Structural Transformation

Joseph Kaboski [1]

[1]University of Notre Dame, STEG

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What is Structural Transformation?

"The rate of structural transformation of the economy is high. Major aspects of structural change include the shift away from agriculture to nonagricultural pursuits and, recently, away from industry to services; a change in the scale of productive units, and a related shift from personal enterprise to impersonal organization of economic firms, with a corresponding change in the occupational status of labor." – Kuznets (1973 Nobel Lecture)

What is Structural Transformation?

- most research focuses on sectoral patterns:
  - labor
  - value-added
  - consumption/final expenditures
- also called “structural change”

Plan for Lectures

1. Today: Focus on understanding ST patterns, implications for growth
2. Seminar: capital accumulation and growth dynamics under ST
3. Tomorrow: More normative ST patterns (agricultural productivity gap, premature industrialization, skill-biased services)

New Research Program

- “Structural Transformation and Economic Growth” (STEG)
- understand ways to industrialize, increase productivity, inclusively grow
- focus on *low income countries*, policy implications (macro development)
- broad both substantively and methodologically
- Partners: Notre Dame (BIG Lab), Oxford, ACET, Groningen, Y-RISE
- DFID-funded, CEPR-run, £12 million, 5 years
- Academic leads are Doug Gollin and I
- Started in 2020: continuing calls for grant proposals, conferences, lectures, etc.
- 2022: IMF course on ST and Inclusive Growth

Figure 1: Sectoral Shares of Employment and Value Added – Selected Developed Countries 1800–2000

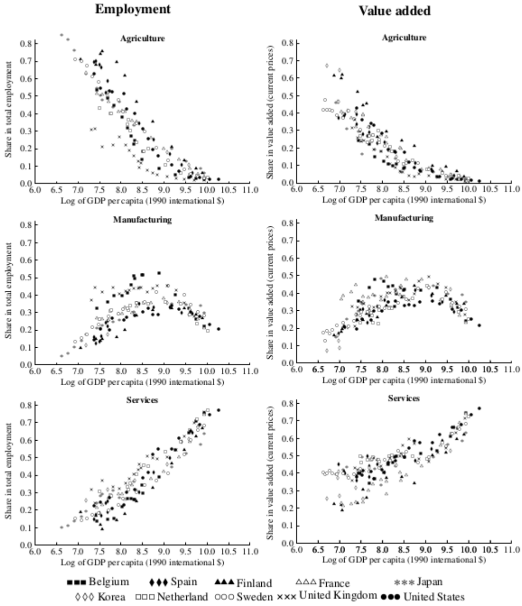


**Figure 2: Sectoral Shares of Hours Worked and Nominal Value Added –
5 Non–EU Countries and Aggregate of 15 EU Countries from EU KLEMS 1970–2007**

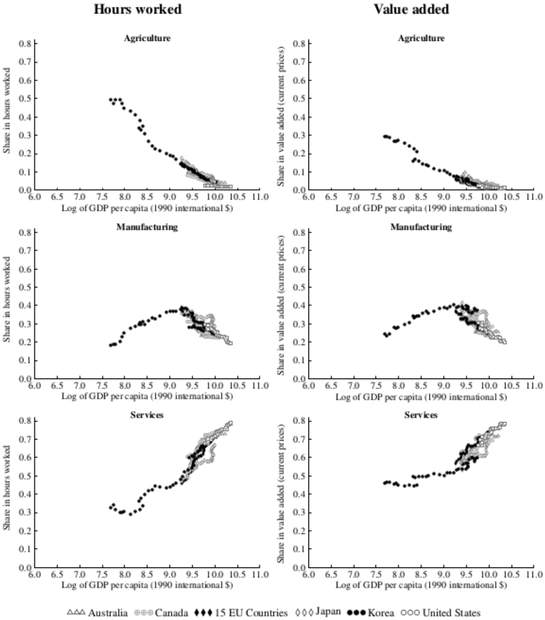


**Figure 5: Sectoral Shares of Employment –
Cross Sections from the WDI 1980–2000**

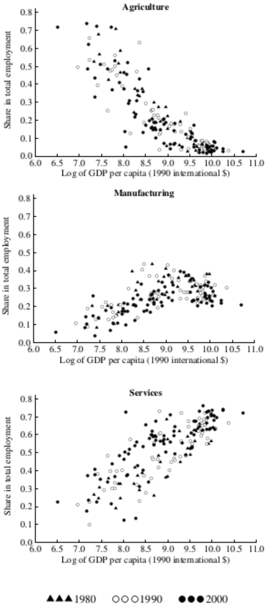


**Figure 6: Sectoral Shares of Nominal Value Added –
Cross Sections from UN National Accounts 1975–2005**

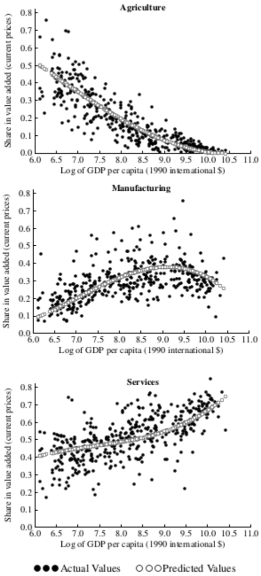


Figure 7: Sectoral Shares of Nominal Consumption Expenditure – US and UK 1900–2008

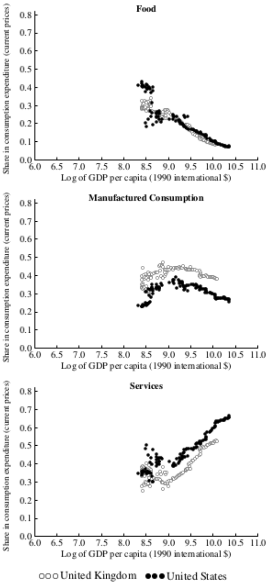
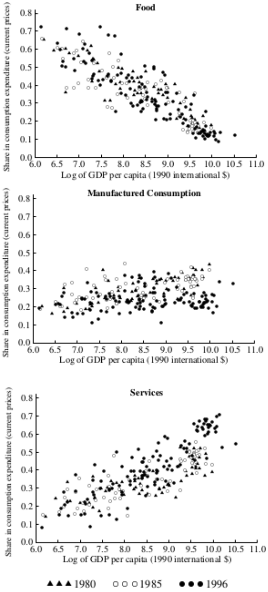
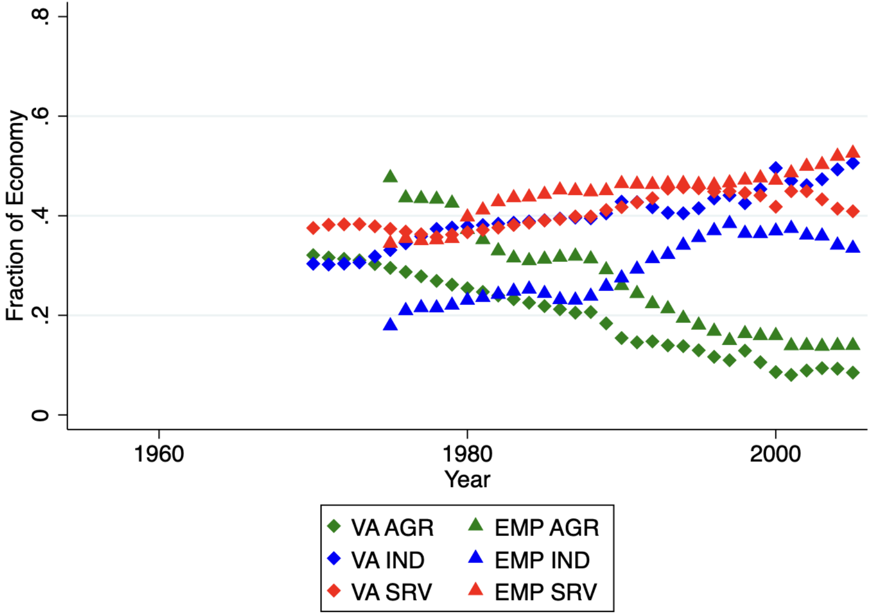


