta-1}. \tag{19}$$

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. Data

This paper mainly uses official data and KLEMS China with necessary adjustment to conduct quantitative analyses. There are several issues with the official data of China, which has been discussed by the literature.[19] The known issues discussed in the

[14] See Section 5.1 for another explanation of heterogeneous 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. 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); Swięcki (2017).

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

[18] See Appendix (C.3) for the equilibrium details.

[19] See Young, 2003; Holz, 2006; Brandt & Zhu, 2010; Wu, 2011 among many others. 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.

Table 3
Parameter values.

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}
$\varepsilon = 0.610$	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

literature have been handled very carefully.[20] For example, 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. To fix this jump, we followed the literature to adjust the data prior to 1990. Another concern on the official aggregate GDP is the discrepancy between local and aggregate GDP. However, Chen, Hsieh, Chen, and Song (2019) suggest that the adjustments in the national GDP reported by the *National Bureau of Statistics of China* are roughly accurate before 2008.

4.2. Calibration

Each period in the model is assumed to be one year. The parameters that need to be calibrated are $\{\bar{a}, A_{j\in\{a,m,ds,ps,h\}}, \gamma_{j\in\{a,m,ds,ps\}}, \theta_{j\in\{a,m,ds,ps\}}, \eta, \varepsilon, \phi, \rho, \nu, \zeta, \beta, \delta, g\}$, the initial capital per worker $k(0) = \frac{K(0)}{L(0)}$ and wage gaps $\mu_{j\in\{a,ds,ps\}}(t)$. 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 results are summarized in Table 3.[21] $\theta_m = 0.596 > \theta_{ds} = 0.531$, which means the manufacturing sector is more capital intensive than the distribution service sector (but the difference is not large).

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.[22] Given $\theta_{j\in\{a,m,ds,ps\}}$ and (11), we use real value added, capital and employment for each sector to pin down TFP growth rate $\gamma_{j\in\{m,ds,ps\}}$ with growth accounting. Because in the model we assume that the households only consume $\bar{a}$, in equilibrium we have

$$\bar{a} = \frac{Y_a(t)}{L(t)} = A_{a0}(1+\gamma_a)^t \left(\frac{K_a(t)}{L(t)}\right)^{\theta_a} \left(\frac{L_a(t)}{L(t)}\right)^{1-\theta_a},$$

where L is total employment. Thus γ_a can be estimated from

$$\log\left[\left(\frac{K_a(t)}{L(t)}\right)^{\theta_a} \left(\frac{L_a(t)}{L(t)}\right)^{1-\theta_a}\right] = \text{constant} - [\log(1+\gamma_a)]\cdot t.$$

We have $\gamma_a = 0.001$, $\gamma_m = 0.056$, $\gamma_{ds} = 0.001$, $\gamma_{ps} = 0.036$.[23]

We use first order condition to back out labor market distortions.[24] Wage gaps $\mu_{j\in\{a,ds,ps\}}$ are calibrated based on (15)–(17).[25] Since wage is the marginal product of labor, the wage ratio is proportional to the ratio of average labor productivity (nominal output per worker):

[20] See Appendix A.1.

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

[22] With this normalization, the TFP growth rate can still be compared with data. Moreover, the elasticity parameters ε, ζ, ρ by definition are independent of units and their values will not be affected by the choice of units. See Rogerson (2008); Duarte and Restuccia (2010) for similar treatments.

[23] The agricultural TFP growth is nearly zero is because it is not a standard growth accounting, but a model based calibration result. The actual production function $Y_a = A_a K_a^{\theta_a} L_a^{1-\theta_a}$ is identical to $\bar{a} = \bar{a}\frac{A_a}{Y_a} K_a^{\theta_a} L_a^{1-\theta_a} \equiv \overline{A_a} K_a^{\theta_a} L_a^{1-\theta_a}$. Hence essentially the calculated agricultural TFP growth $\overline{A_a}$ can be explained as the actual TFP growth relative to the output growth: A_a/Y_a. Therefore it is not comparable to other growth accounting literature using different model setup. Nevertheless, the Engel's law is captured well and the research purpose can be served. See Gollin et al. (2002) for a similar treatment.

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

[25] See Appendix D1 for the patterns of μ_j across time.

