# 1. Idea

## 1.1 Facts

This chapter focus on two long run growth features in US: structural change and rising skill premium. Here skill premium refers to both quantity premium (relative supply of high-skill to low-skill labour) and price premium (wage premium). A few relevant facts have been documented by literature:

1. Structural Change: services rose relative to agriculture and manufacturing since 1947 (Herrendorf et al. 2013; Comin et al. 2015).

2. Marketization of Services: if we disaggregate services into market service and home service, both of their consumption share were around 40 percent at 1947. Since 1947, market service rose from 40 percent to more than 60 percent while home service declined from 40 percent to less than 30 percent (Moro et al. 2017).

3. Skill-Biased Structural Change: if we disaggregate services into high skill (larger than average labour share of college-educated) service and low skill service, both of them had value added share at about 30 percent at 1950. Since 1950, high skill service rose to more than 50 percent at 2000 while low skill service dropped to around 20 percent at 2000 (Buera and Kaboski 2012a).

4. Skill-Biased Technical Change: services sector (0.55) had larger labour share in high-skill (college and above) worker than goods sector (0.28) in 1977; since then the high-skill labour share increased to 0.66 and 0.55 respectively for services and goods in 2005 (Buera et al. 2015, 2013).

5. Rising Skill Premium: both the relative supply and demand of high-skill to low-skill labour rose during 1950-2000. The fraction of college educated labour rose from 15 percent to 60 percent; the wage premium of college to high school rose from 1.25 to 2 (Buera and Kaboski 2012a).

## 1.2 Research Question

Two steps of question. First, propose a unified theory to explain the above facts of structural change and rising skill premium. Specifically why structural change happens

from goods (agriculture and manufacturing) to services? Within services why structural change happens from home service to market service? and why from low-skill service to high-skill service? Does the secular structural change related to the rise of relative supply and demand of high-skill labour? Do these facts have common origins? If time is not enough, the third chapter stops at the first step. Time permitting, can continue to work on the second step.

In the second step, it would be interesting to quantify the model. The second step will aim for quantifying the role of three different type of factors in structural change and rising skill premium: sector-biased technical change ($T_{it}$, $T_{ht}$); skill-biased technical change ($\alpha_{it}$, $\alpha_{ht}$); and the trade cost ($\tau_{ijt}$, $\tau_{hst}$). For notation, see the below model setup.

## 1.3 Qualitative Mechanisms

### 1.3.1 Structural Change from Goods to Services

Three mechanisms:

1. Price Effect: given higher growth rate of efficiency in goods than services, price of services rises relative to goods. Since consumer takes goods and services as complement, labour moves from goods to services (Ngai and Pissarides 2007).

2. Income Effect: services has higher income elasticity than goods. As income rises, consumer spends more in services (Kongsamut et al. 2001).

3. Intermediate Input Supply Effect: market service supply relatively more I.I than goods to downstream sectors. In order to meet the relatively rising outsourced demand, labour moves from goods to market service (chapter 2).

### 1.3.2 Structural Change from Home to Market Service (Marketization)

This process is coined as service marketization by Ngai and Petrongolo (2017). Two mechanisms:

1. Price Effect: in Ngai and Petrongolo (2017), higher growth rate of TFP in market service and substitutable between market and home service, makes structural change from home service to market service. In this chapter I propose a different mechanism but largely consistent with the price effect in Ngai and Petrongolo

(2017). I endogeneize the consumer choice of services in a binary Eaton and Kortum (2002) framework. See the model setup below for detail. Following this setup, the rising of market service relative to home service is due to higher TFP growth and lower price growth in market service relative to home service. Compare to Ngai and Petrongolo (2017), the service choice is endogenous. Compare to Buera and Kaboski (2012a) and Buera and Kaboski (2012b), this endogeneity strategy is more tractable.

2. Income Effect: in Moro, Moslehi and Tanaka (2017), the calibration result shows that income elasticity is larger in market service than home service. Therefore income effect favors market service rather than home service over time. Under my model setup, if the trade cost from market service to consumer declines, the consumption share of market service rises relative to home service. This is largely consistent with the income effect. As economy develops (income rises), the development favors less costly sector (more income elastic).

### 1.3.3 Rising Skill Premium

The theory aims for explaining both the rising demand and supply of high-skill relative to low-skill labour:

1. Rising Demand of Skill Premium: there are two processes leading the rising demand of skill. First, both the above structural change and marketization mechanisms favor market service relative to all other sectors. Over time market service sector grows relative to the rest of economy. Second, market service is the most intensive use of high-skill labour sector as suggested by fact 4. Actually the skill-biased technical change continues to make market service the most high-skill intensive sector, though other sectors also see increasing labour share in high-skill. These two processes push up relative demand of high-skill to low-skill, which rises wage premium.

2. Rising Supply of Skill Premium: rising wage premium gives the incentive to supply relatively more high-skill labour to low-skill labour.