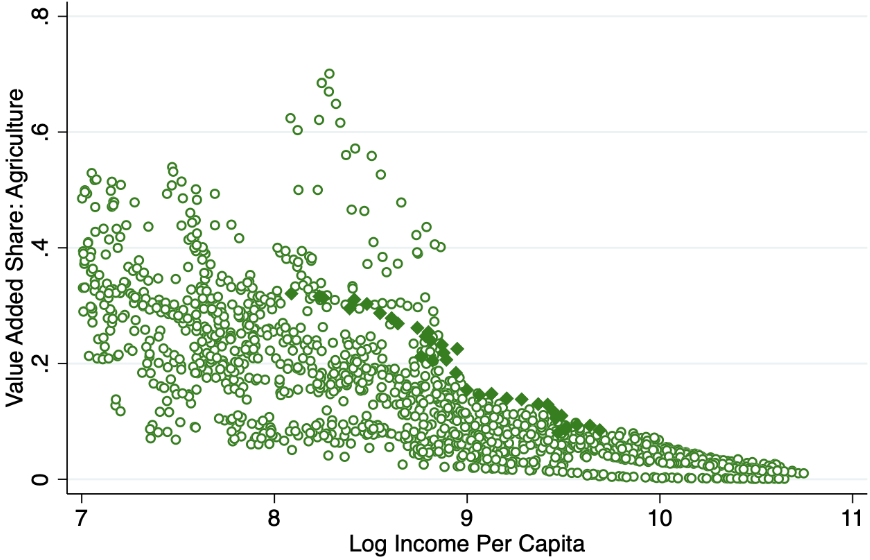
Figure 9: Sectoral Shares of Nominal Consumption Expenditure – Cross Sections from the ICP Benchmark Studies 1980, 1985, 1996



Malaysia's VA and Employment Shares over Time



Comparing Malaysia's Agriculture VA Share with Other Countries



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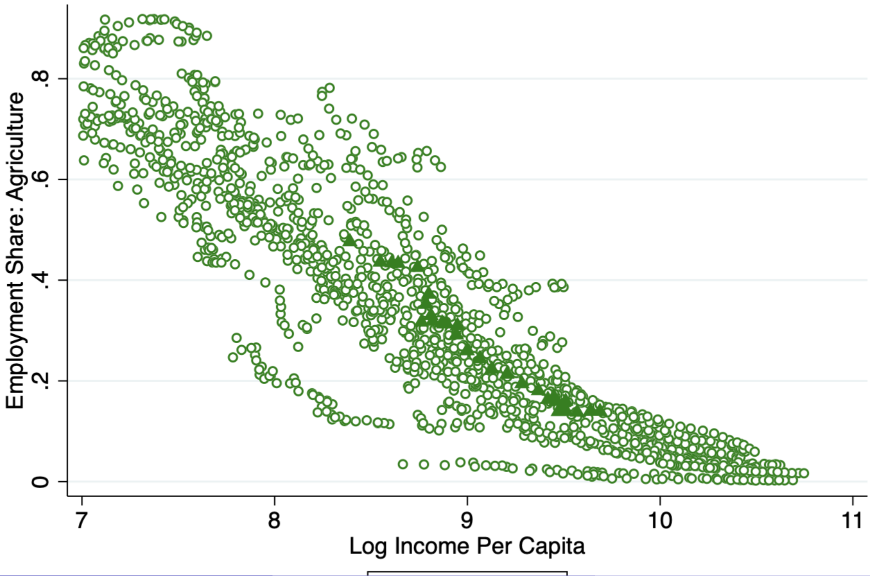
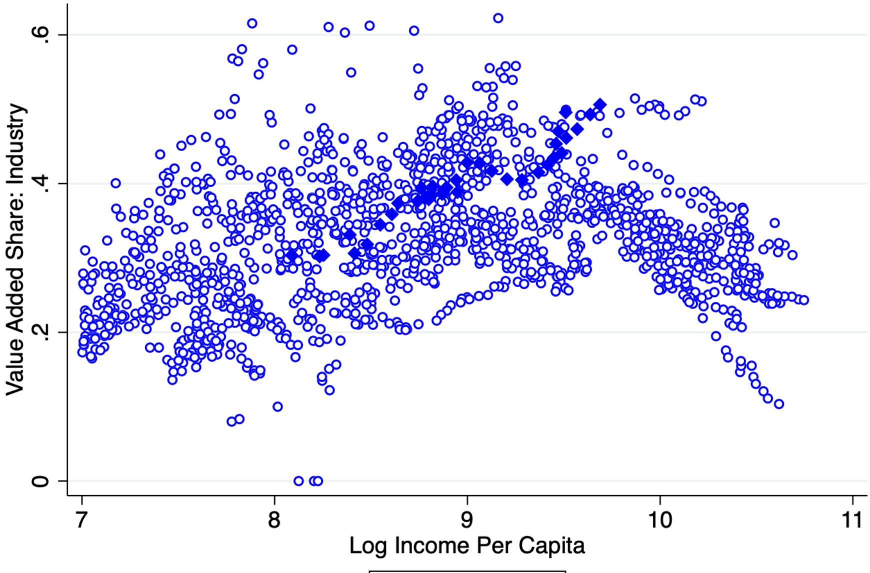
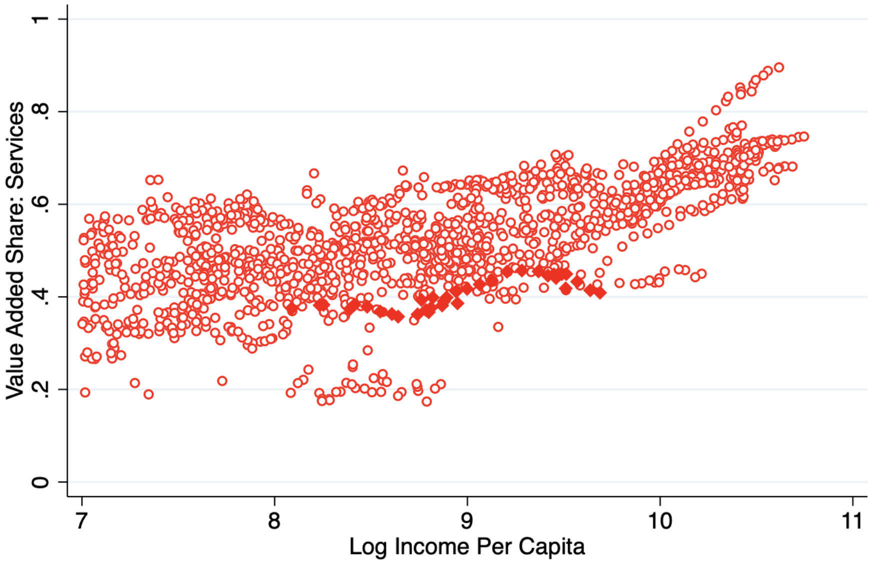