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

Given $\frac{L_m(t)}{L_{ds}(t)}$, $\frac{L_{ps}(t)}{L_h(t)}\frac{K_{ds}(t)}{L_{ds}(t)}$, $\frac{K_m(t)}{L_m(t)}$, $\frac{K_{ps}(t)}{L_{ps}(t)}$ 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: (18) and (19).[26] 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, $\varepsilon = 0.61 < 1$ 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 final goods C_g and composite services C_s.[27] $\bar{a} = 0.779$, which is about 30 percent of initial output per worker. $k(0) = 566.3$, 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.[28] The average annual growth rate of labor employment is 1 percent, so $g = 0.01$. Table 3 summarizes all the parameter values.

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. Fig. 7 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.[29] 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.[30]

We test the calibration by comparing the valued added shares generated by the model with the data. See Fig. 8 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.

We also check the capital dynamics, which are not the target of our calibration. Fig. 9 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.[31]

4.3. 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 (Engel's law);
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*);
4. Substitution between the the final goods C_g and composite services C_s;
5. Changes of intersectoral wage gap $\mu_{j\in\{a,ds,ps\}}$.

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

[27] 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.

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

[29] Although we only calibrate the TFP trend, the employment shares fluctuate over time due to ever-changing intersectoral wage gaps. See Appendix D.2 for the model fitness with constant μ_j.

[30] 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.

[31] See Bai, Hsieh, and Qian (2006); Song et al. (2011).

