Heterogeneous Paths of Structural Transformation

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Background

- Structural transformation is a robust feature of economic development
  - Reallocation of labor from agriculture into manufacturing and services
  - Hump-shaped pattern in manufacturing and rise in services
- Extensive literature on factors driving the process of labor reallocation away from agriculture
- This paper belongs to the literature on labor allocation between manufacturing and services
  - Heterogeneous patterns across economies
  - Implications for growth and development

Motivation

- Rodrik (2016) documents
  - Premature Deindustrialization: Lower and earlier peaks of manufacturing hump shapes in later developers relative to earlier developers
  - Global trend of deindustrialization: Decline in the share of manufacturing in both developed and developing economies in recent decades
  - Attribute to global sources: rising globalization and labor-saving technology in manufacturing
  - Implication: Timing of development matters for economic growth $\rightarrow$ Later developers run out of industrialization and growth opportunities
- Huneeus and Rogerson (2022) suggest alternative explanation
  - Variation in rate of convergence to the frontier across countries
  - Variation in agricultural productivity growth is the key factor

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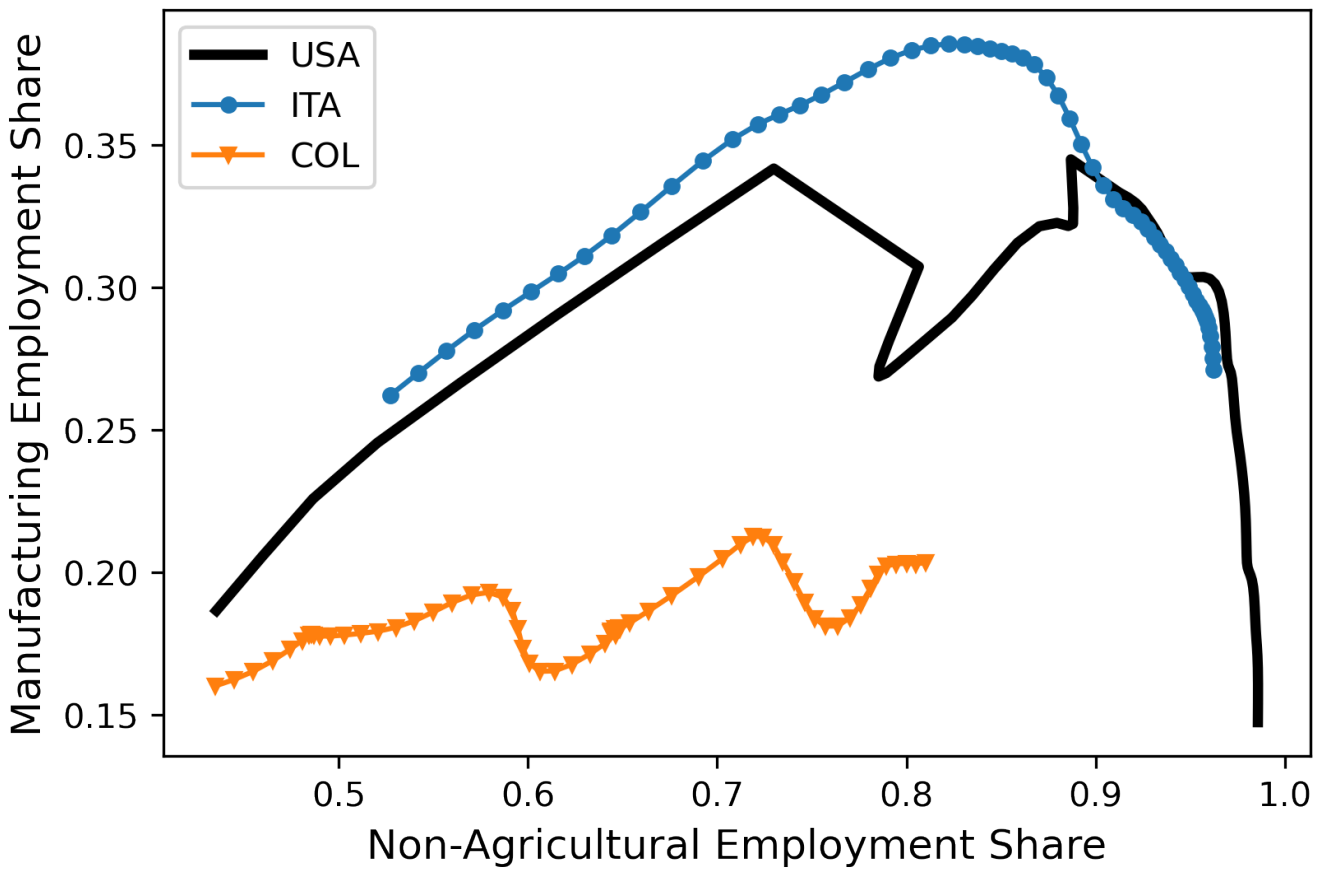
Findings and Implications

- Fact 1: Many countries follow flat profiles of manufacturing without noticeable sign of deindustrialization different from conventional steep hump-shaped path in the US