Comparing Malaysia's Industry VA Share with Other Countries

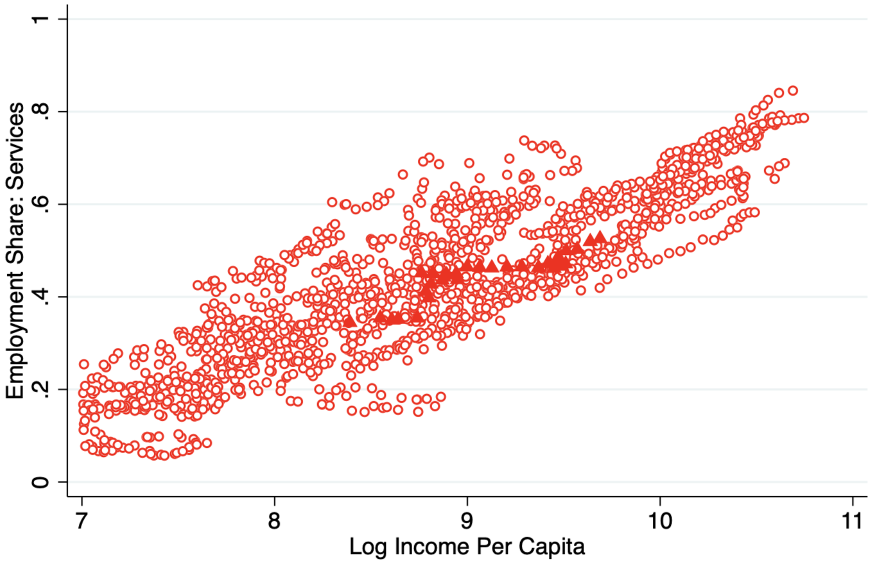


Comparing Malaysia's Industry Emp. Share with Other Countries

Comparing Malaysia's Service VA Share with Other Countries



Comparing Malaysia's Service Emp. Share with Other Countries



Why Do We Care about Structural Change?

Several possible reasons:

1. Dramatic effect on the structure of society
    - disrupts communities
    - change in style of living
    - related to other changes like female labor force participation, family life, etc.

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ST-Relevant Policies

Each of these influence can influence efficiency, growth, and inequality in principle

1. Integration
   - external: trade policy, capital flows
   - internal: infrastructure
2. Subsidies and taxes
   - Removing distortions - all standard models
   - Efficiency enhancing industrial policy
   - Formalizing small-scale producers
3. Human capital - especially schooling
4. Financial development - large scale tradable sectors

Overview

This presentation draws upon several papers:

- Buera and Kaboski (2009)
- Kongsamut, Rebelo, Xie (2001)
- Ngai and Pissarides (2007)
- Acemoglu and Guerrieri (2008)
- Comin, Mestieri, and Lashkari (2021)

Lecture Outline

1. Theory: Balanced Growth and Structural Change
    - Puzzles
    - Unsatisfying Solutions
    - Aggregate Implications
2. Fitting the Data: Difficulties and Advances
3. Normative Policy/Concerns

Kaldor's Stylized Facts

1. Output per worker grows at a constant rate
2. Capital per worker grows at a constant rate
3. Returns on capital are constant
4. Capital/output ratio is constant $\Longrightarrow$ K and Y grow at same rate
5. Capital and labor's shares are constant
6. Wide variation in growth rates of different countries

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How do we reconcile these patterns with dramatic structural transformation?

Two classic approaches to sectoral reallocation:

1. Preferences/Demand Story
   - Non-homothetic preferences
   - Agriculture is a necessity, while services are a luxury
2. Technology/Supply Story:
   - Differential produtivity growth
   - A has high productivity growth,
   - S has low productivity growth
   - sectoral elasticity of substitution <1.

Constant growth puzzle 1: Non-homotheticicities

Euler Equation:

$$u'(c_t) = \beta(1 + r)u'(c_{t+1})$$

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Standard preferences imply constant growth:

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$$\frac{c_{t+1}}{c_t} = [\beta(1+r)]^{1/\theta}$$

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Subsistence requirement $\underline{c}$ implies increasing growth:

$$u(c) = \frac{(c-\underline{c})^{1-\theta}}{1-\theta}$$

$$\frac{c_{t+1}-\underline{c}}{c_t-\underline{c}} = [\beta(1+r)]^{1/\theta}$$

Balanced growth puzzle: differential productivity

- CES Aggregator over 2 intermediates:

$$
\begin{aligned}
y_t(x_{1,t}, x_{2,t}) &= \left(\phi_1 x_{1,t}^{\frac{\varepsilon-1}{\varepsilon}} + \phi_2 x_{2,t}^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}} \\
x_{1,t} &= A_1 \gamma_1^t l_t \\
x_{2,t} &= A_2 \gamma_2^t (1 - l_t) \\
\gamma_2 &> \gamma_1
\end{aligned}
$$

- if $\varepsilon < 1$, l_t increases over time, and $\frac{y_{t+1}}{y_t}$ falls over time (as $l \to 0$, $\frac{y_{t+1}}{y_t} \to \gamma_1$ when $l \to 1$, $\frac{y_{t+1}}{y_t} \to \gamma_2$)
- "Baumol's Disease" – slowest growth sector sucks up resources and drags the economy down (think health care)

Balanced growth puzzle 3: sector capital shares

Think of differences in shares across sectors

$$y_i = A_i \gamma_i^t k_{i,t}^{\alpha_i} l_{i,t}^{1-\alpha_i}.$$

$$\alpha_1 < \alpha_2$$

$$z \equiv \frac{p_1 y_1}{p_1 y_1 + p_2 y_2}$$

$$s_k \equiv \frac{RK}{Y}$$

$$s_k = \frac{Rk_1 + Rk_2}{p_1 y_1 + p_2 y_2}$$

$$s_k = \alpha_1 z + \alpha_2 (1 - z)$$

So if $z \uparrow$ (i.e., sector 1 grows faster), agg. capital share $\downarrow$

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Consider Combined Framework: BK (2009)

Allows for:

- generalized Stone-Geary non-homotheticities
- biased productivity growth
- sector-specific factor shares

KRX (2001), NP (2007), AG (2008) are special cases

Non-Homothetic Preferences

Generalized Stone-Geary:

$$\begin{aligned} U(c) &= \sum \beta^t \frac{\tilde{C}_t^{1-\theta} - 1}{1-\theta} \\ \tilde{C}_t &= \left[\sum_{i=a,m,s} \phi_i \left(c_{i,t} - \underline{c}_i \right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}} \end{aligned}$$