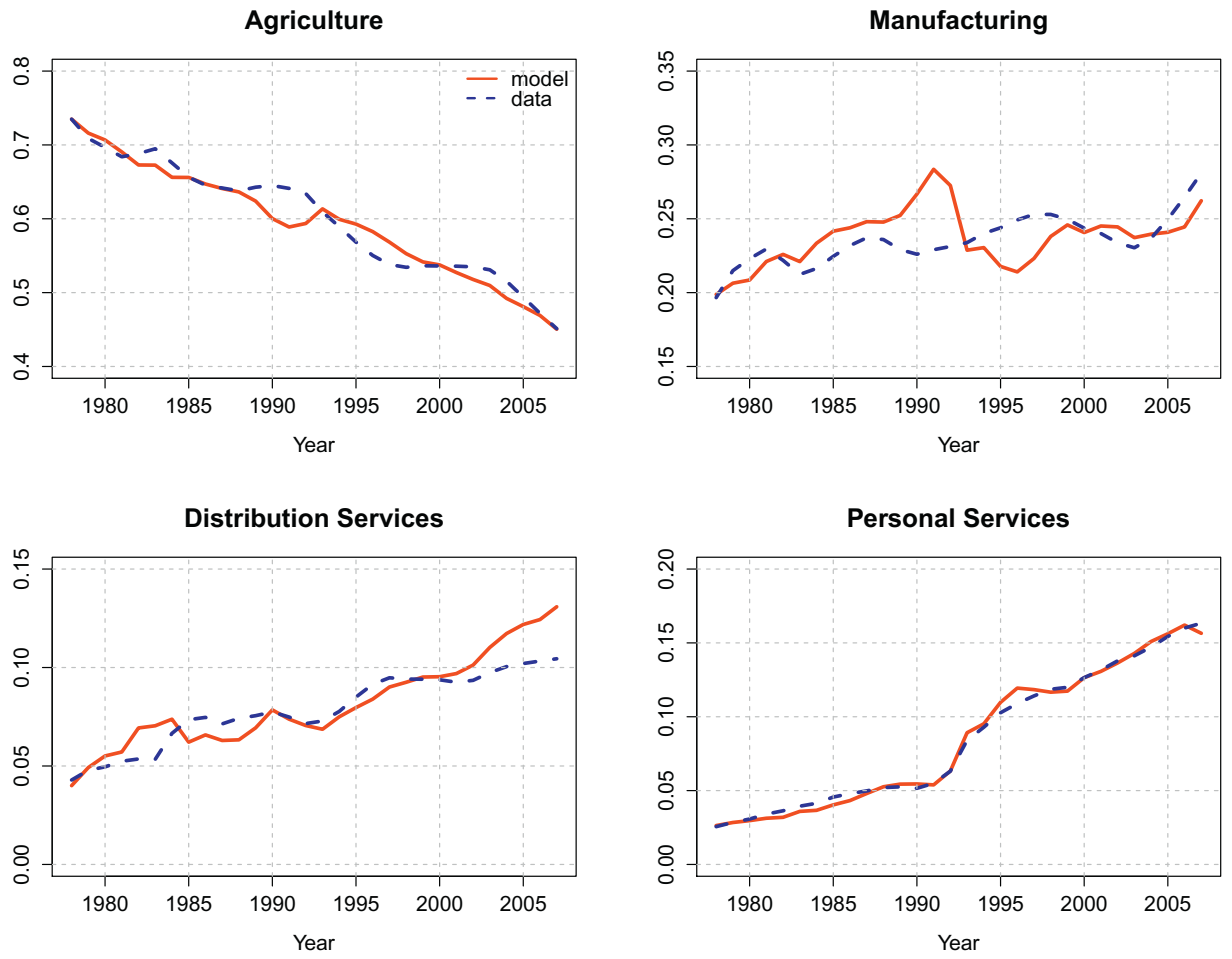

Fig. 7. Sectoral employment share of China.

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 Fig. 7 and Fig. 8), 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.

4.3.1. Failure of Engel's law

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. Fig. 10 shows the simulation result. We can see the agricultural employment share is relatively constant over time because the overall changes of μ_j are small. When Engel's law fails, labor is kept in the agricultural sector, and all employment shares in non-agricultural sectors decrease significantly (comparing with the data).

4.3.2. 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 ($\varepsilon = 1$) to disable the labor reallocation between these two sectors. From Fig. 11 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.