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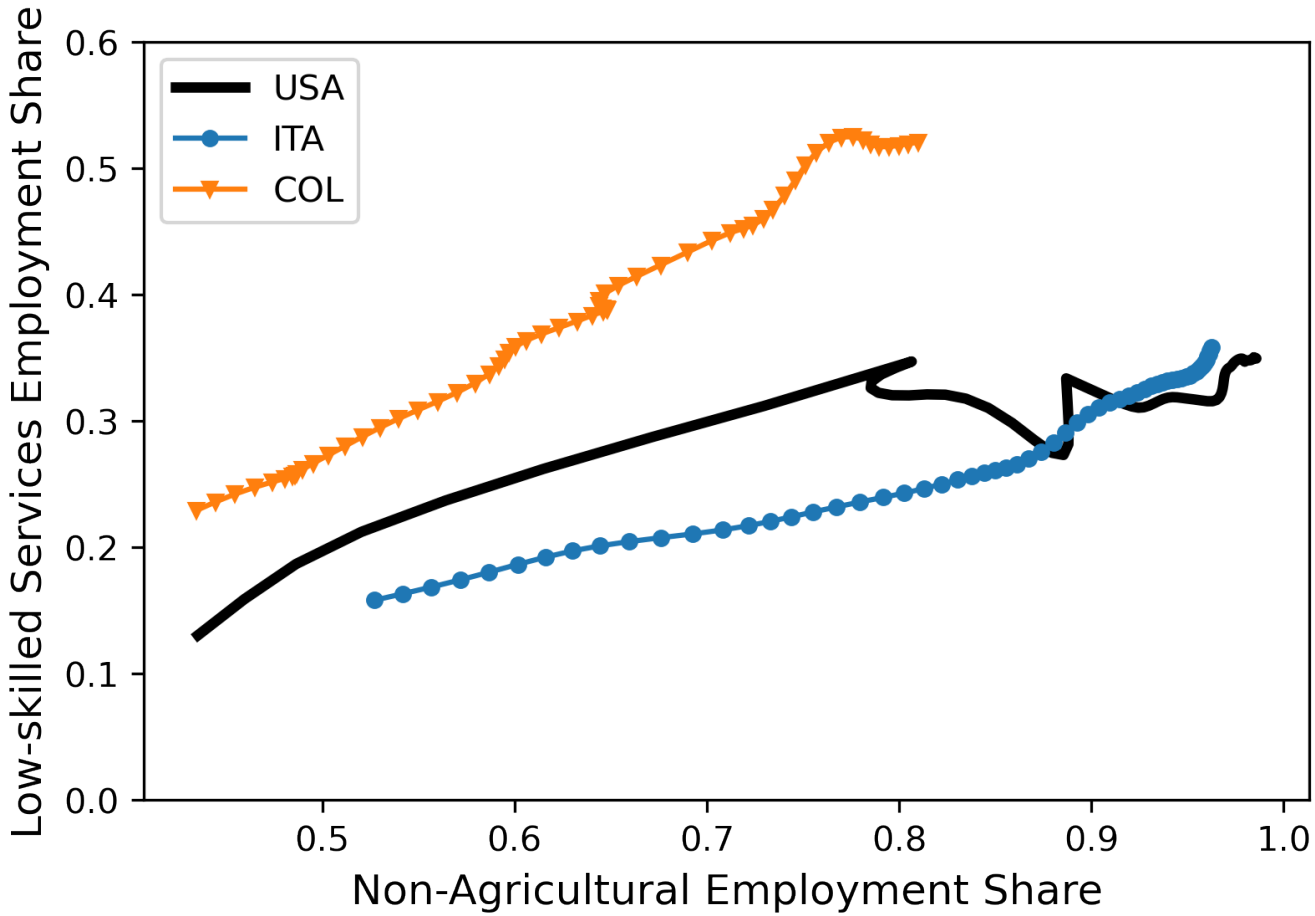
- Fact 2: "Flat manufacturing" countries become services economies but they become low-skilled services economies different from high-skilled services in high-income countries



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- Fact 2: "Flat manufacturing" countries become services economies but low-skilled services economies different from high-skilled services in high-income countries
- Fact 3: Heterogeneous patterns are observed in both early and late developers $\rightarrow$ Not simply explained by the timing of development
- Explanation: Variation in relative productivity levels between manufacturing and low-skilled services
- Implication: country-specific factors/distortions are major driving forces behind the phenomenon $\rightarrow$ Potential role for domestic policies/institutions

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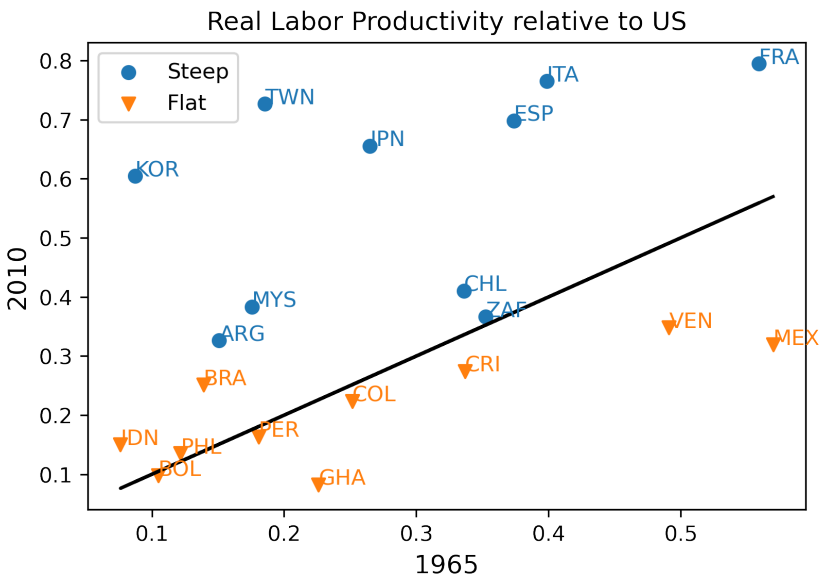
Implication for Aggregate Growth

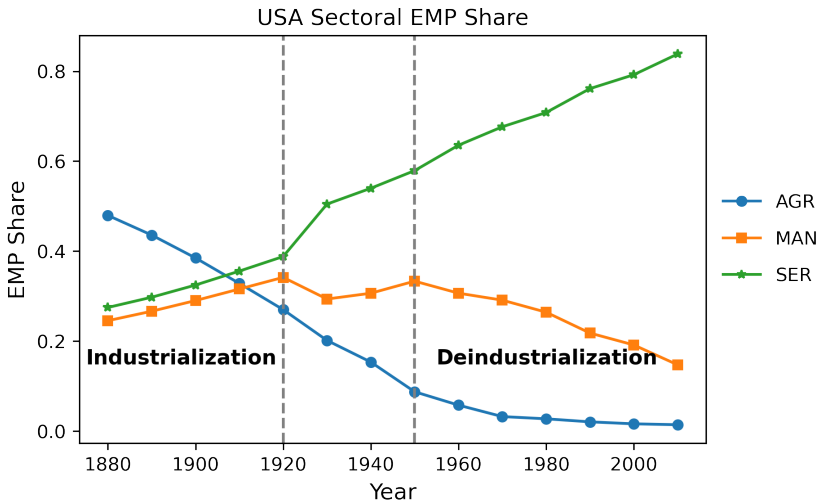


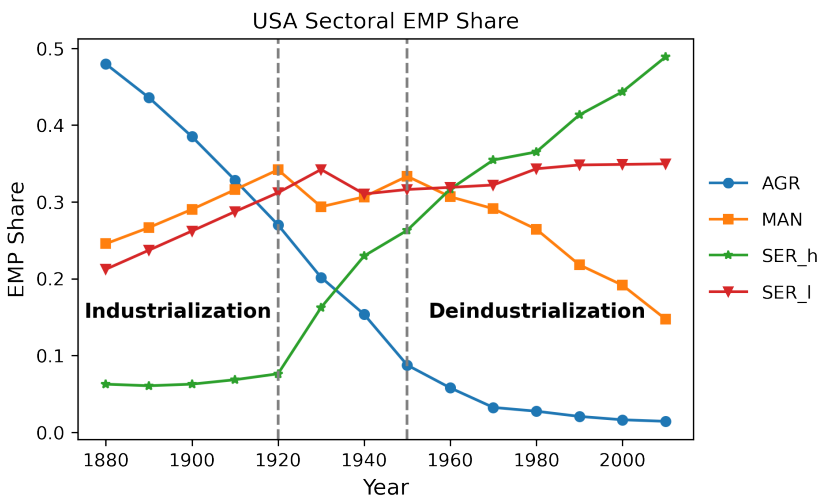
- Different structural transformation patterns are associated with different aggregate growth experience
- During the period 1960-2010, relative to the US (frontier economy),
  - Steep Manufacturing: fast catch up
  - Flat Manufacturing: stagnation or decline
- Labor allocation between manufacturing and services sectors have important implication for growth and development