Consumer's Problem

$$\max_{\{c_{i,t}\}_{i=a,m,s},k_t} U(c)$$

$$s.t.$$

$$p_{mt}I_t + \sum_{i=a,m,s} p_{i,t}c_{i,t} \leq R_t k_t + w_t h$$

$$k_{t+1} = (1-\delta)\,k_t + I_t$$

Optimality

Intratemporal FOC:

$$\frac{\phi_i}{\phi_j}\left(\frac{c_{i,t}-\underline{c}_i}{c_{j,t}-\underline{c}_j}\right)^{-1/\varepsilon}=\frac{p_{i,t}}{p_{j,t}} \tag{1}$$

Euler Equation:

$$\frac{\tilde{C}_{t+1}}{\tilde{C}_t}^{\theta-1/\varepsilon}\left(\frac{c_{m,t+1}-\underline{c}_m}{c_{m,t}-\underline{c}_m}\right)^{1/\varepsilon}=\left[\frac{R_{t+1}}{p_{m,t}}+1-\delta\right]$$

Constant growth requires both:

1. constant R and p_m
2. $\underline{c}_m=0$

Kongsamut, Rebelo, Xie (2001): Demand Driven

- Supply Assumptions:

$$\frac{p_{i,t}}{p_{j,t}} = \frac{p_i}{p_j}$$

by intratemporal FOC, growth $\frac{\tilde{C}_{t+1}}{\tilde{C}_t} = \frac{\tilde{c}_{i,t+1}}{\tilde{c}_{i,t}}$ (constant).

- Demand Assumptions:

$$\begin{aligned} \underline{c}_a &> 0,\ \underline{c}_s < 0,\ \underline{c}_m = 0 \\ p_a \underline{c}_a &= -\underline{c}_s p_s \end{aligned}$$

- Consumption is then

$$\begin{aligned} C_t &= p_a c_{a,t} + p_m c_{m,t} + p_s c_{s,t} \\ &= p_a \left(c_{a,t} - \underline{c}_a\right) + p_m c_{m,t} + p_s \left(c_{s,t} - \underline{c}_s\right) \end{aligned}$$

KRX (2001): Unsatisfying Solution

- Results:
  - labor, consumption, output grows:
    - slower in agriculture
    - faster in services
  - constant Kaldor growth
- How? No net subsistence requirement/endowment in budget
- Caveats:
  1. predicts flat manufacturing share
  2. predicts early growth in services
  3. requires (counterfactually) flat relative prices
  4. needs cross-restrictions on technology/preferences

Production

Allow for biased sectors:

$$y_i = A_i \gamma_i^t k_{i,t}^{\alpha_i} l_{i,t}^{1-\alpha_i}$$

Firms' Problem:

$$\max_{k_i, h_i, l_i} p_{i,t} A_i \gamma_i^t k_{i,t}^{\alpha_i} l_{i,t}^{1-\alpha_i} - \left(1 + \tau_k^i\right) R k_i - \left(1 + \tau_w^i\right) w h_i l_i$$

Here τ_k^i and τ_w^i are any friction or wedge on using inputs in sector i.

Results for Symmetric Cobb-Douglas

- Assuming $\alpha_i = \alpha \implies$ linear PPFs

$$\frac{p_{it}}{p_{jt}} = \frac{A_j \gamma_j^t}{A_i \gamma_i^t} \left(\frac{1+\tau_k^i}{1+\tau_k^j} \right)^{\alpha} \left(\frac{1+\tau_w^i}{1+\tau_w^j} \right)^{1-\alpha}$$

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- Since R and w are constant across sectors:

$$\frac{1+\tau_k^i}{1+\tau_w^i} \frac{k_i}{h_i l_i} = \frac{1+\tau_k^j}{1+\tau_w^j} \frac{k_j}{h_j l_j}$$

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- If $\tau_w^i = \tau_w, \tau_k^i = \tau_k$, output and labor payment measures equal:

$$\frac{p_i y_i}{\sum_j p_j y_j} = \frac{w h_i l_i}{w \sum_j h_j l_j} = f_i$$

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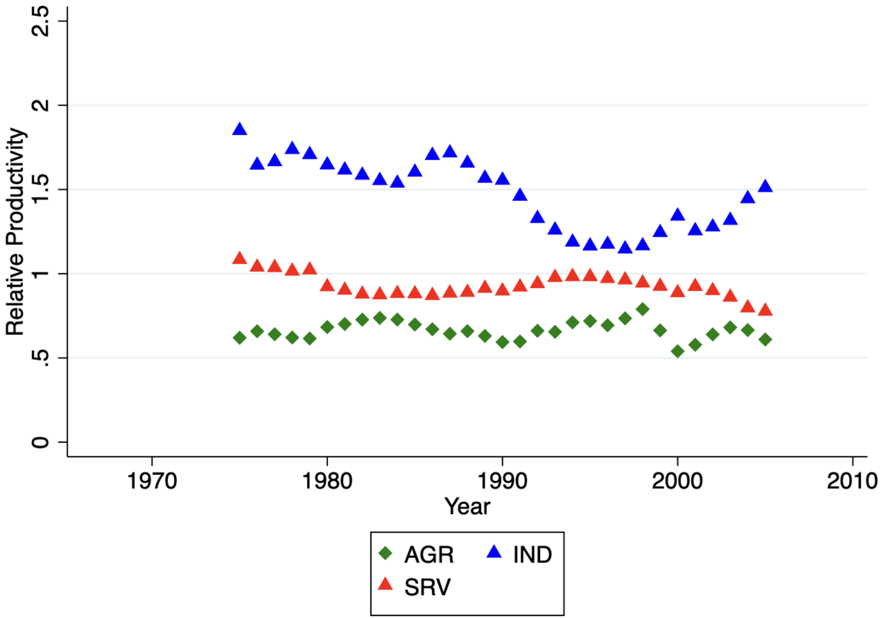
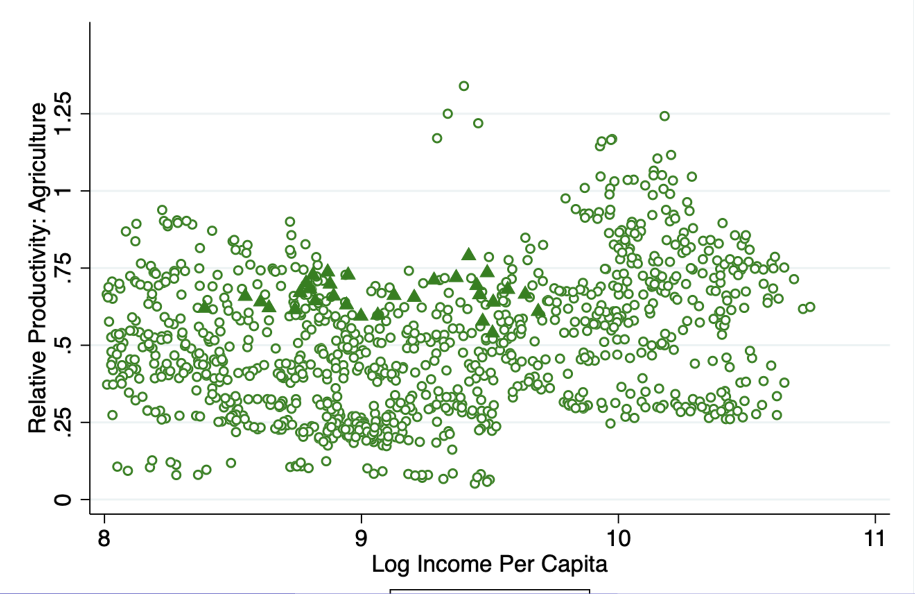