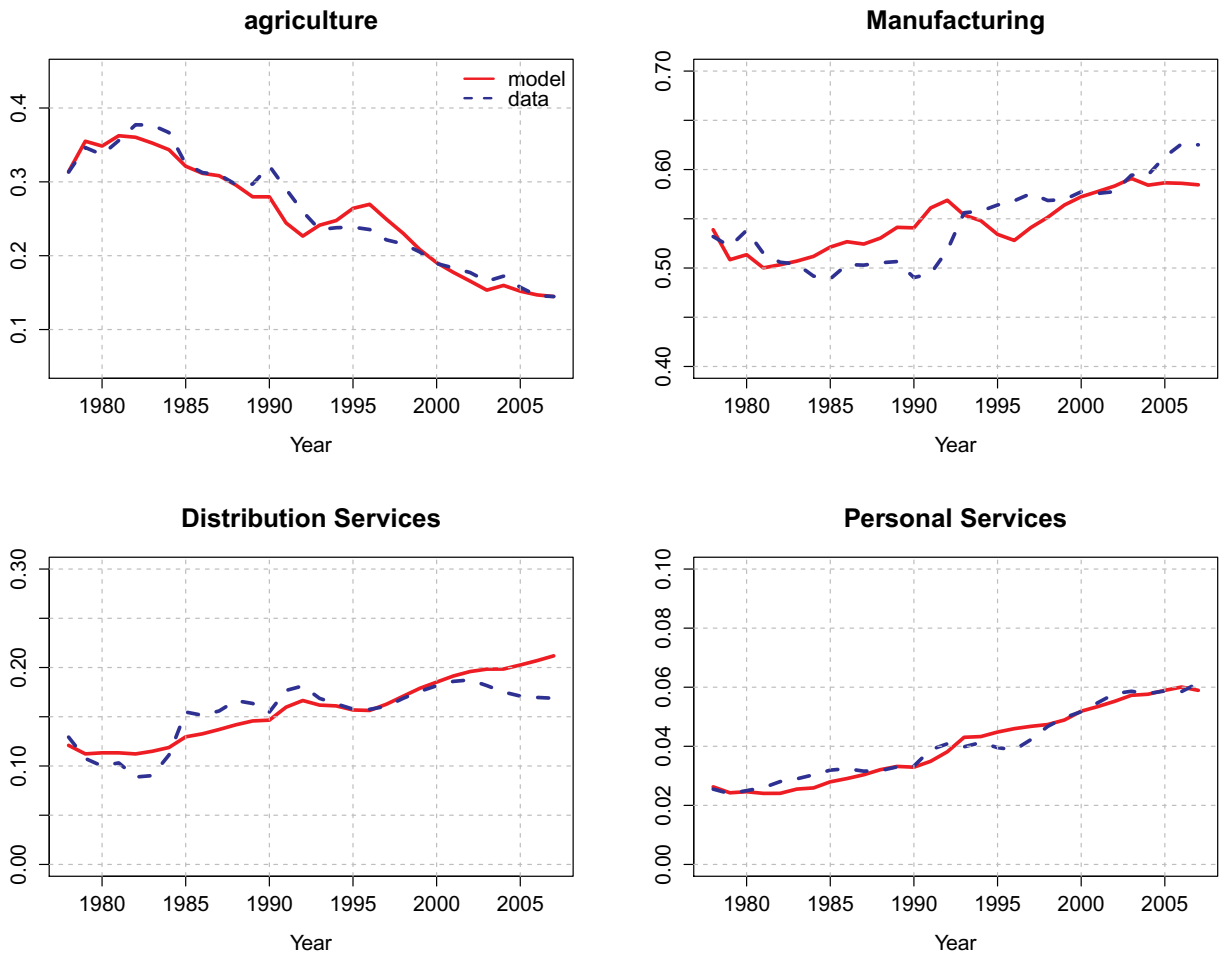

Fig. 8. Sectoral value added share of China.

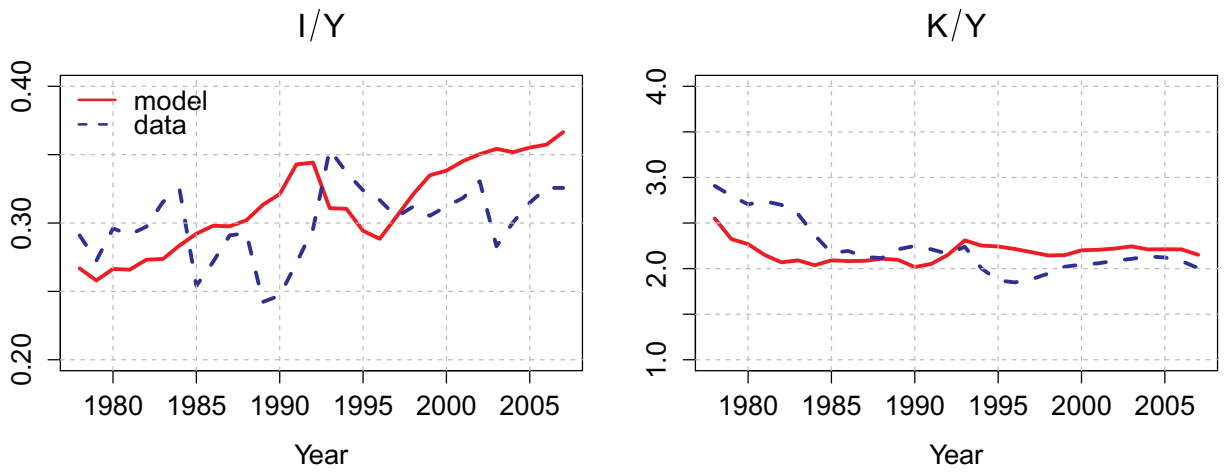

Fig. 9. Capital dynamics.

4.3.3. 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. Fig. 12 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

