The Rise of Service Economy

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Overview

1. Introduction to Structural Transformation
2. Literature Review
   - Economic Forces: Preference-driven vs. Technology-driven
   - A Review Representative-agent Models
   - Calibration, Simulation, and Extensions
3. Phenomenons Unexplained by Representative-agent Models
4. Buera and Kaboski (2012)
   - Model Setup: Preference, Schooling, and Technology
   - Analytical Results, Dynamics and Simulation
   - Linkage to Representative-agent Models
5. Discussion

Structural Transformation

- **Structural Transformation** (or Structural Change):
  - The reallocation of economic activities across the broad sectors of agriculture, manufacturing, and service (Herrendorf et al., 2014)
- **Kuznets Facts:**
  - **Labor** transfers from agriculture to manufacturing and service
  - Agriculture **share of GDP** decreases, while service share increases
  - What does **'share of GDP'** means?
    - Value-add share
    - Final consumption share
- Significance:
  - A classical research field with sizeable literature
  - Sharpen our understanding of development and inequality
  - Received a lot of attention in policy debates

Evidence and Macroeconomic Data

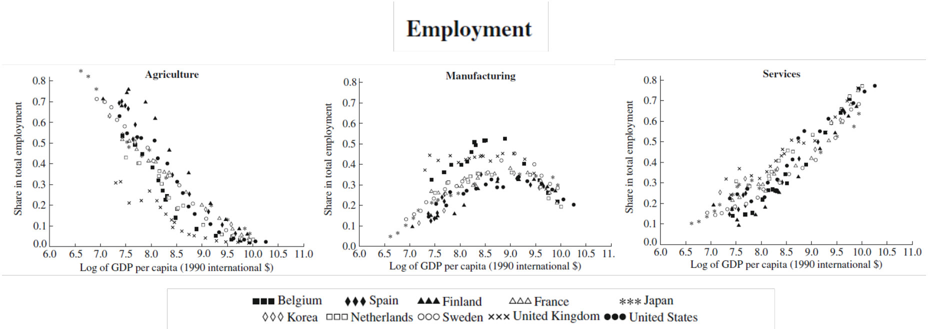

Figure 6.1 Sectoral shares of employment and value added—selected developed countries 1800–2000. *Source: Various historical statistics, see Appendix A.*

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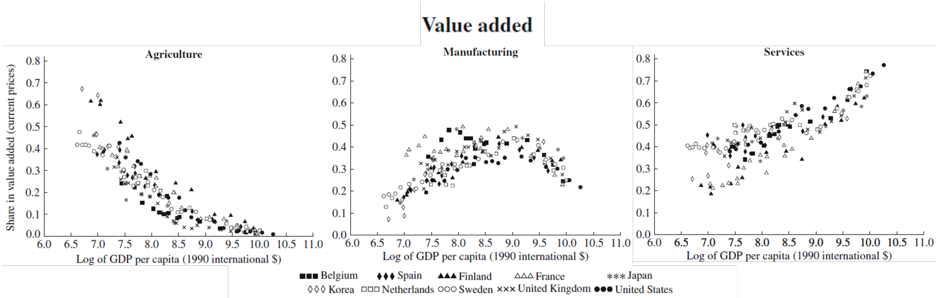

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Political Attention on Structural Transformation

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Raising America's Pay

Political Attention on Structural Transformation

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朱民：中国经济结构转型，根本问题是提高服务业劳动生产率

张雪晴 徐新宇/央视财经
2019-07-01 21:32

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2019年世界经济论坛第十三届新领军者年会，即"夏季达沃斯论坛"于7月1日至3日在中国大连举行。清华大学国家金融研究院院长朱民作为嘉宾出席今天夏季达沃斯分论坛"中国经济前景展望"。在接受央视财经记者采访时，他表示，中国现在面临一个巨大的结构转型，就是从产业经济走向服务业。中国服务业的劳动生产率比工业劳动生产率低20%。所以，提高服务业的劳动生产率，是当前结构转型的一个最根本的问题。

History of Studies in Structural Transformation

- **Before 2000s: Early exploration**
  - **Evidences:** Kuznets (1957, 1966), Chenery (1960), etc.
  - **Models:** Baumol (1967), Pasinetti(1981), Laitner (2000), etc.
- **2000s to mid-2010s: Consolidate Kaldor and Kuznets facts**
  - **Preference-driven:** Kongsamut et al. (2001), etc.
  - **Technology-driven:**
    - Relative price effect: Nagi & Pissardes (2007)
    - Factor intensity effect: Acemoglu & Guerrieri (2008)
    - Factor substitution effect: Alvarez-Cuadrado et al. (2017)
  - **Empirical:** Herrendorf et al. (2013, 2015), Guo et al. (2017), etc.
- **After 2010s: Extending the benchmark model; heterogeneity**
  - Trade (Uy et al., 2013), labor market distortions (Cai, 2015), economic history of socialist nations (Cheremukhin, 2013, 2015, 2017), etc.
  - Service and labor heterogeneity: Buera & Kaboski (2012)

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Economic Forces Behind Structural Transformation

- **Preference-driven** Structural Transformation (Engel Effect)
  - Representative paper: Kongsamut et al. (2001),
  - Mechanism: different income-elasticity of demand across goods
    i.e. income growths ⇒ propensity to consume service than food
  - Theoretical backgroud of **Engelian coefficient**
  - Mathematics representation: introduction of non-homothetic preference

$$U = \sum_{t=0}^{\infty} \beta^t \left[\omega_a{}^{\frac{1}{\epsilon}} (c_{at} - \bar{c}_a)^{\frac{\epsilon-1}{\epsilon}} + \omega_m{}^{\frac{1}{\epsilon}} (c_{mt})^{\frac{\epsilon-1}{\epsilon}} + \omega_s{}^{\frac{1}{\epsilon}} (c_{st} + \bar{c}_s)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$$

converge to Stone-Geary form as $\epsilon \to 1$

$$U = \sum_{t=0}^{\infty} \beta^t \left[\omega_a \ln(c_{at} - \bar{c}_a) + \omega_m \ln(c_{mt}) + \omega_s \ln(c_{st} + \bar{c}_s) \right]$$