Comparing Malaysia's Agricultural Rel. Prod. with Other Countries



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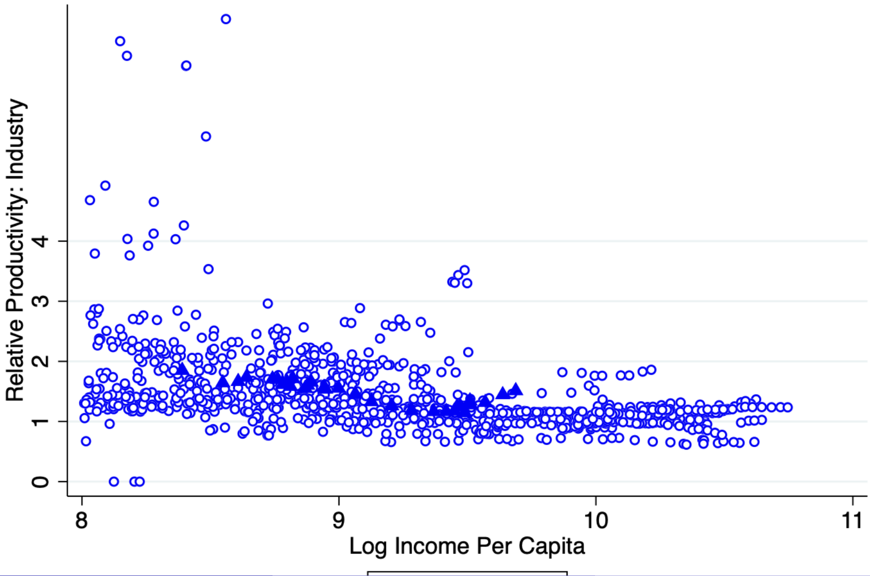
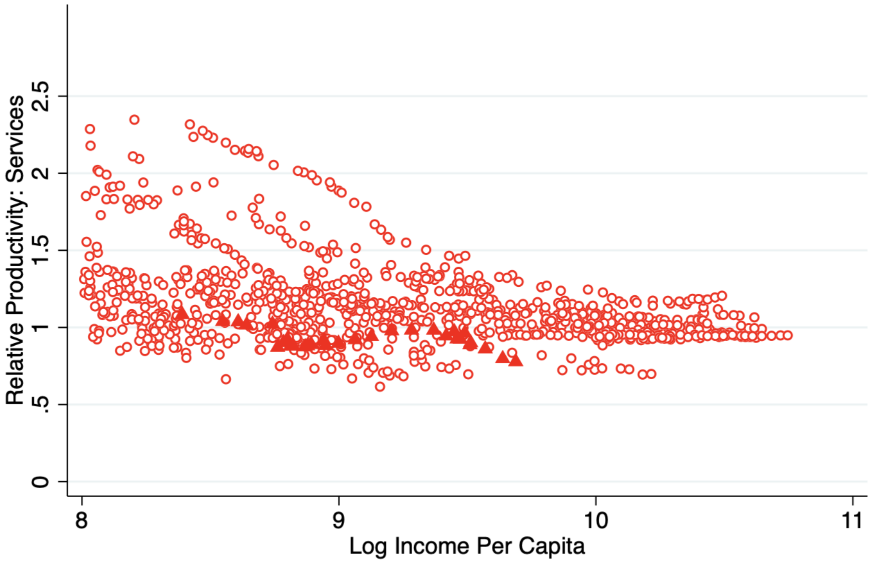


Comparing Malaysia's Service Rel. Prod. with Other Countries



Ngai and Pissarides (2007): Supply Driven Explanation

- Supply Assumptions:
  - differential productivity growth: $\gamma_a > \gamma_m > \gamma_s$
  - $\implies p_{it}/p_{jt}$ vary over time, but make c_m the numeraire
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- Demand Assumptions:
  - Homothetic preferences (i.e., $\underline{c}_i = 0$)
  - Low elasticity of substitution: $\varepsilon < 1$
  - Log intertemporal substitution: $\theta = 1$
    $\implies BGP$ (investment doesn't respond to changing capital price)

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    $\implies BGP$ (investment doesn't respond to changing capital price)
- Key equations:

$$n_i \equiv \frac{l_i}{L} = \frac{p_i c_i}{PY}$$

$$\frac{\dot{n}_i}{n_i} = (1 - \varepsilon)(\overline{\gamma} - \gamma_i)$$

$$\overline{\gamma} \equiv \sum_i n_i \gamma_i$$

NP (2007): Unsatisfying Solution

- Results:
  - labor, consumption, output grows:
    - slower in agriculture
    - faster in services
    - *slight* hump share in manufacturing
  - constant Kaldor growth
- How? Log intertemporal elasticity and non-changing numeraire
- Caveats:
  1. predicts almost flat manufacturing share
  2. predicts constant growth in services
  3. requires no income effects
  4. doesn't *really* avoid Baumol's disease

Growth Implications of Generalized Model

- Equivalent Program for Linear PPF Case:

$$\max_{C_t, k_t} \sum \hat{\beta}_t \frac{C_t^{1-\theta}}{1-\theta} s.t.$$
$$I_t + C_t \leq R_t k_t + w_t h - \sum p_{i,t} \underline{c}_i$$
$$k_{t+1} = (1-\delta) k_t + I_t$$

$$C_t = \left[\sum_{i=a,m,s} \left(\frac{\phi_i}{\phi_m} \right)^{\varepsilon} \left(\frac{A_m \gamma_m^t}{A_i \gamma_i^t} \right)^{1-\varepsilon} \right] (c_{mt} - \underline{c}_m)$$
$$\hat{\beta}_t = \beta^t \left[\sum_{i=a,m,s} \left(\frac{\phi_i}{\phi_m} \right)^{\varepsilon} \left(\frac{A_m \gamma_m^t}{A_i \gamma_i^t} \right)^{1-\varepsilon} \right]^{\frac{\theta-1}{1-\varepsilon}}$$

- Both models set $\underline{c}_m = 0$ and $\sum p_{i,t} \underline{c}_i = 0$
- In NP, Baumol's disease still present in C and effective discount rate
- When Kaldor holds, ST irrelevant for growth

Acemoglu and Guerrieri (2008): Rybczinski Supply Story

- Supply Assumptions:
  - different capital shares: $\alpha_i > \alpha_j$
  - allow for different productivity growth, as long as

$$(\gamma_1)^{\frac{1}{1-\alpha_1}} < (\gamma_2)^{\frac{1}{1-\alpha_2}}$$

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- Demand Assumptions: Same as NP
- What is the impact of capital deepening?
- *Rybczinski Theorem:* when a factor of production (e.g., K) is increased there is a decline in the relative price of the good whose production is relatively intensive in that factor