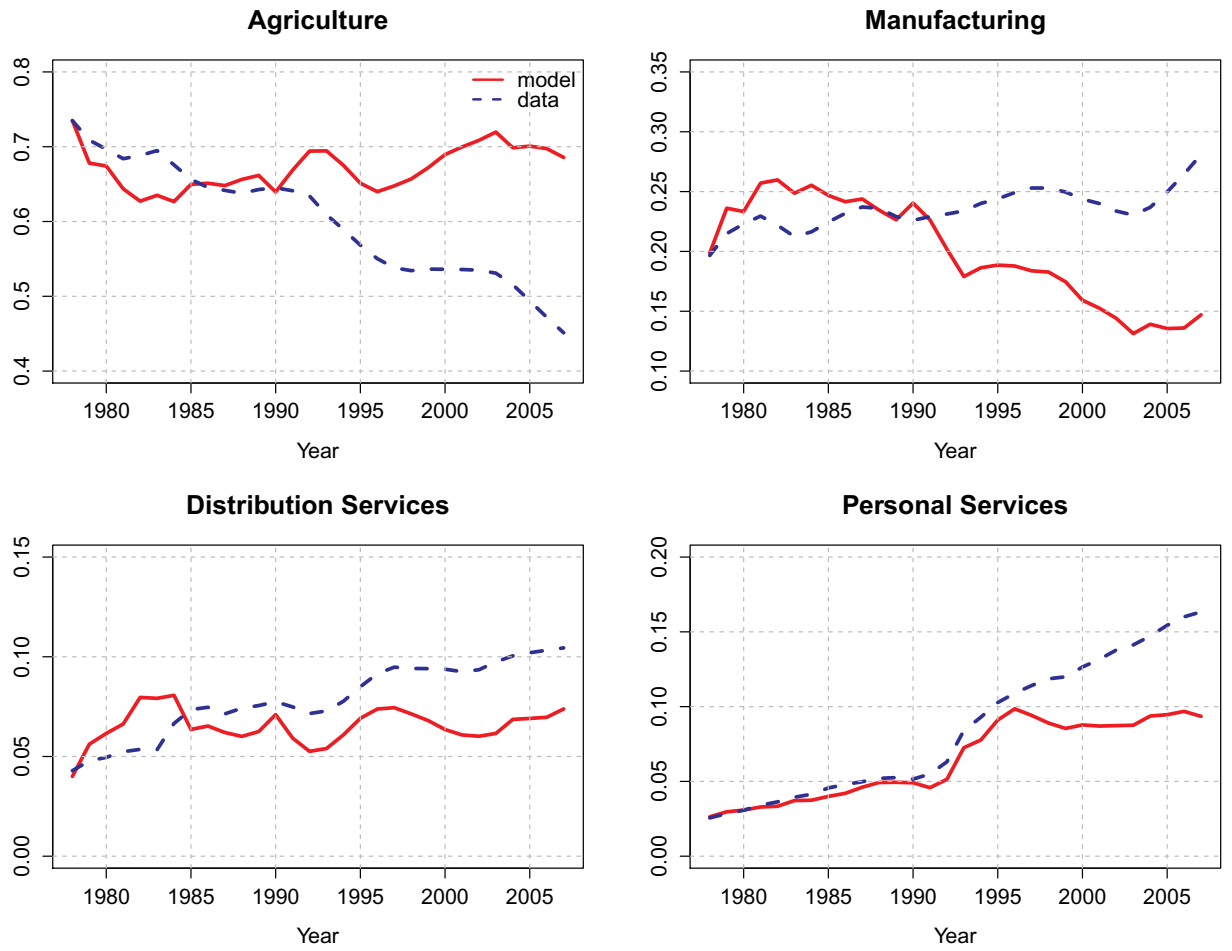

Fig. 10. Counterfactual: Constant expenditure share of agricultural goods.

other three sectors increase due to labor reallocation.

4.3.4. Unitary elasticity of substitution between C_g and C_s

From Fig. 13 we can see if the elasticity of substitution between the final goods C_g and composite services C_s 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.

Table 4 summarizes the changes of sectoral employment share generated by all the 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 ΔL_a, manufacturing ΔL_m, distribution services ΔL_{ds}, personal services ΔL_{ps}) and the aggregate service sector $\Delta L_s = \Delta L_{ds} + \Delta L_{ps}$. The values in parentheses show the relative percentage changes comparing to the benchmark model.

4.3.5. 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.

We can see the counterfactual results in Table 4. 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