Breakdown of Services Sector

- Large degree of heterogeneity within services sector
- Standard classification of services sectors by skill intensity: hour share of high-skilled labor over all labor
- Final classification:
  - Low-skilled services: G+H (Trade, Hotel, Restaurants), I (Transport, Storage, Communications), O+P (Community and Personal Services)
  - High-skilled services: J+K (Finance, Real estate, Business services) and L+M+N (Government, Education, Health)

Structural Transformation in the United States





- Different types of *SER* rise at different stage of development
- Different patterns between industrialization and deindustrialization phases
- Industrialization: Labor out of AGR is mostly reallocated to *MAN* and SER_l
- Deindustrialization: Decline in MAN is associated with the rise of SER_h

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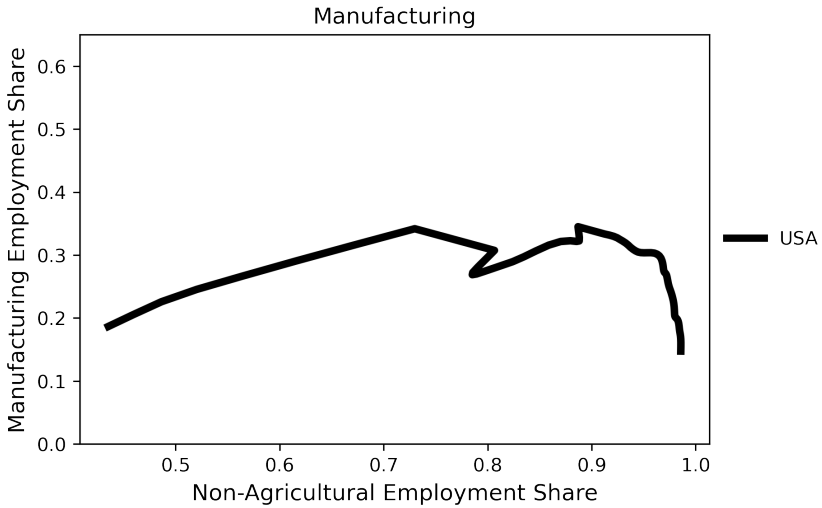
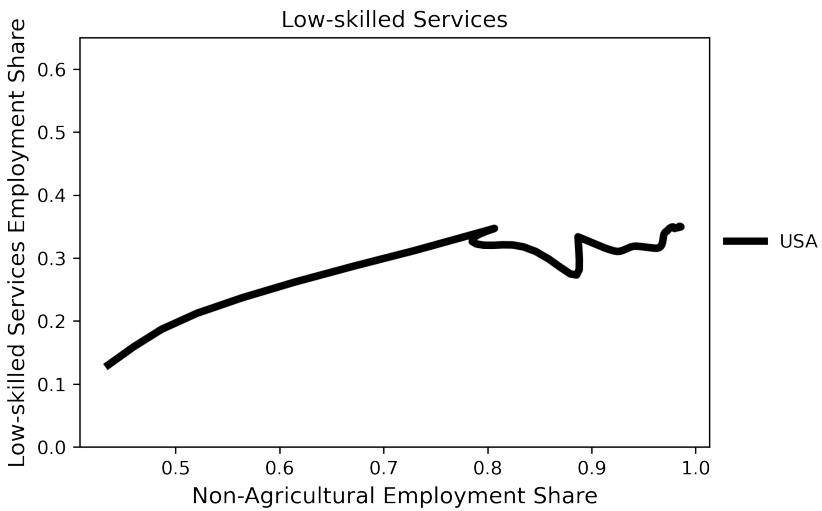
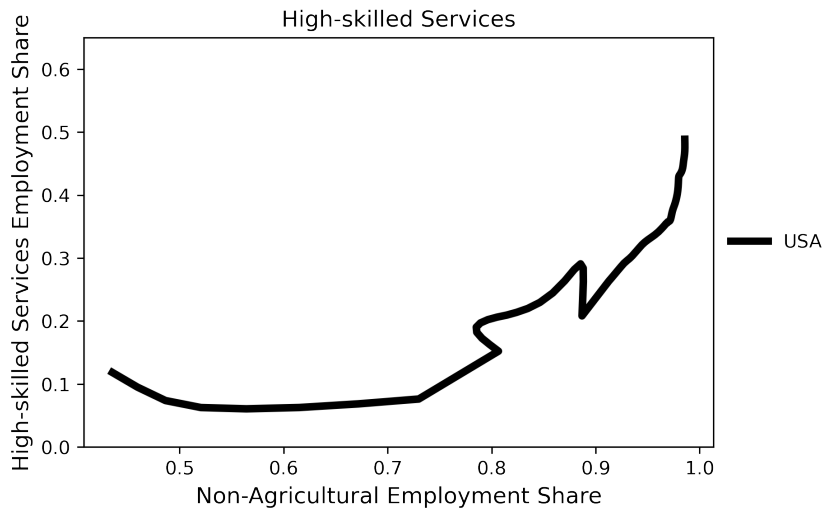
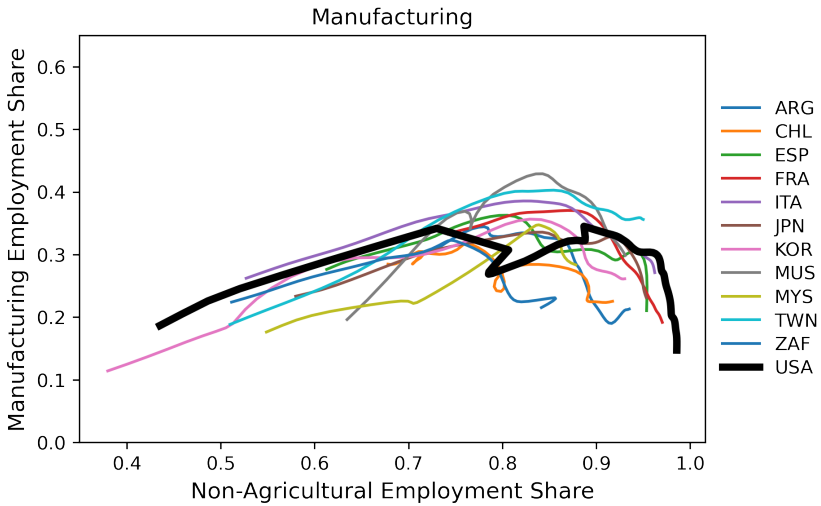