# 2. Model Setup

## 2.1 Production

There are three market sectors: agriculture (a), manufacturing (m) and market service (s). The aggregate gross output $Q_t$ is nonhomothetic CES aggregation of the three market sectoral gross output $Q_{it}$:

$$\sum_{i=a,m,s} \Psi_{it}^{\frac{\kappa}{\rho}} Q_t^{\frac{\xi_i-\rho}{\rho}} Q_{it}^{\frac{\rho-1}{\rho}} = 1 \tag{1}$$

Sectoral gross output $Q_{it}$ is a standard homothetic CES aggregate of individual sectoral intermediate inputs $X_{ijt}$ potentially from other sector j:

$$Q_{it} = \left( \sum_{j=a,m,s} X_{ijt}^{\frac{\theta}{1+\theta}} \right)^{\frac{1+\theta}{\theta}} \tag{2}$$

Sectoral intermediate input $X_{ijt}$ is another homothetic CES aggregate of firm level intermediate input varieties:

$$X_{ijt} = \left[ \int_0^1 X_{ijt}(\omega)^{\frac{\nu-1}{\nu}} d\omega \right]^{\frac{\nu}{\nu-1}} \tag{3}$$

Production of firm level variety $X_{ijt}(\omega)$ has two choices: production in-house or outsourcing. If a firm chooses to produce in house $X_{ijt}^h(\omega)$, it hires both high-skill and low-shill workers:

$$X_{ijt}^h(\omega) = a_{ijt}^h(\omega) \left[ \alpha_{it} H_{ijt}(\omega)^{\frac{\rho_h-1}{\rho_h}} + (1-\alpha_{it}) L_{ijt}(\omega)^{\frac{\rho_h-1}{\rho_h}} \right]^{\frac{\rho_h}{\rho_h-1}} \tag{4}$$

Otherwise if a firm chooses to outsource $X_{ijt}(\omega)$, assume there is always a firm in sector j can directly use the sectoral gross output $Q_{jt}$ to produce the outsourced production:

$$X_{ijt}^x(\omega) = a_{ijt}^x(\omega) Q_{ijt}(\omega) \tag{5}$$

The binary choice therefore is

$$P^*_{ijt}(\omega) = \min(P^h_{ijt}(\omega), P^x_{ijt}(\omega)) \tag{6}$$

Assume that firm level productivity follows sectoral specific Fréchet distribution:

$$\Pr[a^H_{ijt} \leq a] \equiv F_{it}(a) = e^{-T_{it}a^{-\zeta}} \tag{7}$$

$$\Pr[a^X_{ijt} \leq a] \equiv F_{jt}(a) = e^{-T_{jt}a^{-\zeta}} \tag{8}$$

Assume the outsourcing incurs trade cost $\tau_{ijt}$.

## 2.2 Consumption

The consumption of services (z) comes from two sectors: market service (s) and home service (h). Assume a representative consumer produces home service at home; and buy market service from individual final service producer. The aggregate consumption $C_t$ is nonhomothetic CES aggregation of sectoral consumption $C_{it}$:

$$\sum_{i=a,m,z} \Omega_i^{\frac{1}{\varepsilon}} C_t^{\frac{\epsilon_i-\varepsilon}{\varepsilon}} C_{it}^{\frac{\varepsilon-1}{\varepsilon}} = 1 \tag{9}$$

The sectoral consumption of service $C_{zt}$ is homothetic CES aggregation of individual variety $C_{zt}(\omega)$:

$$C_{zt} = \left[\int_0^1 C_{zt}(\omega)^{\frac{\nu_z-1}{\nu_z}} d\omega\right]^{\frac{\nu_z}{\nu_z-1}} \tag{10}$$

Each service variety consumption has two choices: home production or market procurement. If the representative consumer chooses to produce at home, she faces the same technology as equation 4, except for the level of labour productivity:

$$C_{ht}(\omega) = a_{ht}(\omega)\left[\alpha_{ht} H_{ht}(\omega)^{\frac{\rho_h-1}{\rho_h}} + (1-\alpha_{ht}) L_{ht}(\omega)^{\frac{\rho_h-1}{\rho_h}}\right]^{\frac{\rho_h}{\rho_h-1}} \tag{11}$$

If the representative consumer chooses to buy market service, assume there is always a final producer in market service sector can directly using the sectoral gross output $Q_{st}$

to produce $C_{st}(\omega)$:

$$C_{st}(\omega) = a_{st}(\omega) Q_{st}(\omega) \tag{12}$$

Here the binary choice of consumer is

$$P^*_{zt}(\omega) = \min(P_{ht}(\omega), P_{st}(\omega)) \tag{13}$$

Similarly Assume that service variety level productivity follows sectoral specific Fréchet distribution:

$$\Pr[a_{ht} \leq a] \equiv F_{ht}(a) = e^{-T_{ht} a^{-\zeta}} \tag{14}$$

$$\Pr[a_{st} \leq a] \equiv F_{st}(a) = e^{-T_{st} a^{-\zeta}} \tag{15}$$

Assume the market service procurement incurs trade cost $\tau_{hst}$.

## 2.3 Skill Supply

To close the model in a easy way, the skill supply decision is adopted by very simple specification. Assume no friction in labour mobility, therefore for a certain skill wage is equivalent between sectors. The annual aggregate labour supply is exogenous $N_t$. The social planner optimally chooses the allocation of high skill labour ($H_t$) and low skill labour ($L_t$). Assume all labours are ex-ante identical. To be high-skill labour, there is education cost. Otherwise there is no education cost. Assume the total education cost $\chi_t$ is a simple convex function of number of high-skill labour, such that $\chi_t = \phi_0 H_t^{\phi_1}$, with $\phi_0 > 0$ and $\phi_1 > 1$. For the social planner, the skill supply decision therefore is

$$W_t(w_t^H, w_t^L) = \max_{H_t, L_t} w_t^H H_t + w_t^L L_t - \chi_t$$

subject to the labour supply constraint $H_t + L_t = N_t$. This simple setup can generate an upward sloping skill supply curve.

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