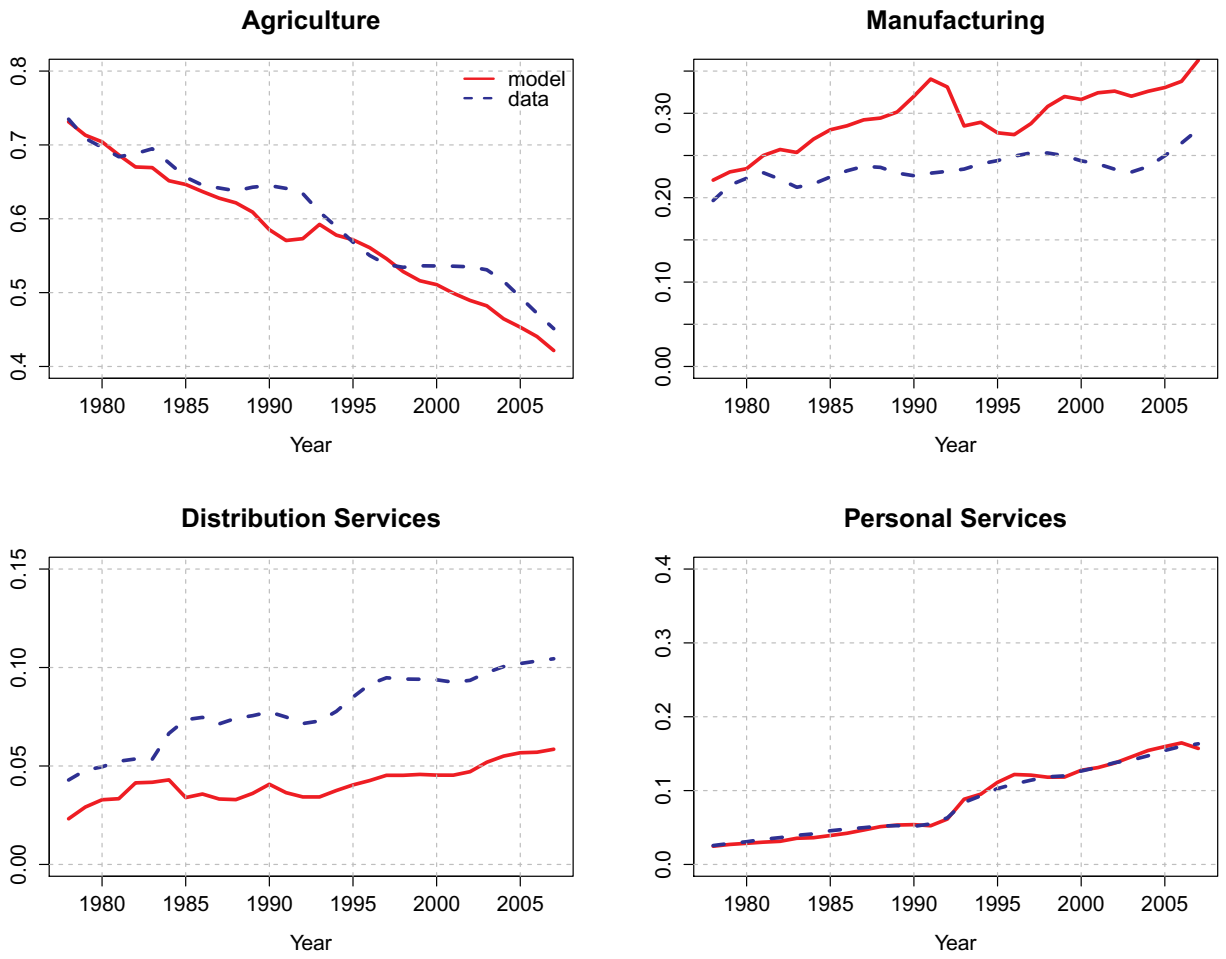

Fig. 11. Counterfactual: $\varepsilon = 1$.

complementarity. The personal service sector is barely affected (± 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 Appendix D.3.1 for the graphic illustration of counterfactual sectoral productivity growth and capital intensity.

4.3.6. 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 $j \in \{a, ds, ps\}$. See Table 4 for the results.

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. 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 Appendix D.3.2 for the graphic illustration of the above counterfactual results.

4.4. 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.