Economic Forces Behind Structural Transformation

- **Technology-driven** Structural Transformation:
- **Channel 1:** Relative price or Baumol Effect (Nagi & Pissardes, 2007)
  - Mechanism is first described by Baumol (1967) as Baumol Disease **Agricultural technology advancing faster** ⇒ decrease of agricultural price ⇒ decrease of nominal share of agriculture
- **Channel 2:** Factor intensity effect (Acemoglu & Guerrieri, 2008)
  - **Agriculture is capital intensive:** capital deepening ⇒ increase in the output of agriculture ⇒ capital and labor away from the sector
- **Channel 3:** Factor substitution effect (Alvarez-Cuadrado et al.,2017)
  - **Capital-labor are more substitutable in agriculture:** capital deepening ⇒ capital substitute labor out in agriculture ⇒ labor transfer from agriculture to manufacturing and service

Representative-agent Models: Firms' Problem

- Benchmark model of Herrendorf et al. (2014)
- Environment: four-sector model with representative producer
  - Production of consumption (agriculture, manufacturing, service):

$$c_{it} = k_{it}^{\theta}(A_{it} n_{it})^{1-\theta},\ i \in \{a, m, s\} \tag{1}$$

$$\max_{k_{it} n_{it}} p_{it} c_{it} - r_t k_{it} - w_{it} n_{it} \tag{2}$$

  - Production of investment:

$$X_t = k_{xt}^{\theta}(A_{xt} n_{xt})^{1-\theta} \tag{3}$$

$$\max_{k_{xt} n_{xt}} p_{xt} c_{xt} - r_t k_{xt} - w_{xt} n_{xt},\ p_{xt} = 1 \text{ as numeraire} \tag{4}$$

  - We first begin C-D production function with same θ in different sector, as a special case of Kongsamut et al. (2001), Nagi & Pissardes (2007)

Representative-agent Models: Firms' Problem

- Labor and capital market clearing:

$$1 = n_{at} + n_{mt} + n_{st} + n_{xt} \tag{5}$$

$$K_t = k_{at} + k_{mt} + k_{st} + k_{xt} \tag{6}$$

- Dynamic of capital:

$$K_{t+1} = (1-\delta)K_t + X_t \tag{7}$$

- Solve the profit maximization problem gives:
  - First order condition:

$$r_t = p_{it}\theta\Big(\frac{k_{it}}{n_{it}}\Big)^{\theta-1}A_{it}^{1-\theta}, \forall i \in \{a, m, s, x\} \tag{8}$$

$$w_t = p_{it}(1-\theta)\Big(\frac{k_{it}}{n_{it}}\Big)^{\theta}A_{it}^{1-\theta}, \forall i \in \{a, m, s, x\} \tag{9}$$

Representative-agent Models: Firms' Problem

- From the FOC we further show that:
    - Determination of product price:

$$p_{it} = \left(\frac{A_{xt}}{A_{it}}\right)^{1-\theta}, \forall i \in \{a, m, s, x\} \tag{10}$$

    - Capital-labor ratio and factor income share equalized across sector:

$$\frac{k_{it}}{n_{it}} = \frac{\theta}{1-\theta}\frac{w_t}{r_t}, \forall i \in \{a, m, s, x\} \tag{11}$$

$$\frac{k_{it}}{n_{it}} = \frac{\sum k_{it}}{\sum n_{it}} = K_t, \forall i \in \{a, m, s, x\} \tag{12}$$

    - **Model Feature 1**: C-D production function and same θ in different sector (as a special case of Nagi & Pissardes, 2007), generates balanced growth of capital-labor ratio across sector (capital share equals labor share in each sector each period).

Representative-agent Models: Firms' Problem

- However, feature 1 is somehow unrealistic:
  - Developed economies (e.g. US) witness a higher growth of capital labor ratio in agriculture.

- Thus, Acemoglu & Guerrieri (2008) generalized the production function (1) by allowing different θ:

$$c_{it} = A_{it} k_{it}^{\theta_i} n_{it}^{1-\theta_i},\ i \in \{a, m, s\} \tag{13}$$

  - **Relative price effect** and **factor intensity effect** coexist
  - **Model Feature 1':** In the most capital and labor intensive sector, capital and labor share always move in same direction as capital deepening.

Representative-agent Models: Firms' Problem

- Alvarez-Cuadrado et al.(2017) further generalized the model using CES production function to replace (1):

$$c_{it} = \left[\theta_i k_{it}^{\frac{\sigma_i - 1}{\sigma_i}} + (1-\theta_i)(a_{it} n_{it})^{\frac{\sigma_i - 1}{\sigma_i}}\right]^{\frac{\sigma_i}{\sigma_i - 1}} \tag{14}$$

  - **Relative price effect**, **factor intensity effect**, and **factor substitution effect** coexist.
  - **Model Feature 1":** Using CES production function with different σ across sector, capital and labor share can move in opposite direction, even in the most capital-intensive or labor-intensive sector.

Representative-agent Models: Households' Problem

- For simplicity, assume intertemporal elasticity of substitution is 1:

$$\max_{\{c_{at}, c_{mt}, c_{st}, K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t C_t$$

$$C_t = \log \left[\omega_a^{\frac{1}{\epsilon}} \left(c_{at} - \bar{c}_a \right)^{\frac{\epsilon-1}{\epsilon}} + \omega_m^{\frac{1}{\epsilon}} \left(c_{mt} \right)^{\frac{\epsilon-1}{\epsilon}} + \omega_s^{\frac{1}{\epsilon}} \left(c_{st} + \bar{c}_s \right)^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$$

$$p_{at} c_{at} + p_{mt} c_{mt} + p_{st} c_{st} + K_{t+1} = (1 - \delta + r_t) K_t + w_t$$

- Define a consumption price index:

$$P_t \equiv \left[\omega_a \left(p_{at} \right)^{1-\epsilon} + \omega_m \left(p_{mt} \right)^{1-\epsilon} + \omega_s \left(p_{st} \right)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}$$