AG (2008): Unsatisfying Solution

- Results:
  - labor, consumption, output grows:
    - slower in capital intensive sector
    - faster in non-capital intensive sector
  - constant growth – but only asympotically
- How? Asymptotically, it is a single sector model
- Caveats:
  1. no big difference in capital share across standard sectors
  2. redefine sectors and get evidence of structural change
  3. changing aggregate capital's share (non-Kaldor)

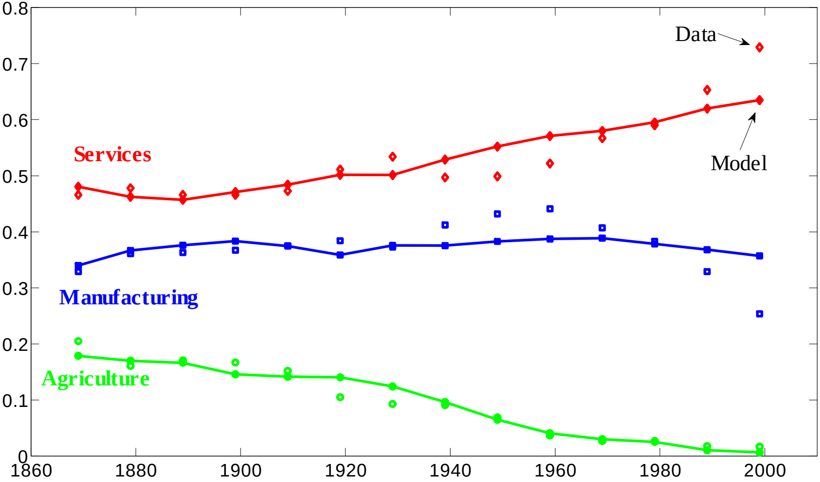
Quantitative and Normative Questions: BK (2008)

1. Can traditional theories fit the data?
2. How important are sectoral distortions/ relative human capital differences?
3. Can the theory predict structural change in a cross-section of countries?

Estimation/calibration

- Data: $\{y_i\}_{i=a,m,s}$, $\left\{\frac{p_i}{p_m}\right\}_{i=a,s}$, k_0
- Parameters: $\{\bar{c}_i\}_{i=a,m,s}$, ε, $\{\gamma_i\}_{i=a,s}$, $\left\{\frac{h_i\left(1+\tau_l^i\right)}{h_a\left(1+\tau_l^a\right)}\right\}_{i=m,s}$,
  $\alpha = 1/3$, $\delta = 0.08$, $\sigma = 1$, $\beta = 0.94$

Model's Fit, US 1870-2000

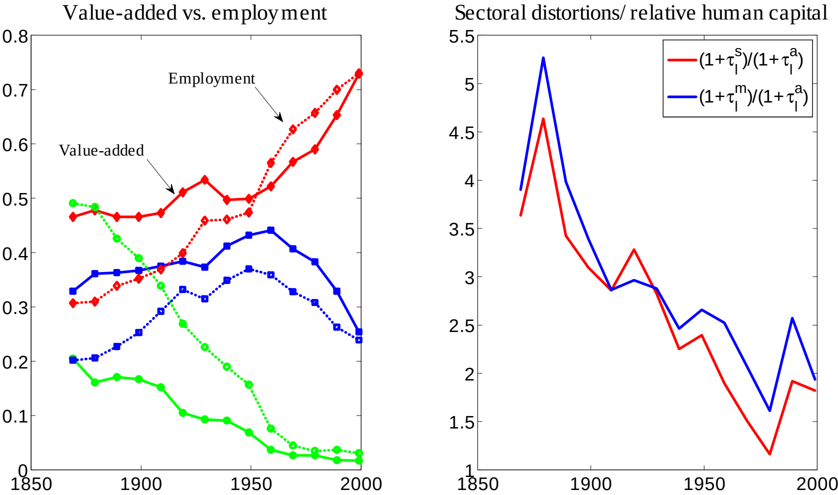


Estimated Role of Demand and Supply

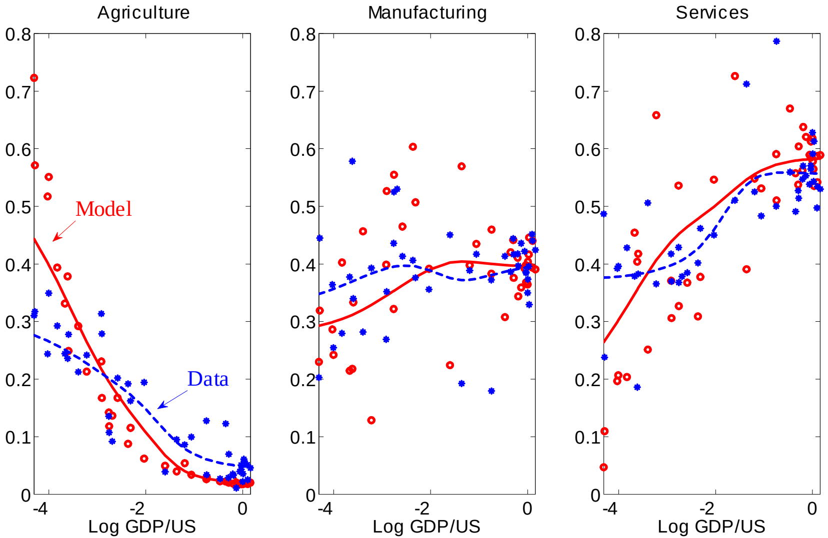
- Agriculture: $\bar{c}_a > 0$ ($\approx$ one dollar a day)
- Services: $\bar{c}_s < 0$
- Manufacturing: $\bar{c}_m = 0$
- $\varepsilon \approx 0$ (Leontief)

Value-added vs. Employment

Sectoral distortions/ relative human capital



Predicting Cross-section of countries in 1990



Summary of Fit

Two key failures:

1. delayed acceleration of services, steep decline of manufacturing
2. differential patterns of value-added and labor shares

This motivates:

1. preferences with more nuanced income effects, ·.g. Boppart (2015), Comin, Lashkari, Mestieri (2021)
2. normative wedge analysis of structural change patterns .g., Cheremukhin et al (2017a,b), Buera et al (2018)

CLM (2021) Preferences

Indirectly defined preferences:

$$\sum_{i=1}^{I} \Omega_i^{\frac{1}{\sigma}} C_t^{\frac{\varepsilon_i - \sigma}{\sigma}} C_{it}^{\frac{\sigma-1}{\sigma}} = 1,$$

- σ is the elasticity of substitution.
- ε_i is the real income elasticity $\rightarrow$ constant (non-diminishing)
- If $\varepsilon_i = 1$, we recover homothetic CES.
- Assume $\sigma \in (0, 1)$ and $\varepsilon_i \geq 1$.