- Representation of US structural change pattern over non-agricultural employment share

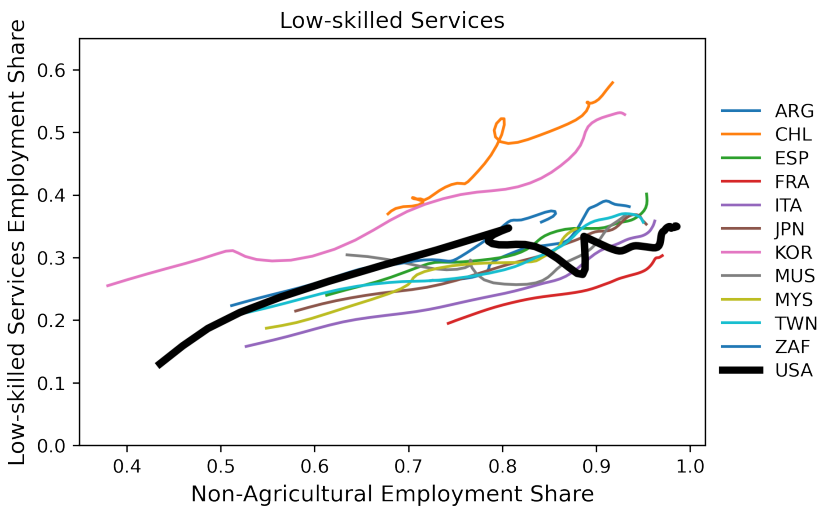


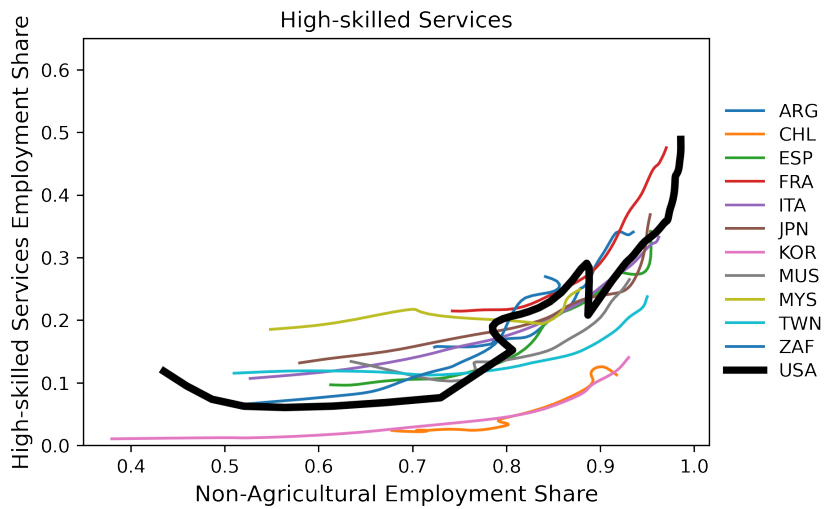


Steep Manufacturing: Structural Transformation Patterns



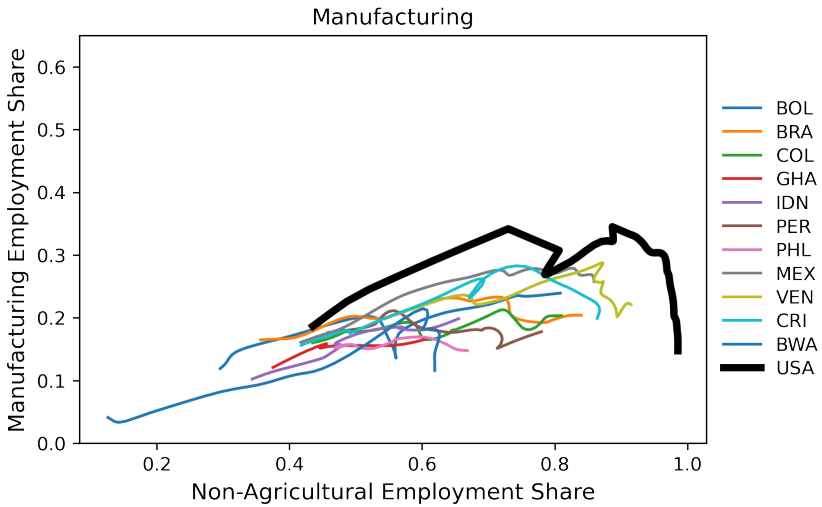
- Similar pattern to the US across steep manufacturing economies
- Different patterns before and after *MAN* peak: Industrialization and Deindustrialization