Representative-agent Models: Households' Problem

- It can be further split to two sub-problem.
  - Intertemporal Problem:

$$\max_{\{C_t, K_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log C_t \quad \text{st} \quad P_t C_t + K_{t+1} = (1 - \delta + r_t) K_t + w_t - p_{at} \bar{c}_a + p_{st} \bar{t}_s$$

  - Intratemporal Problem:

$$\max_{c_{at}, c_{mt}, c_{st}} \left[\omega_a^{\frac{1}{\epsilon}} (c_{at} - \bar{c}_a)^{\frac{s-1}{\epsilon}} + \omega_m^{\frac{1}{\epsilon}} (c_{mt})^{\frac{\epsilon-1}{\epsilon}} + \omega_s^{\frac{1}{\epsilon}} (c_{st} + \bar{c}_s)^{\frac{s-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}}$$

$$\text{st} \quad p_{at} c_{at} + p_{mt} c_{mt} + p_{st} c_{st} = P_t C_t + p_{at} \bar{c}_a - p_{st} \bar{t}_s$$

Equilibrium Case 1: Only Relative Price Effect

- A special case of Ngai and Pissarides (2007)
- Parametric setting:
  - $\bar{c}_a = \bar{c}_s = 0 \Rightarrow$ Homothetic CES Preference $\Rightarrow$ Mutes income effect.
  - Different growth rate of TFP $\Rightarrow$ Opens Relative Price effect
  - The consumption is governed by:

$$\frac{c_{at}p_{at}}{c_{mt}p_{mt}} = \frac{n_{at}}{n_{mt}} = \frac{\omega_a}{\omega_m}\Big(\frac{A_{at}}{A_{mt}}\Big)^{(\epsilon-1)(1-\theta)} \tag{15}$$

$$\frac{c_{st}p_{st}}{c_{mt}p_{mt}} = \frac{n_{st}}{n_{mt}} = \frac{\omega_s}{\omega_m}\Big(\frac{A_{st}}{A_{mt}}\Big)^{(\epsilon-1)(1-\theta)} \tag{16}$$

  - $\epsilon < 1$: Nominal consumption (labor) move against technology.
  - The model defines a unique Generalized BGP [See Ngai and Pissarides (2007) for more details].

Equilibrium Case 2: Only Income Effect

- A special case of Kongsamut et al. (2001)
- Parametric setting:
  - $\bar{c}_a > 0,\ \bar{c}_s > 0 \Rightarrow$ Non-homothetic Preference $\Rightarrow$ Opens income effect.
  - Same growth rate of TFP $\Rightarrow$ Mutes Price effect
  - If we consider Stone-Geary form ($\epsilon \to 1$):

$$U = \sum_{t=0}^{\infty} \beta^t \left[\omega_a \ln(c_{at} - \bar{c}_a) + \omega_m \ln(c_{mt}) + \omega_s \ln(c_{st} + \bar{c}_s)\right] \tag{17}$$

Equilibrium Case 2: Only Income Effect

- The consumption is governed by:

$$c_{at} = \omega_a \frac{P_t}{p_{at}} C_t + \bar{c}_a \tag{18}$$

$$c_{mt} = \omega_m \frac{P_t}{p_{mt}} C_t \tag{19}$$

$$c_{st} = \omega_s \frac{P_t}{p_{st}} C_t - \bar{c}_s \tag{20}$$

$$\text{where} \quad \frac{p_{it}}{P_t} = \frac{p_{i0}}{P_0}, \quad i \in \{a, m, s\} \tag{21}$$

  - Blue parts are constant over time, and structural transformation happens as C_t growth.
  - The model defines also a unique Generalized BGP under certain parametric setting (e.g. $\bar{c}_a/\bar{c}_s = (A_{a0}/A_{s0})^{1-\theta}$) [See Kongsamut et al. (2001) for more details]

Calibration

- We have several theories $\Rightarrow$ Who is right?
  $\Rightarrow$ Which factor is quantitatively dominate?
- Herrendorf et al. (2013, AER; 2015 AEJ Macro):
  - Herrendorf et al. (2013, AER) focuses on preference.
  - Herrendorf et al. (2015, AEJ Macro) focuses on technology.
  - The researchers calibrate the above model using US post-war data.

Calibrate Utility Function

- Herrendorf et al. (2013, AER)
- **Final consumption v.s. value-add**
  - **If final consumption data is used:**
    e.g. Whole canteen catering is attributed to service.
  - $\epsilon = 0.85 \approx 1 \quad \Rightarrow$ Stone-Geary Utility is a good approximation
  - **If value-add data is used:**
    e.g. Canteen cooking is service. Raw foods are agriculture, and cookers are manufacturing.
  - $\epsilon = 0.002 \approx 0 \quad \Rightarrow$ Leontief Utility with $\bar{c}_a, \bar{c}_s$.
  - Both data show $\bar{c}_a > 0, \bar{c}_s > 0 \Rightarrow$ Strong support to Kongsamut et al. (2001).

Calibrate Production Function

- Herrendorf et al. (2015, AEJ Macro)

$$F_i\left(K_{it}, L_{it}\right) = \left[\alpha_i \left[\exp\left(\gamma_{ik} t\right) K_{it}\right]^{\frac{\sigma_i - 1}{\sigma_i}} + \left(1 - \alpha_i\right)\left[\exp\left(\gamma_{il} t\right) L_{it}\right]^{\frac{\sigma_i - 1}{\sigma_i}}\right]^{\frac{\sigma_i}{\sigma_i - 1}}$$

TABLE 1—ESTIMATION RESULTS

	Aggregate	Agriculture	Manufacturing	Services
σ	0.84***	1.58***	0.80***	0.75***
	(0.041)	(0.068)	(0.015)	(0.020)
γ_k	−0.010	0.023***	−0.045***	−0.002
	(0.006)	(0.003)	(0.009)	(0.004)
γ_l	0.022***	0.050***	0.044***	0.016***
	(0.003)	(0.004)	(0.007)	(0.002)
$\bar{\theta}$	0.33	0.61	0.29	0.34

- Three factors co-exit and CES production is preferred.