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- Assume $\sigma \in (0, 1)$ and $\varepsilon_i \geq 1$.
- Can freely normalize one Ω_i and one ϵ_i

CLM (2021) Demand Equations

- Much simpler demand equations

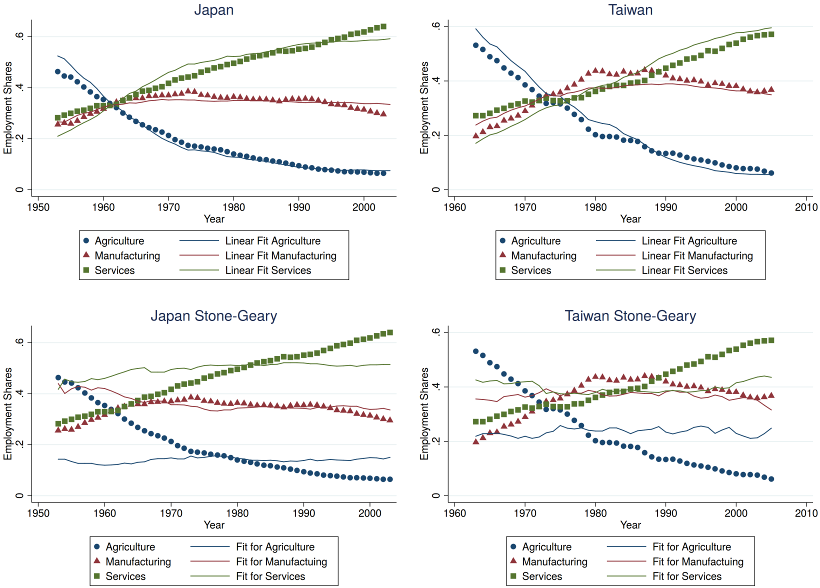
$$\ln s_{it} = \ln \Omega_i - \sigma \ln \tau_{Cict} - (1-\sigma) \ln \left(\frac{p_{ict}}{P_{ct}} \right) + (\epsilon_i - 1) \ln \left(\frac{p_{ict}}{P_{ct}} \right)$$

  $\epsilon_i = 1 \rightarrow$ Homotheticity, $\sigma = 1 \rightarrow$ Cobb-Douglas.

- Can estimate, quantify channels:
  $\Longrightarrow$ majority income effects: 86%(A), 57%(M), 82%(S)
- Much improved fit

Asia - Nonhomothetic CES vs. Stone-Geary

Uses World Estimates for All Elasticities, $\{\sigma, \varepsilon_a - \varepsilon_m, \varepsilon_s - \varepsilon_m\}$



Asia

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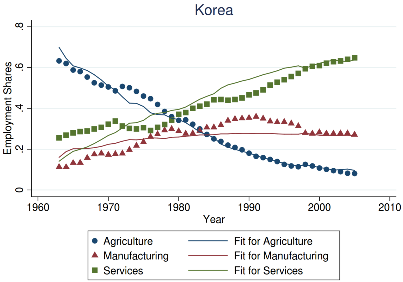

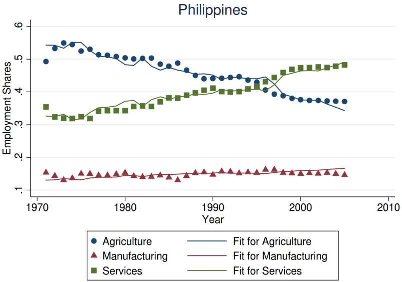

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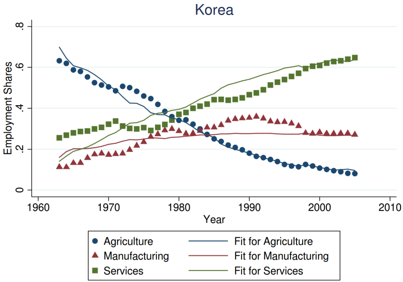
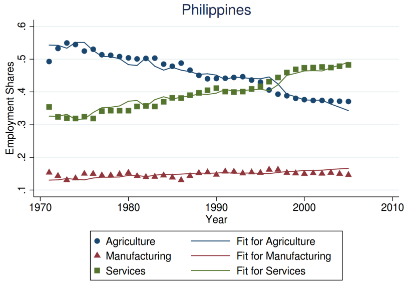
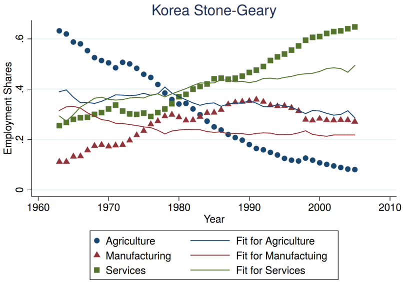
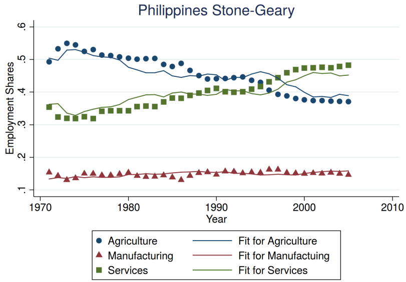


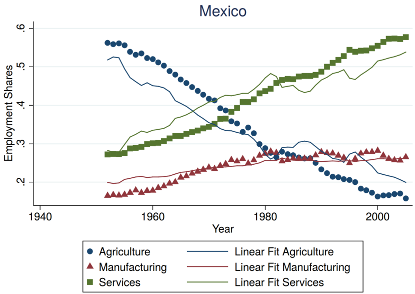


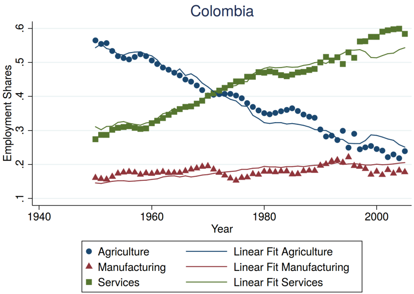




Latin America

Uses World Estimates for All Elasticities, $\{\sigma, \varepsilon_a - \varepsilon_m, \varepsilon_s - \varepsilon_m\}$





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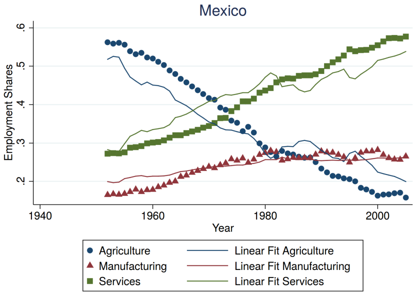
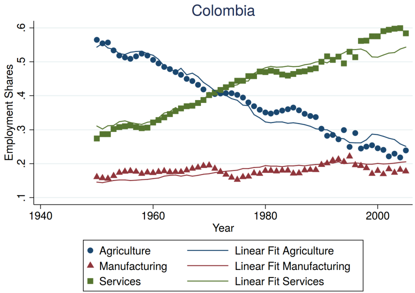
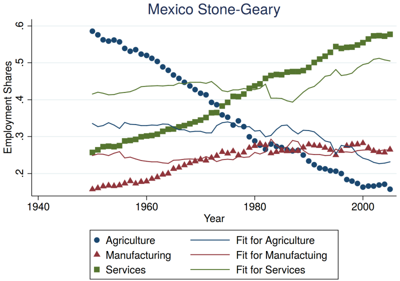
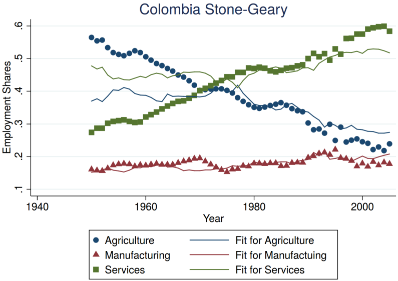