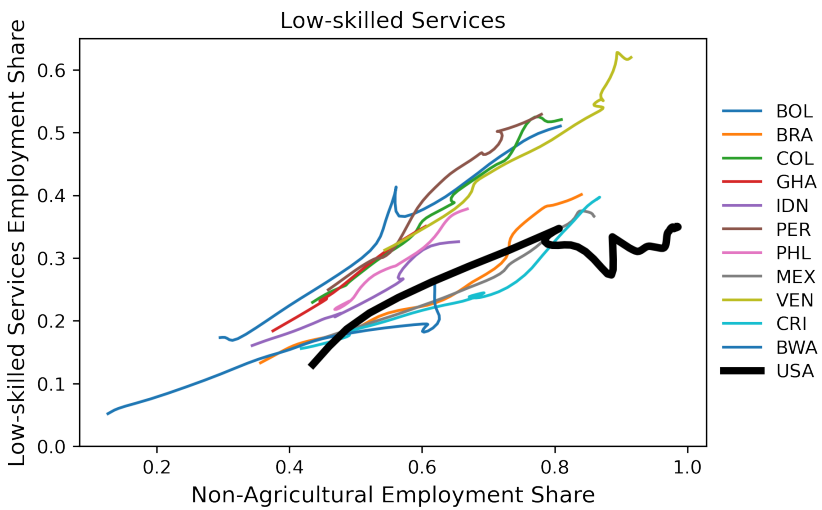


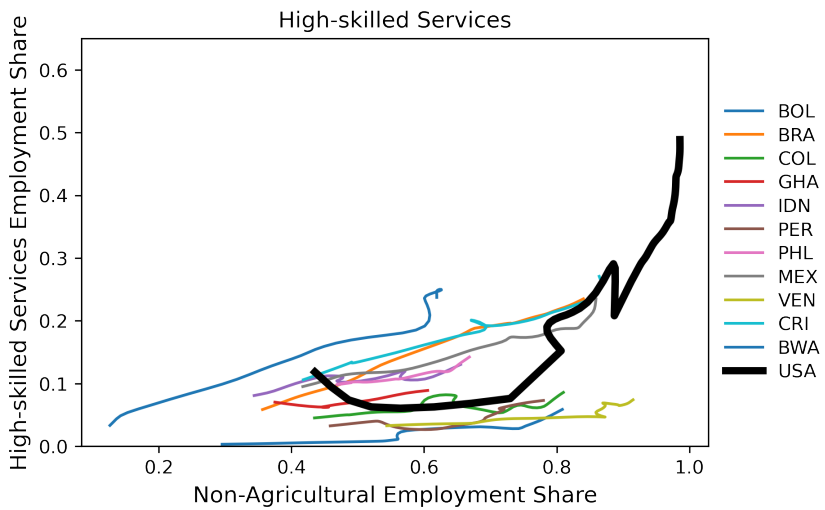
▸ Industrialization ▸ Deindustrialization

Flat Manufacturing: Structural Transformation Patterns



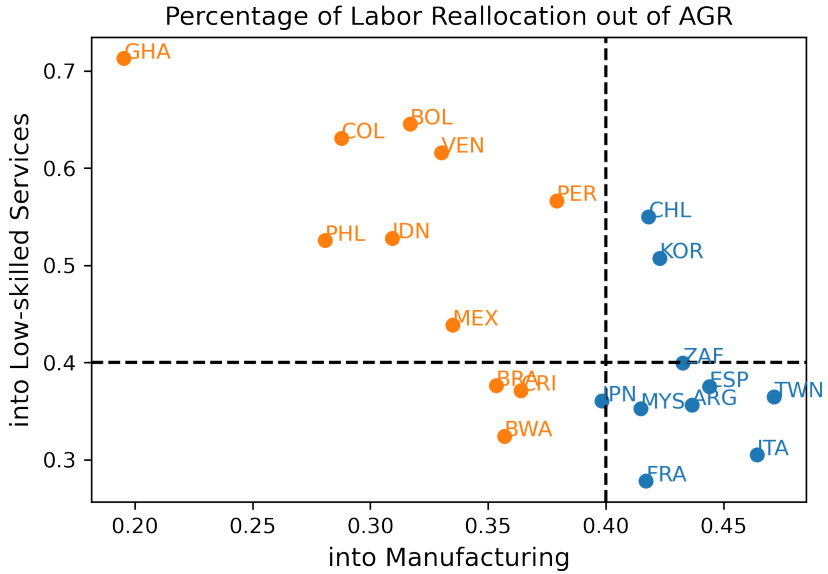
- Insignificant difference in patterns before and after the manufacturing peak
- *MAN* labor share is relatively flat
- Most labor is allocated towards low-skilled *SER*
- High-skilled *SER* sector is relatively small for most economies

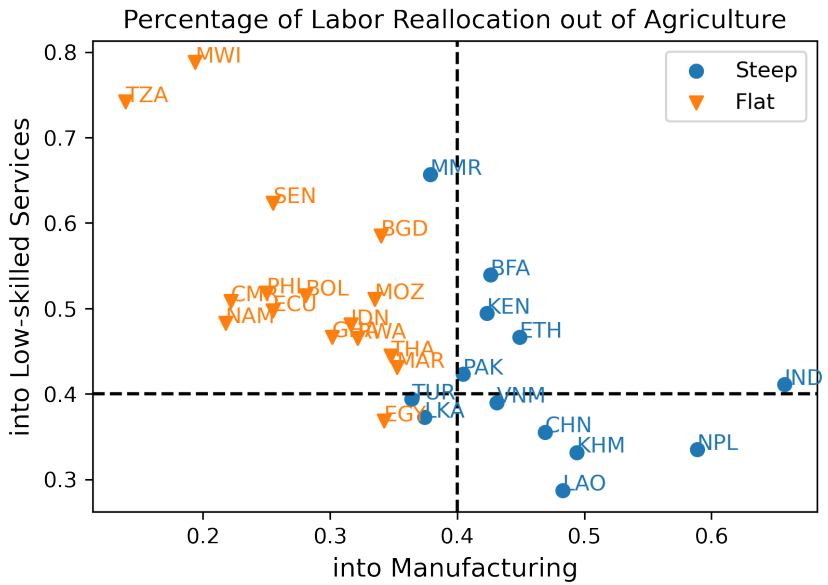




▸ Recent Trend

Structural Transformation: Early and Late Developers





- These two figures show the slope of labor reallocation into *MAN* against into SER_I.
- Upper figure presents the pattern in the countries included in 10-Sector Database during the earlier period 1950s-2010s.
- Lower figure presents the pattern in the countries included in Economic Transformation Database during the later period 1990-2018.
- Both steep and flat manufacturing patterns are prevalent in both samples.

Explanatory Factors

- Question: What factors quantitatively account for heterogeneous patterns of structural change?
- Theory: Differences in evolution of sectoral productivity
  - Initial condition: Initial sectoral productivity levels
  - Sectoral productivity growth rates
- Quantitative Exercise:
  - Initial sectoral productivity levels are the major driving forces
  - Indicate important role of country-specific distortions

4-sector Model

- 4 sectors: *AGR* (a), *MAN* (m), SER_l (ls) and SER_h (hs)
- Technologies linear in labor (L_i):

$$Y_i = A_i L_i \ , i \in \{a, m, ls, hs\}$$

- Endowments: representative household with 1 unit of time, population size is normalized to 1
- Preferences $u(c_a, c_m, c_{ls}, c_{hs})$ with two main features:
  - Gollin et al.(2002): Subsistence *AGR* consumption $\bar{a}$
  - Conditional on $c_a \geq \bar{a}$, consumers have CES preferences over *MAN*, SER_l and SER_h: $\sigma \in (0, 1)$

$$u(c_m, c_{ls}, c_{hs}) = \left[\varphi_m^{\frac{1}{\sigma}} c_m^{\frac{\sigma-1}{\sigma}} + \varphi_{ls}^{\frac{1}{\sigma}} c_{ls}^{\frac{\sigma-1}{\sigma}} + \varphi_{hs}^{\frac{1}{\sigma}} c_{hs}^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

Competitive Equilibrium

A competitive equilibrium is a set of prices $\{p_i\}$, allocations $\{c_i\}$ for households and labor inputs $\{L_i\}$ for firms such that