Extending on Representative-agent Models

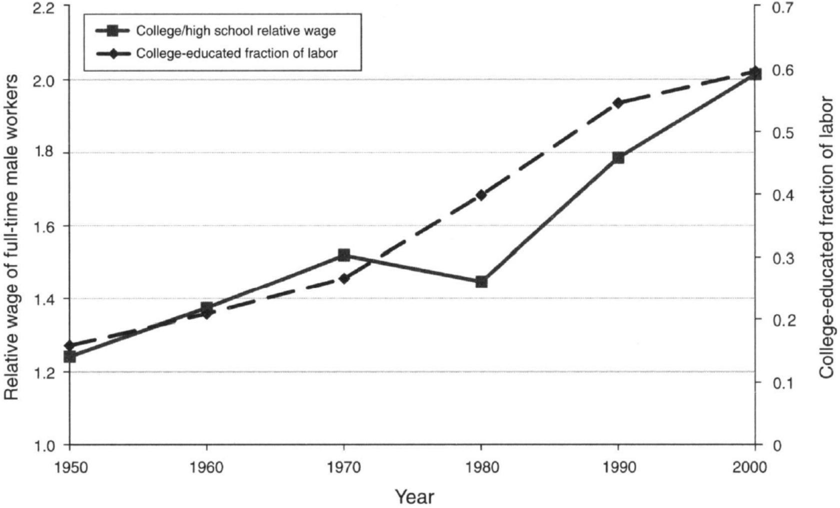
- Structural transformation and distortion
  - Factor prices (wage rent) are not equalized across sector.
  - Cai (2015) accounts the effect of distortion by adding wedges:

$$\begin{array}{l} \max_{\{c_a, c_m, c_s, n_a, n_m, n_s\}} U(c_a, c_m, c_s) \\ \text{s.t.: } \sum p_i c_i = w_a n_a + (1 - \tau_m) w_m n_m + (1 - \tau_s) w_s n_s + TR \end{array} \tag{22}$$

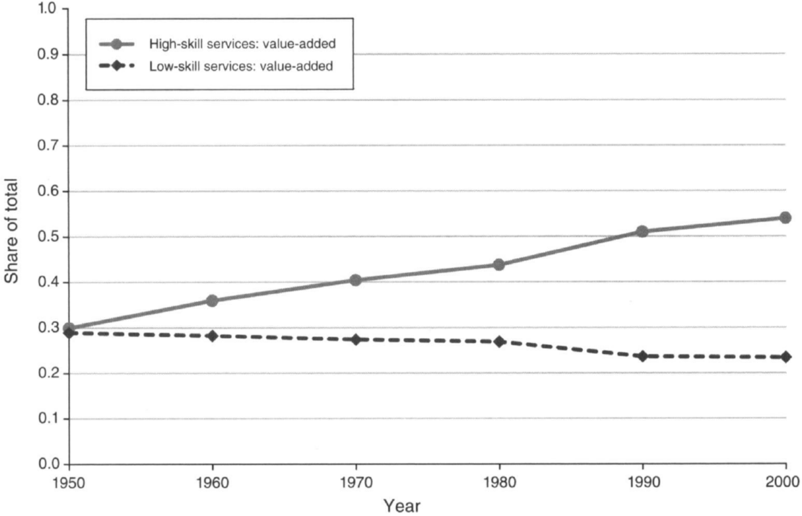
  - Cheremukhin er al. (2017) use similar approach to account the distortions in USSR.

- Structural transformation in open economy
  - Uy et al. (2013) analyze the effect of trade on the structural transformation of Korea by adding Eaton and Kortum's (2002) framework into the model.

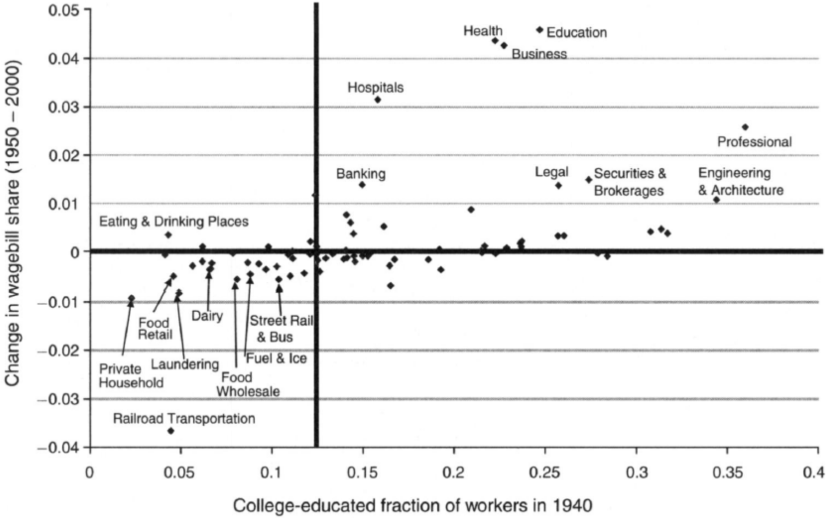
Rise of High-skilled Labor and Skill Premium



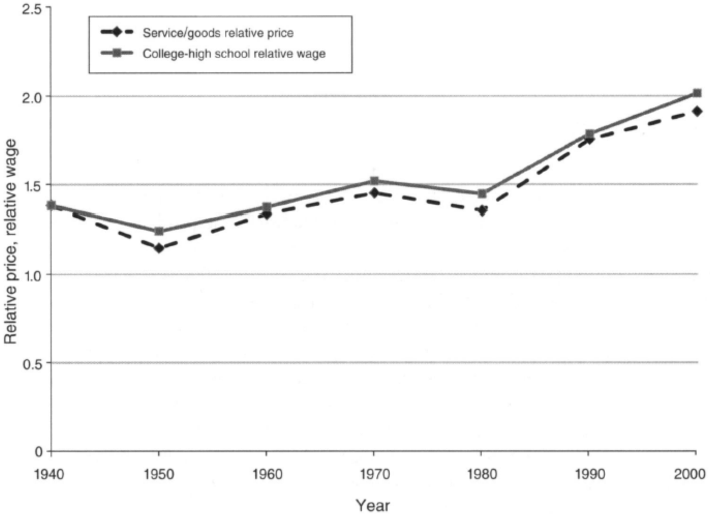
Low- and High-Skill Service Shares



Decomposition of Service



Correlation of Service Price and Wage Premium



Home-made Service

$$U = \sum_{t=0}^{\infty} \beta^t \left[\omega_a \ln(c_{at} - \bar{c}_a) + \omega_m \ln(c_{mt}) + \omega_s \ln(c_{st} + \bar{c}_s)\right]$$