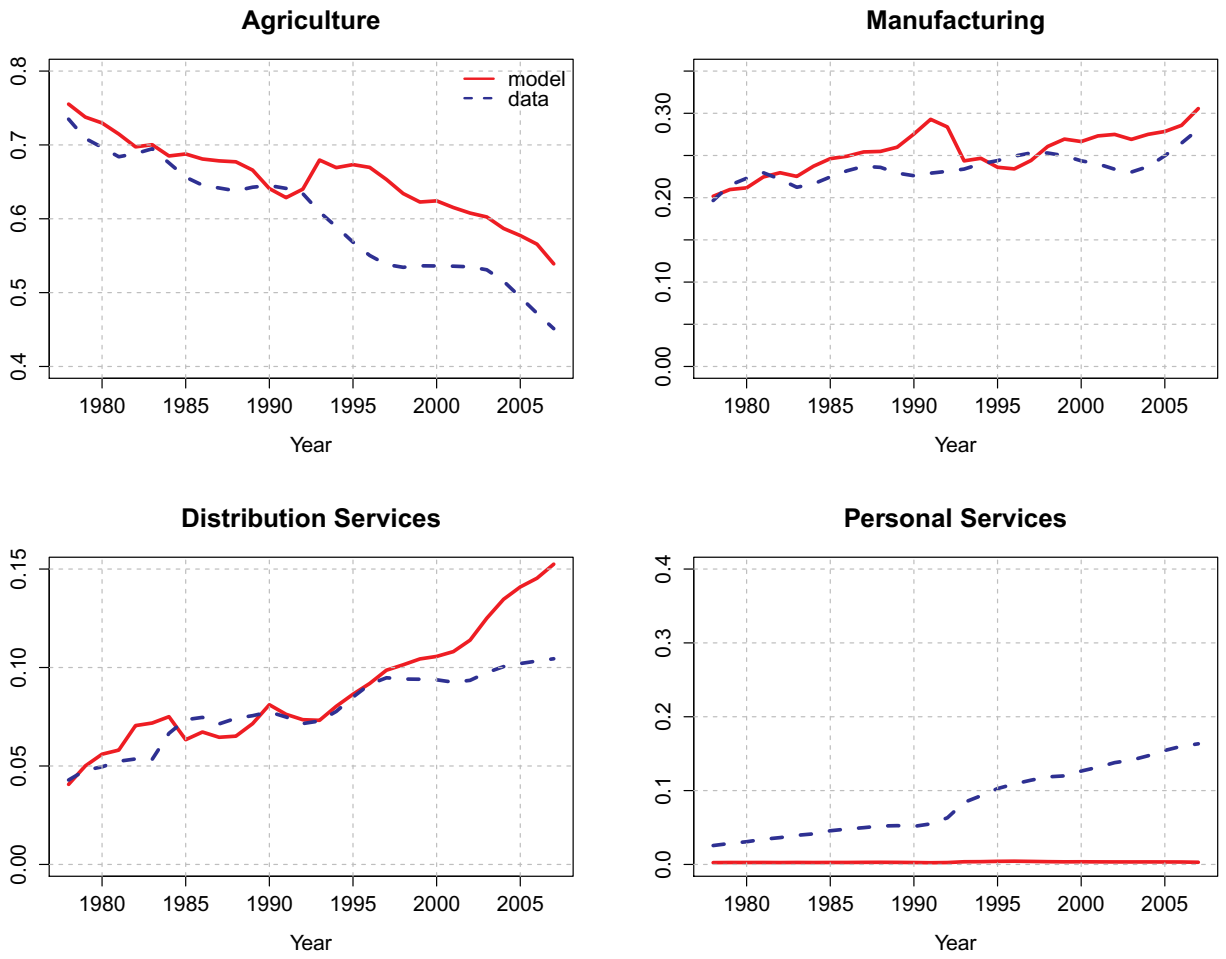

Fig. 12. Counterfactual: $\zeta = 1$.

We also compare the above three channels with Japan and Korea. Table 5 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.

5. Model discussion

5.1. 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.

5.1.1. 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 6). Therefore, human capital accumulation in the service