- Given prices $\{p_i\}$, $\{c_i\}$ solves the household's problem

$$\max u(c_a, c_m, c_{ls}, c_{hs}) \quad \text{s.t.} \quad p_a c_a + p_m c_m + p_{ls} c_{ls} + p_{hs} c_{hs} = 1$$

- Given price p_i, L_i solves the firm's problem

$$\max p_i A_i L_i - L_i \ , i \in \{a, m, ls, hs\}$$

- Markets for labor and goods clear

$$L_a + L_m + L_{ls} + L_{hs} = 1$$
$$c_i = Y_i \ , i \in \{a, m, ls, hs\}$$

Analytical Solution

- From the firm's problem:

$$p_i = \frac{1}{A_i} \ , i \in \{a, m, ls, hs\}$$

- Focus on case $A_a > \bar{a}$, household only consumes $\bar{a}$ amount of agricultural goods and allocate labor

$$L_a = \frac{\bar{a}}{A_a}$$

- FOCs from household's problem imply that for $i, j \in \{m, ls, hs\}$,

$$\frac{p_i c_i}{\sum_j p_j c_j} = \frac{\varphi_i p_i^{1-\sigma}}{\sum_j \varphi_j p_j^{1-\sigma}} \quad \text{or} \quad \frac{p_i c_i}{p_j c_j} = \frac{\varphi_i p_i^{1-\sigma}}{\varphi_j p_j^{1-\sigma}}$$

Analytical Solution

- Goods market clearing conditions imply that $p_i c_i = p_i Y_i = L_i$
- Labor share of sector $i, j \in \{m, ls, hs\}$ can be derived as

$$\frac{L_i}{L_j} = \frac{\varphi_i}{\varphi_j} \left(\frac{A_j}{A_i} \right)^{1-\sigma}$$

- Combining with labor market clearing, we can solve for labor share in sector $i \in \{m, ls, hs\}$ as

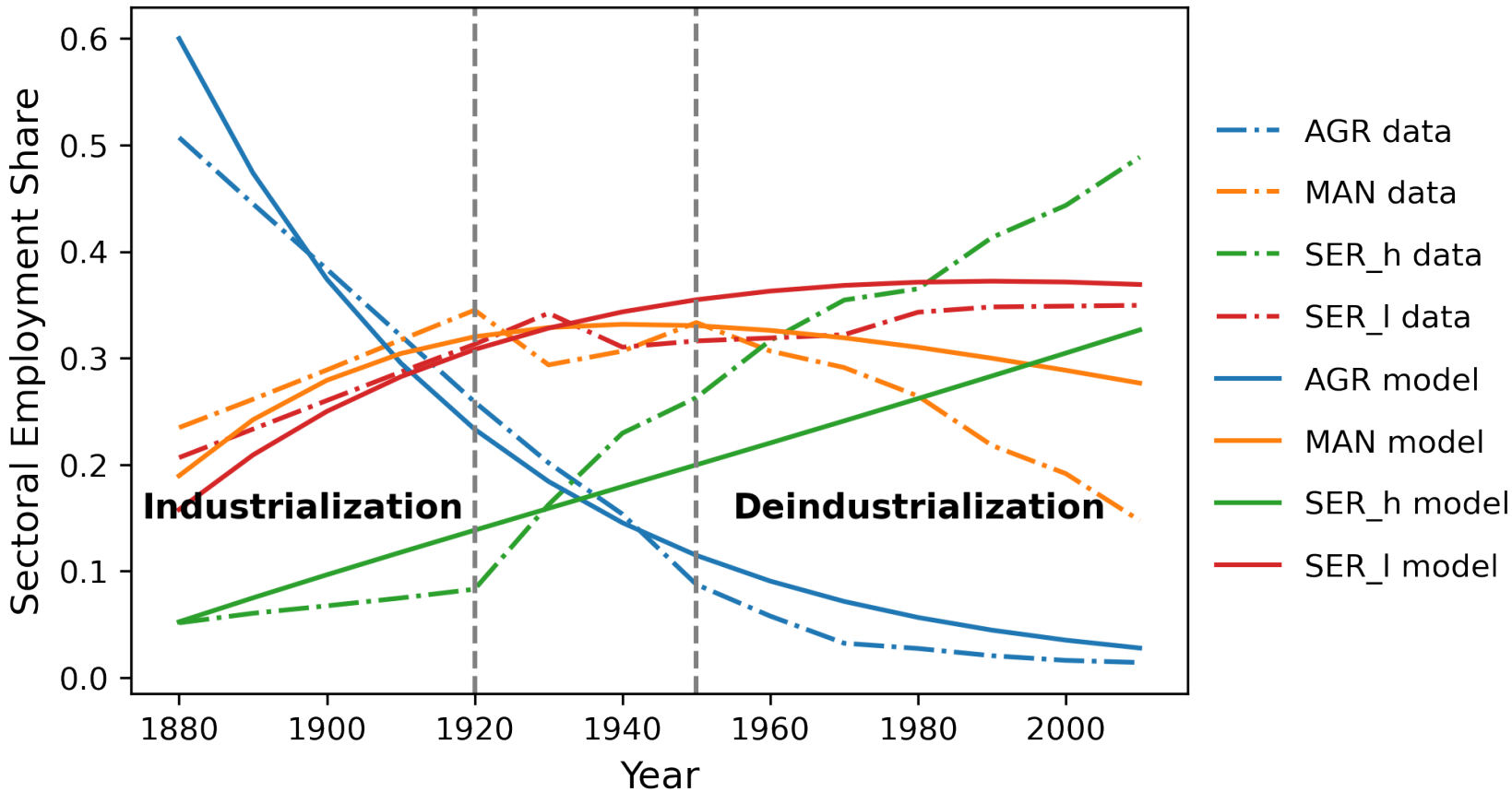
$$L_i = \frac{\varphi_i A_i^{\sigma-1}}{\sum_j \varphi_j A_j^{\sigma-1}} \left(1 - \frac{\bar{a}}{A_a} \right)$$

Calibration to USA Historical Data

- Standard calibration practice in literature: Huneeus and Rogerson (2020)
- Assume constant sectoral productivity growth: annualized growth between 1950-1970
- Set initial productivity level of all sectors to 1
- Set $\bar{a}$ to 0.6
- Calibrate σ, φ_i to match USA sectoral employment shares during industrialization phase 1880-1960