- It is easy to understand that everyone has a **'servival level of agricultural consumption'** $\bar{c}_a$
- How about **'home-made service'** $\bar{c}_s$?
  - Who produced 'home-made service'?
  - Does a wealthy and busy businessman cook at home?
    $\Rightarrow$ Heterogeneity in providing home-made service.

The Rise of Service Economy

- By Francisco J. Buera and Joseph P. Kaboski, 2012, AER
- This paper answer the question: Why only high-skill-intensive services rather than low-skill-intensive services has risen during a period of increasing relative wage and increasing quantities of high-skill labor.
- This paper develop a model:
  - Introducing heterogeneity of consumption and labor to structural transformation theory
  - Generating structural transformation through **neither** sector-biased technological progress **nor** exogenous nonhomothetic preference, but endogenously through **the skill specialization nature of education**
  - linking the study of structural transformation and skill premium

A. Preference

- The authors adopt similar preference structure as Foellmi and Zweimuller (2008), but restricting it to only **extensive margin:**
- Consider a economy with two types of labor labeled by $e \in \{l, h\}$
- There are a continuum of discrete, satiable wants, indexed by $z \in \mathbb{R}^+$.
- All the wants are service which are arranged from the simplest $(z \to 0+)$ to the most complex $(z \to +\infty)$ can be produced at home or purchase in market.
- Define two indicator functions:
  - $\mathcal{C}^e(z) : \mathbb{R}^+ \to \{0, 1\}$ indicates whether a want is satisfied
  - $\mathcal{H}^e(z) : \mathbb{R}^+ \to \{0, 1\}$ indicates whether a want is satisfied and produce at home

A. Preference

- Household can choose:
  - the fraction of high-skilled labor f^h and low-skill labor $f^l = 1 - f^h$;
  - whether to satisfy a want $\mathcal{C} = \{\mathcal{C}^l(z), \mathcal{C}^h(z)\}$;
  - how to satisfy it $\mathcal{H} = \{\mathcal{H}^l(z), \mathcal{H}^h(z)\}$
  - in order to maximize:

$$u(\mathcal{C}, \mathcal{H}) = \sum_{e=l,h} f^e \int_0^\infty [\mathcal{H}^e(z) + \nu (1 - \mathcal{H}^e(z))] \, \mathcal{C}^e(z) dz \qquad (23)$$

  - Home-produced service is more customized and give higher utility if $\nu \in (0, 1)$
  - Intelligent way of introducing heterogeneity.

B. Schooling

- A household can choose to let $f^h \in (0,1)$ fraction of family member to attend school, and:
  - they have to spend θ fraction of time in school without production;
  - they become a high-skill labor specialized in a unique good.

- Upward cost function of producing high-skill labor:
  - $\theta(f^h)$ is a continuous, increasing, and strictly convex
  - i.e. $\theta'(f^h), \theta''(f^h) > 0$
  - Technical assumption to ensure $f^h \in (0,1)$:

$$\lim_{f^h \to 0} 1 - \theta(f^h) - f^h \theta'(f^h) \geq 1 \tag{24}$$

$$1 - \theta(1) - \theta'(1) < 0 \tag{25}$$

C. Technology

- All kinds of final consumption (i.e. wants) are services:
  - require q unit of **specialized** goods and **1 unit of efficient labor** no matter it is produced at home or in market
  - e.g.
    - Home-produced service: You purchase $q = \$10$ of food and 1 efficient hour to cook a dinner yourself
    - Market service: The student canteen purchases $q = \$10$ of food and 1 efficient hour to cook a dinner, and you can buy food from it.
  - Efficient labor if producing in market:

$$A_l(z)L(z) + A_h(z)H(z) \tag{26}$$

  - Efficient labor if producing at home:

$$A_l(z)L(z) \tag{27}$$

  - Where $A_l(z)$ and $A_h(z)$ are productivity for low and high-skill labor.

C. Technology

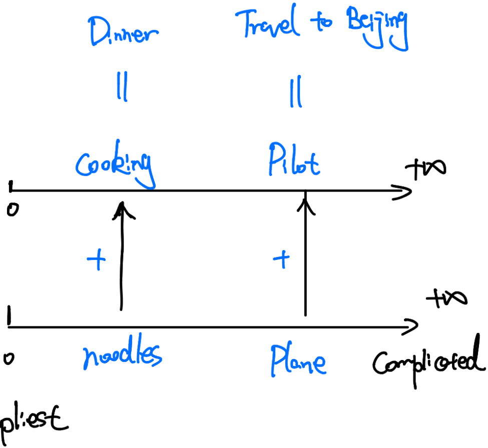
Final Consumption

=

Service 1x

+

Goods 9x



C. Technology

- Production functions are:
  - (Market) Goods:

$$G(z) = A_l(z)L_G(z) + A_h(z)H_G(z) \tag{28}$$

  - Market Services:

$$S_M(z) = \min\left\{A_l(z)L_M(z) + A_h(z)H_M(z), \frac{G_M(z)}{q}\right\} \tag{29}$$

  - Nonmarket (Home-produced) Service:

$$s_N(z) = \min\left\{A_l(z)n(z), \frac{g_N(z)}{q}\right\} \tag{30}$$

  - where $n(z)$ is time devoted to home-produced service.