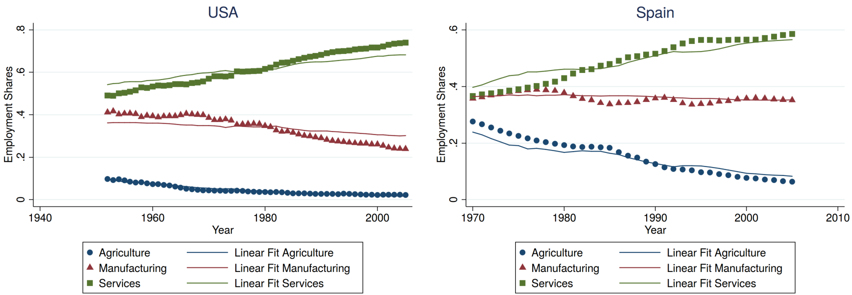






OECD*

Uses World Estimates for All Elasticities, $\{\sigma, \varepsilon_a - \varepsilon_m, \varepsilon_s - \varepsilon_m\}$



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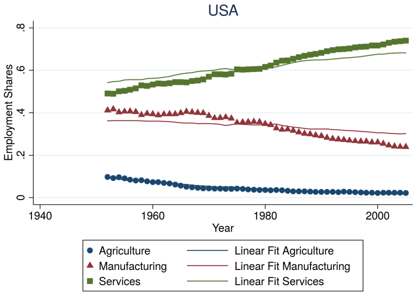
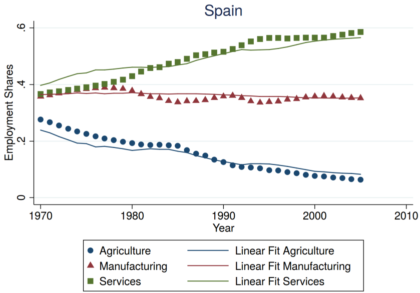
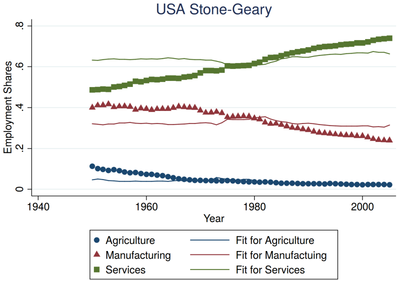
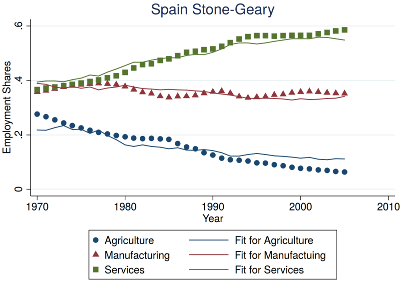


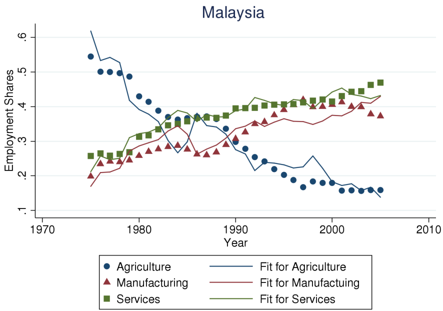


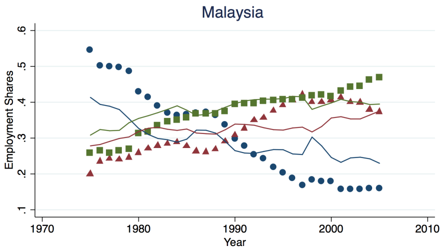




Malaysia's Fit

Uses World Estimates for All Elasticities, $\{\sigma, \epsilon_a - \epsilon_m, \epsilon_s - \epsilon_m\}$





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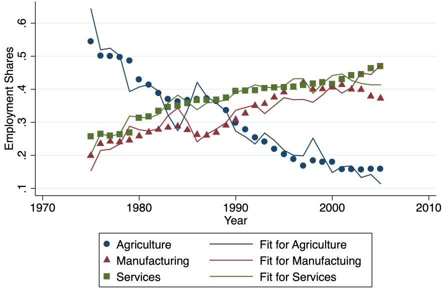
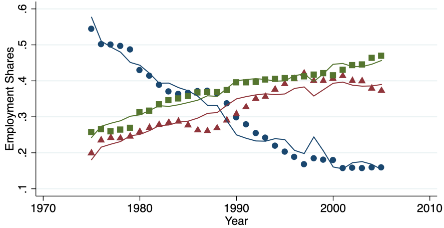


Stone-Geary

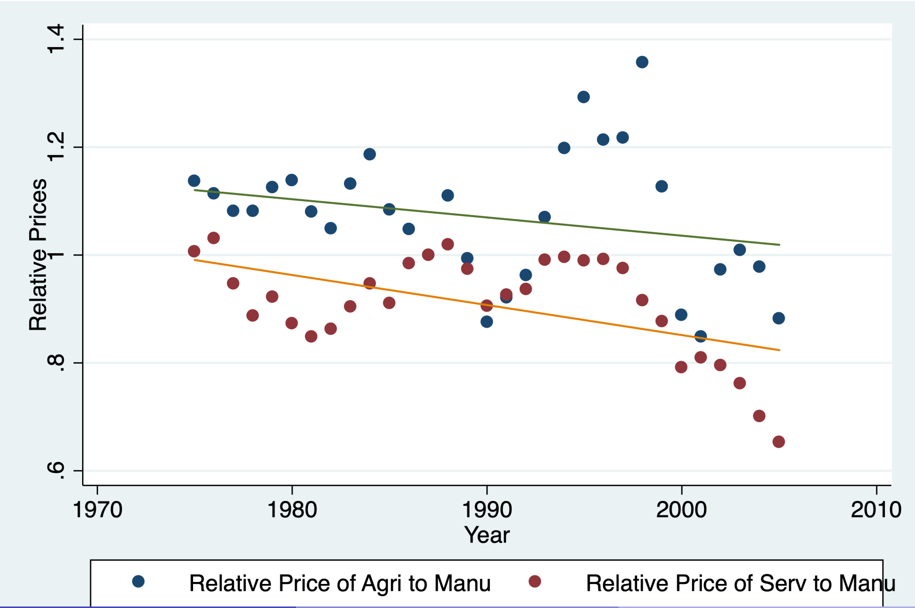


Understanding Poor Malaysia Fit for Stone-Geary

1. Stone-Geary income effects are short-lived, so need a lot of work from relative prices
2. Malaysia is unusual in that the relative price of services falls over time (rises elsewhere)
3. very little action from relative prices, so fit is flat
4. country-specific estimate fits better but imputes manufacturing as a luxury good

Malaysia's Relative Prices

Uses Malaysia Estimates for All Elasticities, $\{\sigma, \epsilon_a - \epsilon_m, \epsilon_s - \epsilon_m\}$



Conclusions

- Important question on many fronts
- Lots of puzzles
- Progress in terms of positive prediction
- Lots of work to do on normative questions