Parameters	σ	$\bar{a}$	φ_m	φ_{ls}	φ_{hs}
Value	0.3	0.60	0.47	0.40	0.13

Model vs. Data: USA Historical Data

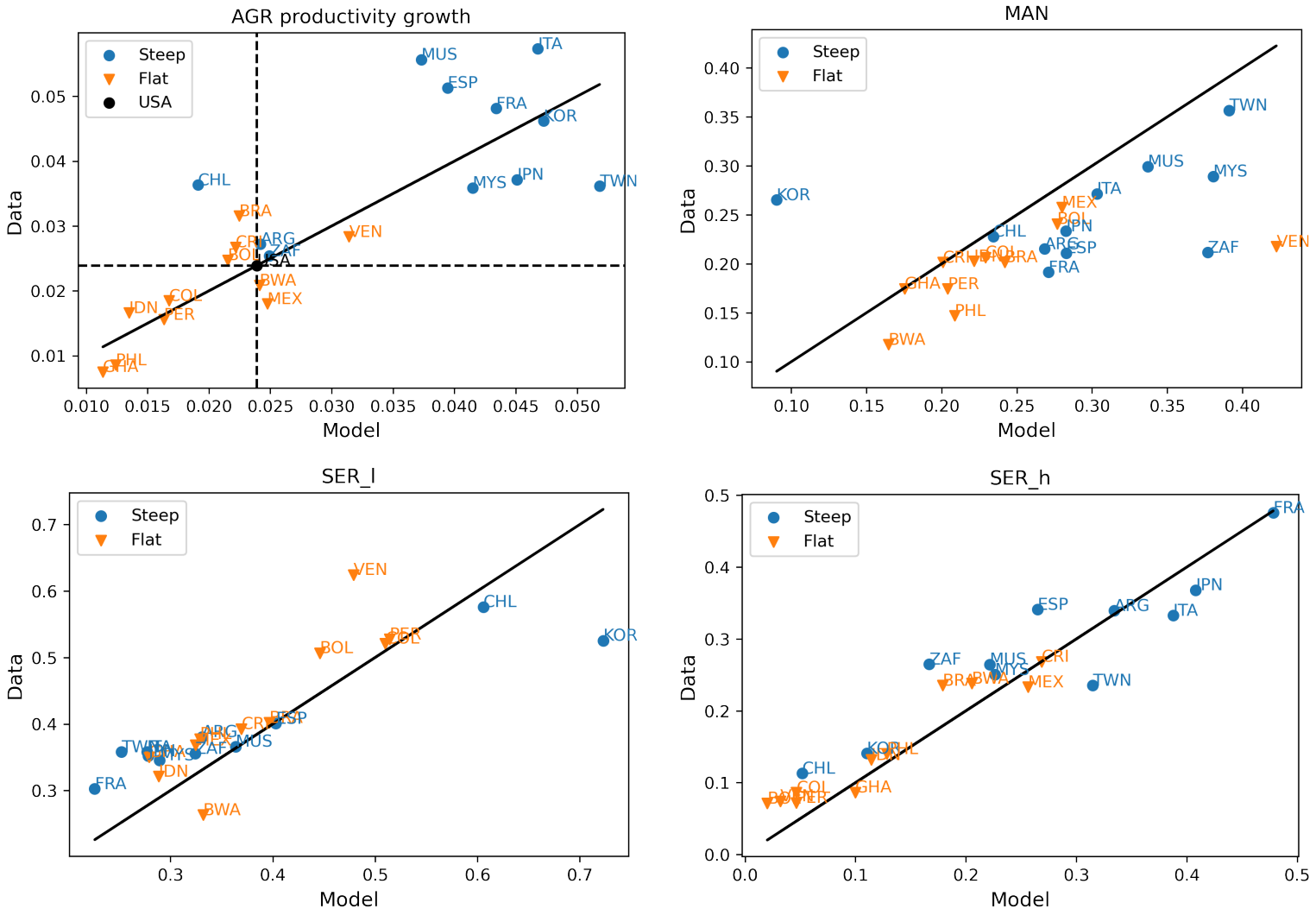


Cross-country Calibration

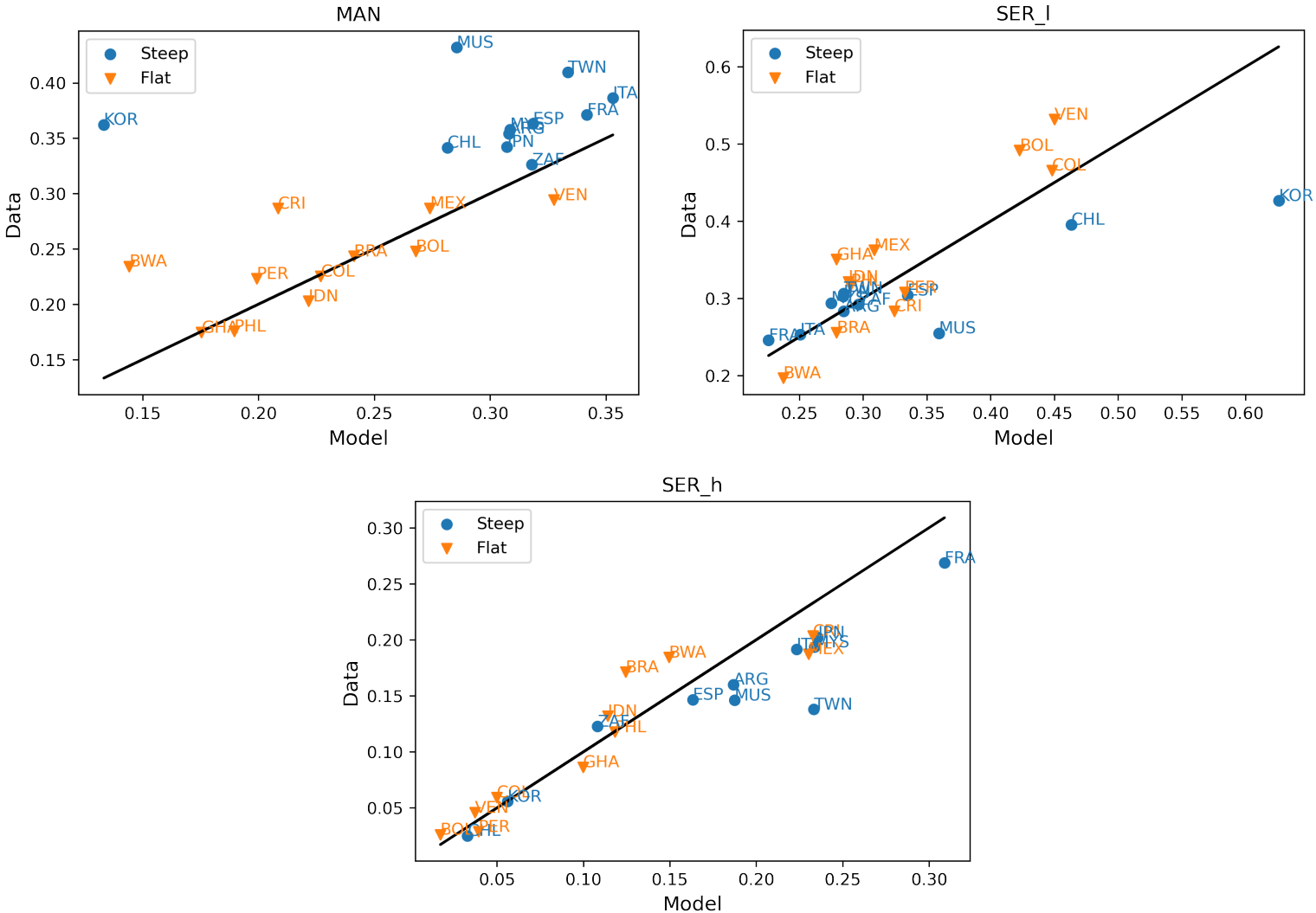
Following Duarte and Restuccia (2010),

- Use the calibrated parameters for the US
- Calibrate agricultural productivity growth (following Huneeus and Rogerson (2020))
- Calibrate initial sectoral productivity level to match
  - initial sectoral EMP share for each country
  - initial aggregate labor productivity relative to the US
- Use annualized growth rate of sectoral labor productivity in data to infer productivity index and employment share

Last-Period EMP Share: 4-sector Model vs. Data



Peak Manufacturing EMP Share: 4-sector Model vs. Data



Factors Drive Structural Transformation Patterns

- Dynamics: Assume constant labor productivity growth g_i for sector $i \in \{a, m, ls, hs\}$
- Labor share of sector $i \in \{hs, ls\}$ relative to manufacturing:

$$\frac{L_{it}}{L_{mt}} = \frac{\varphi_i A_{it}^{\sigma-1}}{\varphi_m A_{mt}^{\sigma-1}} = \frac{\varphi_i}{\varphi_m} \left(\frac{A_{i0}}{A_{m0}} \right)^{\sigma-1} e^{(\sigma-1)(g_i - g_m)t}$$

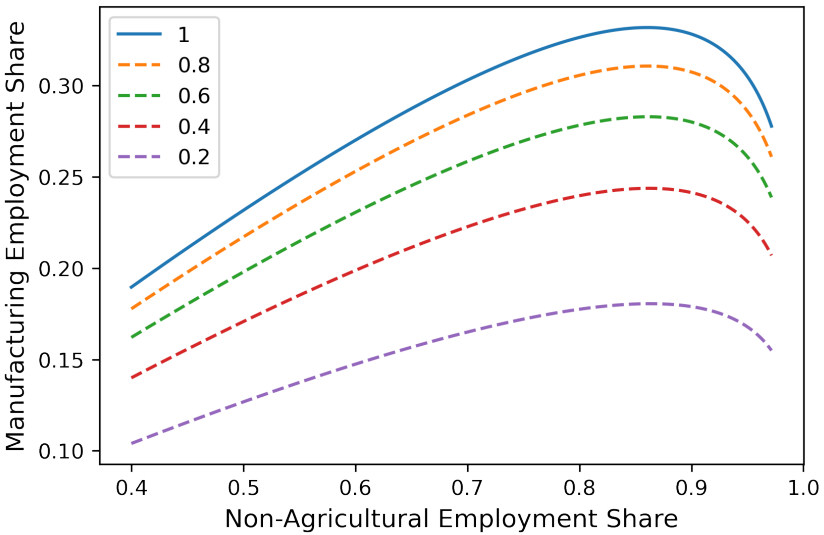
- Factors leading to different structural change patterns from a benchmark economy (USA):
  - *AGR* labor productivity growth g_a