C. Technology

- Why high-skill labor share same productivity with low-skill labor at home?
  - **Specialization nature of modern education**
  - Intuition: Schooling let a labor to become productive in only a **unique** product and service, but you face infinite number of consumption to feed your wants.
  - So a rational labor in a perfect market have incentive to 'sell' his high productivity in one unique consumption and exchange for consumption that other people specialized in.
  - $\Rightarrow$ **'The Rise of Service Economy'**

  - **Mathematically**: A point have no measure on real line.

C. Technology

- Parametric assumption on productivity:

$$A_l(z) = Az^{-\lambda_l} \tag{31}$$

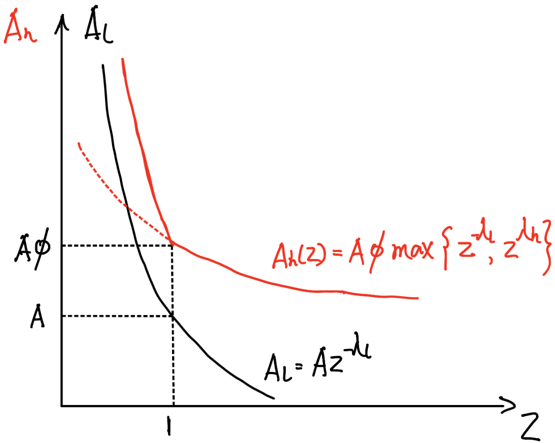
$$A_h(z) = A\phi \; max\{z^{-\lambda_l}, z^{-\lambda_h}\} \tag{32}$$

  - λ_l, λ_h are constant parameters while A grows as time flies.
  - Why this form? We will see later.

- Parametric assumptions:
  - $\phi > 1$: Absolute advantage of high-skill labor.
  - $\lambda_l, \lambda_h > 0$: The higher z, the more complex the consumption is.
  - $\lambda_l \geq \lambda_h$: High-skill labor has a (weak) comparative advantage in complex good with $z > 1$.

  - **Comparative advantage** is the core of the story.

C. Technology



Equilibrium: Definition

Definition of Competitive Equilibrium

A competitive equilibrium is given by:

- Price functions for goods and market service: $p_G(z)$,and $p_S(z)$;
- Wages for high-skill and low-skill labor: w_h and w_l;
- Fraction of people who attend schooling: f^h and $f^l = 1 - f^h$;
- Skill-specific consumption decisions: $\mathcal{C}^e(z), \mathcal{H}^e(z), \forall e \in \{h, l\}$;
- Skill-specific home production decisions: n^h and n^l;
- Market labor allocation $H_G(z), H_M(z), L_G(z)$, and $L_M(z)$,

such that:

- Household maximize utility by choosing schooling, consumption, and home production, subject to common budget constraint and home production constraints;
- Firms maximize profits taking prices as given;
- Labor markets clear;
- Goods and services markets clear.

Firms' Problem

- Firms' problem:
  - Firms in goods market:

$$\max_{L_G(z), H_G(z)} p_G(z)G(z) - L_G(z)w_l - H_G(z)w_h \tag{33}$$

$$\text{s.t.} \;\; G(z) = A_l(z)L_G(z) + A_h(z)H_G(z) \tag{34}$$

  - Firms in services market:

$$\max_{L_M(z), H_M(z)} p_S(z)S_M(z) - L_M(z)w_l - H_M(z)w_h \tag{35}$$

$$\text{s.t} \; S_M(z) = \min\left\{A_l(z)L_M(z) + A_h(z)H_M(z), \frac{G_M(z)}{q}\right\} \tag{36}$$

Firms' Problem: Price

- Equilibrium price is characterized by FOC of the firms' problem:
  - Price of goods:

$$p_G(z) = \min\left\{\frac{w_l}{A_l(z)}, \frac{w_h}{A_h(z)}\right\} \tag{37}$$

  - Price of market services:

$$p_S(z) = qp_G(z) + \min\left\{\frac{w_l}{A_l(z)}, \frac{w_h}{A_h(z)}\right\} = (q+1)p_G(z) \tag{38}$$

  - Setting numeraire $P_G 1{=}1$, and define skill-premium $w = w_h/w_l$.

Firms' Problem: Wage and Skill-premium

- When $\lambda_l = \lambda_h$, there is no comparative advantage for all goods:
  - $w = \phi$, and labor are perfectly substitutable;
  - i.e. There is no different for firm to hire low or high-skill labor

- When $\lambda_l = \lambda_h$:
  - No comparative advantage for $z \leq 1$ goods
    $\Rightarrow$ above results holds when only $z \leq 1$ goods are produced.

  - Given $w \geq \phi$, there exists a threshold complexity $\hat{z}$:

$$\hat{z}(w) = \left(\frac{w}{\phi}\right)^{\frac{1}{\lambda_l - \lambda_h}} \tag{39}$$

  - such that $z > \hat{z}$ are cost efficiently produced using high skilled labor, and vice versa. $\Rightarrow$ Trade off between customization and cost-efficiency.

Households' Problem

- Symmetry of problem with respect to consumption allocation:

$$\mathcal{C}(z) = \mathcal{C}^h(z) = \mathcal{C}^l(z) \tag{40}$$

$$\mathcal{H}(z) = \mathcal{H}^h(z) = \mathcal{H}^l(z) \tag{41}$$

- Represent household spending on goods and services as:

$$C_G \equiv \int_0^\infty \mathcal{C}(z)\mathcal{H}(z) q p_G(z) dz \tag{42}$$

$$C_S \equiv \int_0^\infty \mathcal{C}(z)[1 - \mathcal{H}(z)] p_S(z) dz \tag{43}$$

Households' Problem

- Household maximize utility:

$$\max_{f^h, f^l, n^h, n^l, \mathcal{C}(z), \mathcal{H}(z)} \int_0^\infty [\mathcal{H}(z) + \nu(1 - \mathcal{H}(z))]\mathcal{C}(z)dz \tag{44}$$

  - Subject to **common budget constrain:**

$$C_G + C_S = \sum_{e=l,h} f^e w^e \left[1 - \theta\left(f^h\right)\mathcal{I}(e = h) - n^e\right] \tag{45}$$