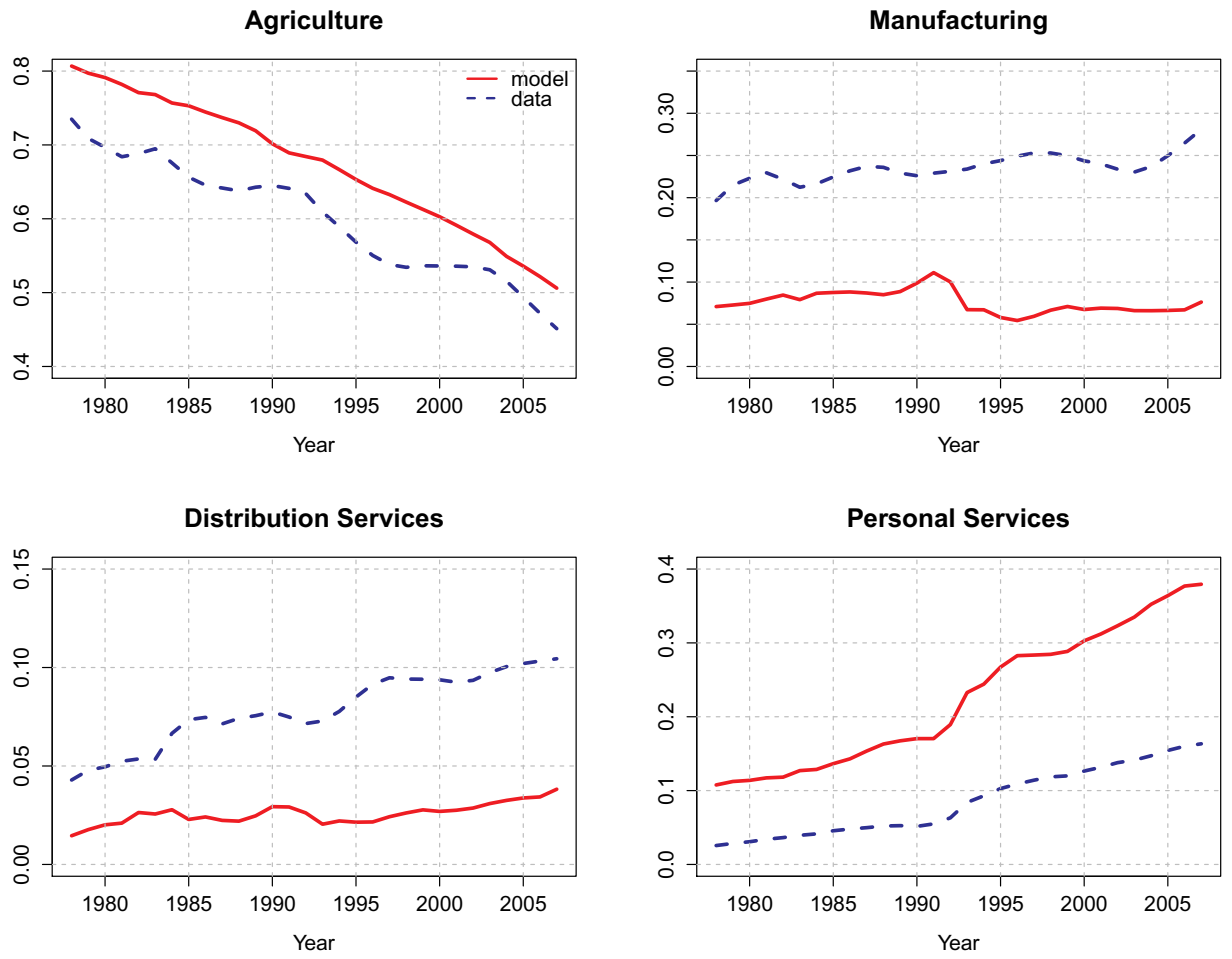

Fig. 13. Counterfactual: $\rho = 1$.

sector itself cannot be an important reason for the past growth of the service sector in China.

Age group of employment ranges from 15-64.

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, Zhao, Park, & Song, 2005). But according to several aggregate level growth accounting analyses (Bosworth & 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.

5.1.2. 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.[32] 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

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

[32] 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).

Table 4
Counterfactual results.

	Change of percentage points											
	Benchmark	Failure of Engel's Law	$\varepsilon = 1$	$\zeta = 1$	$\rho = 1$	$\gamma_{ds} = \gamma_m$	$\theta_{ds} = \theta_m$	$\gamma_{ps} = 0$	$\theta_{ps} = 0$	$\mu_a(t) = \mu_a(0)$	$\mu_{ds}(t) = \mu_{ds}(0)$	$\mu_{ps}(t) = \mu_{ps}(0)$
ΔL_s	0.221	0.101 (−54%)	0.168 (−24%)	0.112 (−49%)	0.295 (33%)	0.186 (−16%)	0.210 (−5%)	0.154 (−30%)	0.115 (−48%)	0.223 (1%)	0.197 (−11%)	0.185 (−16%)
ΔL_{ds}	0.091	0.034 (−63%)	0.035 (−62%)	0.112 (23%)	0.024 (−74%)	0.062 (−32%)	0.075 (−18%)	0.104 (14%)	0.112 (23%)	0.092 (1%)	0.054 (−41%)	0.129 (42%)
ΔL_{ps}	0.130	0.067 (−48%)	0.132 (2%)	0.001 (−99%)	0.272 (109%)	0.124 (−5%)	0.136 (5%)	0.050 (−62%)	0.003 (−98%)	0.130 (0%)	0.142 (9%)	0.056 (−57%)
ΔL_m	0.063	-0.052 (−183%)	0.142 (125%)	0.103 (63%)	0.005 (−92%)	0.136 (116%)	0.099 (57%)	0.090 (43%)	0.104 (65%)	0.068 (8%)	0.071 (13%)	0.141 (124%)
ΔL_a	0.284	0.049 (−83%)	0.31 (9%)	0.215 (−24%)	0.301 (6%)	0.322 (13%)	0.310 (9%)	0.244 (−14%)	0.219 (−23%)	0.29 (2%)	0.268 (−6%)	0.326 (15%)

Table 5
Personal service comparison for China, Japan, and Korea.

	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 6
Education level of employee in the service sector in year 2000.

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

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 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

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

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 4.2, μ_j can also reflect the change of sectoral skill components. The role of μ_j has been discussed in Section 4.3.

5.2. 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, & Zhang, 2013). Święcki (2017) 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 & 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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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chieco.2019.101385.

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