  - and **home production constrain**:

$$\int_0^\infty \mathcal{C}(z)\mathcal{H}(z)\frac{z^{\lambda_l}}{A}dz = \sum_{e=l,h} f^e n^e \tag{46}$$

Households' Problem

Proposition 1

In the competitive equilibrium:

a. Equilibrium consumption decisions $\mathcal{H}(z)$ and $\mathcal{C}(z)$ are characterized by thresholds $\underline{z} \leq \bar{z}$, such that:

$$\mathcal{H}(z) = \begin{cases} 1 \text{ if } z \leq \underline{z} \\ 0 \text{ if } z > \underline{z} \end{cases} \quad \text{and} \quad \mathcal{C}(z) = \begin{cases} 1 \text{ if } z \leq \bar{z} \\ 0 \text{ if } z > \bar{z} \end{cases}$$

b. No high-skilled workers will produce service at home: $n^h = 0$;

c. No low-skilled worker will produce service in market: $\bar{z} \leq \underline{z}$

- $\underline{z}$ and $\bar{z}$ are the most complex service produced at home and in market.
- a comes from the trade off between customization and cost-efficiency.
- b and c come from the incentive of two types of workers.

- See Buera and Kaboski (2009) p.13-p.15 for rigorous proof.

Proposition 1

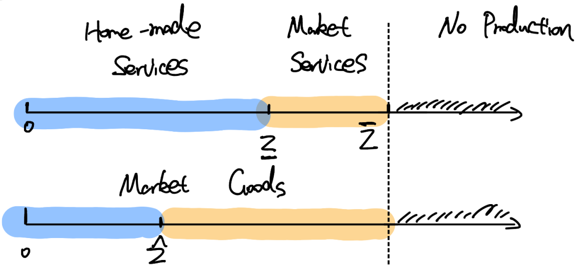
Final Consumption

=

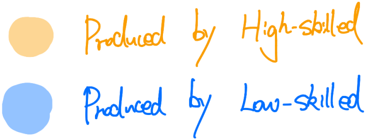
Service 1X

+

Goods 9X



Simplest



Households' Problem

- By using proposition 1, we can simplify the households' problem:

$$\max_{0\leq f^h\leq 1, n\leq 1-f^h, \underline{z}\leq \bar{z}} (1-v)\underline{z} + v\bar{z} \tag{47}$$

- Subject to **common budget constrain:**

$$q\int_0^{\underline{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi}z^{\lambda_h}\right\} dz + (1+q)\int_{\underline{z}}^{\bar{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi}z^{\lambda_h}\right\} dz \\ = wAf^h\left(1-\theta\left(f^h\right)\right) + A\left(1-f^h-n\right) \tag{48}$$

- and **home production constrain**:

$$\int_0^{\underline{z}} \frac{z^{\lambda_l}}{A} dz = n \tag{49}$$

Households' Problem

- Combine the above two constraint, we have:

$$q \int_0^{\underline{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi} z^{\lambda_h}\right\} dz + (1+q) \int_{\underline{z}}^{\bar{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi} z^{\lambda_h}\right\} dz \\ + \int_0^{\underline{z}} z^{\lambda_l} dz = wAf^h \left(1 - \theta\left(f^h\right)\right) + A\left(1 - f^h\right) \tag{50}$$

  - Target function is a increasing function of $\underline{z}$ and $\bar{z}$;
  - LHS of the constraint is a increasing function of $\underline{z}$ and $\bar{z}$;
  - RHS has neither $\underline{z}$, nor $\bar{z}$, but a function of f^h.

- This means the independence of schooling decision
  $\Rightarrow$ We can split the households' problem to two sub-problems.

Households' Problem

- **First, the schooling problem:**
  - Maximize the efficient income $V(w^l, w^h; \theta)$ by choosing schooling policy:
$$V(w^l, w^h; \theta) = \max_{f^h} \{(1 - f^h) + f^h w(1 - \theta(f^h)\} \tag{51}$$
- **Second, the income allocation problem:**
  - Allocate efficient income to home and market production by choosing the $\underline{z}$, and $\bar{z}$ to equalized the marginal return:

$$\max_{0 \leq f^h \leq 1, n \leq 1 - f^h, \underline{z} \leq \bar{z}} (1 - v)\underline{z} + v\bar{z} \tag{52}$$

$$\begin{aligned} &q \int_0^{\underline{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi} z^{\lambda_h}\right\} dz + (1 + q) \int_{\underline{z}}^{\bar{z}} \min\left\{z^{\lambda_l}, \frac{w}{\phi} z^{\lambda_h}\right\} dz \\ &+ \int_0^{\underline{z}} z^{\lambda_l} dz = V(w^l, w^h; \theta) A \end{aligned} \tag{53}$$

Households' Problem

- The FOC of the schooling problem is:

$$w\left[1-\theta\left(f^{h}\right)-f\theta'\left(f^{h}\right)\right]=1 \tag{54}$$

  - As we can see, f^h is a function of w;
  - The technical assumptions make sure $f^h \in (0,1)$.

Rise of Service, Skill Premium, and Supply of Skill

Proposition 2

Under assumption 1 (which ensures low-skilled workers supply positive labor to market) and assumption 2 (which ensures $A_1 \leq A_2$) There exist two productivity thresholds $A_1 \leq A_2$, such that:

- $A < A_1$: $\frac{\partial \ln \bar{z}}{\partial A} = \frac{\partial \ln \underline{z}}{\partial A}$, $\frac{\partial f^h}{\partial A} = 0$, and $\frac{\partial w}{\partial A} = 0$
- $A_1 \leq A < A_2$: $\frac{\partial \ln \bar{z}}{\partial A} > \frac{\partial \ln \underline{z}}{\partial A}$, $\frac{\partial f^h}{\partial A} = 0$, and $\frac{\partial w}{\partial A} = 0$
- $A_2 \leq A$: $\frac{\partial \ln \bar{z}}{\partial A} > \frac{\partial \ln \underline{z}}{\partial A}$, $\frac{\partial f^h}{\partial A} > 0$, and $\frac{\partial w}{\partial A} > 0$

- A_1 is the productivity that $\bar{z} = 1$.
- A_2 is the productivity that the fraction of labor f_0 produced $z > 1$ goods solves the FOC of schooling problem with $\phi = w$.

- See online appendix p.1-p.7 for rigorous proof.

Dynamic of Economy When $A < A_1$

- According to proposition 2, when $A < A_1$:
  - Balanced growth of market and non-market service
    i.e. $\underline{z}$ and $\bar{z}$ growth at same rate.
  - Constant skill-premium and supply of high-skilled worker.
  - No structural transformation:
    i.e. $C_S/(C_S + C_G)$ is constant.

  - This is consistent with US data before WW2, when most service are home-made.

Dynamic of Economy When $A_1 \leq A < A_2$

- According to proposition 2, when $A_1 \leq A < A_2$:
  - Unbalanced growth of market and non-market service: i.e. Market service grows faster than home-made services
  - Constant skill-premium and supply of high-skilled worker.
  - Structural transformation: rise of the service sector i.e. $C_S/(C_S + C_G)$ is increasing.

Dynamic of Economy When $A_2 \leq A$

- According to proposition 2, when $A_2 \leq A$:
  - Unbalanced growth of market and non-market service: Market service grows faster than home-made services;
  - Increasing skill-premium and supply of high-skilled worker.
  - Structural transformation is ambiguous: but the share of service sector $C_S/(C_S + C_G)$ is increasing. rise when λ_h is close enough to 0 (see online appendix p.10-p.12 for rigorous proof)

- This is consistent with US data after 1947, and are generally considered as stylized fact.

Relative Price of the Economy

- Define price index $P_S(A, A_0)$ and $P_G(A, A_0)$ as:

$$P_S(A, A_0) = \int_{\underline{z}(A_0)}^{\bar{z}(A_0)} p_S(z; A)dz, \text{ and } P_G(A, A_0) = \int_0^{\underline{z}(A_0)} p_G(z; A)dz$$

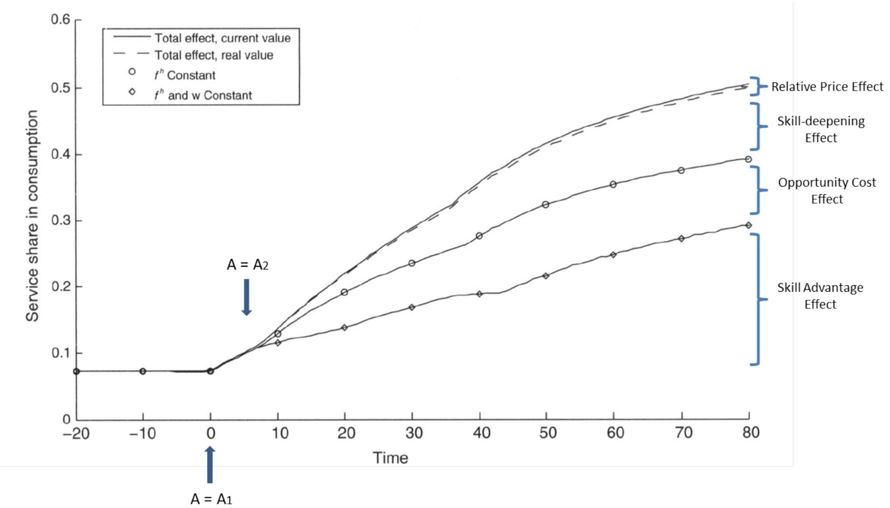
  - Average price of consumption bundle at A_0, evaluated at A.

Proposition 3

Assume $A \leq A_2$ and $A_0 = A$. Then $\frac{\partial [P_S(A,A_0)/P_G(A,A_0)]}{\partial A} > 0$

  - This proposition shows that after threshold A_2 the relative price of service grows, which is also consistent with US data after WW2.

Simulation


Total effect, current value
Total effect, real value
f^h Constant
f^h and w Constant
Service share in consumption
0.6
0.5
0.4
0.3
0.2
0.1
0
–20
–10
0
10
20
30
40
50
60
70
80
Time
A = A2
A = A1
Relative Price Effect
Skill-deepening Effect
Opportunity Cost Effect
Skill Advantage Effect

A Representative-agent Representation

- What changes when $A = A_1$?
- Income allocation problem (problem 2) can be rewritten as:
  - When $A < A_1$:

$$\max_{c_m, c_s} b_1 C_G^{\sigma_I} + b_2 \left[C_S + b_3 C_G\right]^{\sigma_I} \tag{55}$$

$$\text{s.t. } \tilde{P}_G C_G + C_S \leq VA \tag{56}$$

  - Where $b_1, b_2, b_3, \tilde{P_G}$ are parameters (See Buera & Kaboski, 2012, p23)

  - **'Quasi-preferences'**: σ are endogenous.
  - $\sigma_I = 1/(\lambda_I + 1)$
  - Preference is homothetic.
    $\Rightarrow$ increase in A leads to no change in share of service sector.

A Representative-agent Representation

- When $A > A_1$ (and $1 < \hat{z} = \underline{z} < \bar{z}$):

$$\max_{c_m, c_s} b_1 C_G^{\sigma_l} + b_2 \left[C_S + b_3 C_G\right]^{\sigma_h} \tag{57}$$

$$\text{s.t. } \tilde{P}_G C_G + C_S \leq VA \tag{58}$$

  - Where $b_1, b_2, b_3, \tilde{P_G}$ are parameters (See Buera Kaboski, 2012, p23)
  - $\sigma_h = \frac{1}{\lambda_h + 1} > \sigma_l = \frac{1}{\lambda_l + 1}$
  - Preference is no longer homothetic.
    $\Rightarrow$ increase in A leads to rise of service sector.

Discussion

- Is there any simpler approach to consolidate with wage-premium?
  - Maybe a representative-agent model with different types of labors (high-skilled and low-skilled).
  - Wage and labor supply data can be easily found.
  - Easy to calibrate and simulate, but cannot generate heterogeneous services.
- Who determines the schooling?
  - Labor himself/herself
  - Parents or household
  - or maybe: social planner or nation (state-owned education system)

Thanks for listening!