  - Relative labor productivity growth $g_i - g_m$ for $i \in \{ls, hs\}$
  - Initial relative labor productivity $\frac{A_{i0}}{A_{m0}}$

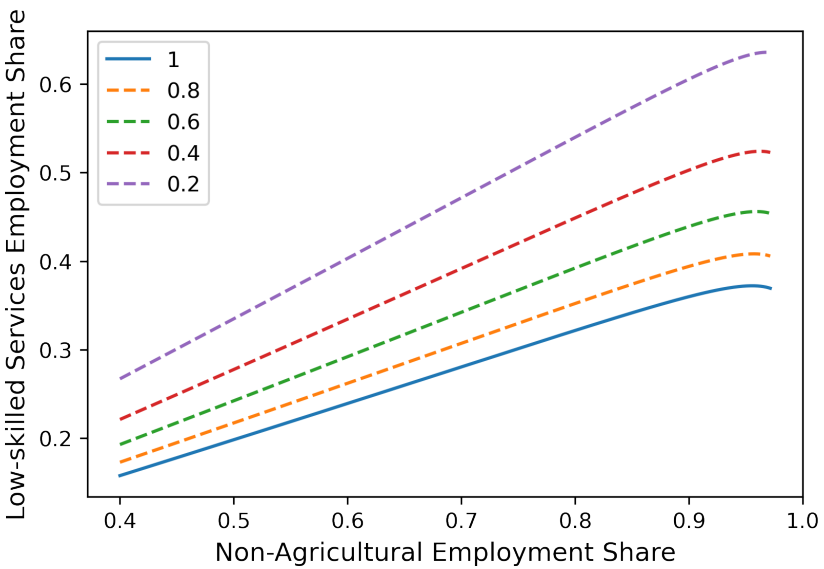
Role of Initial Relative Labor Productivity

- $\frac{A^c_{i0}}{A^c_{m0}}$ measure the "gap" in relative labor productivity between a country c and the US.
- The size of "gap" is proportional to deviation in structural change pattern from the US.
- If the relative growth of a country c is similar to the US, the "gap" does not change over time:

$$\frac{A^c_{it}/A^c_{mt}}{A^{US}_{it}/A^{US}_{mt}} = \frac{A^c_{i0}/A^c_{m0}}{A^{US}_{i0}/A^{US}_{m0}} \frac{e^{(g_i - g_m)t}}{e^{(g_i - g_m)t}} = \frac{A^c_{i0}}{A^c_{m0}}$$

Low-Skill SER Initial Relative Labor Productivity





- Counterfactuals to USA model
  - Blue connected line is US structural change pattern (initial productivity is 1 for all sectors)
  - Dotted lines are counterfactuals with lower values of initial SER_l productivity
- Results: Lower relative SER_l productivity can generate observed patterns
  - *MAN* share: Lower and flatter hump-shape curve
  - SER_l share: Higher and steeper increase

Counterfactuals with USA growth

- Counterfactual Methods
  - Use the initial sectoral productivity level for each country that match initial employment share
  - Calculate counterfactual employment share by using USA sectoral productivity growth
- Results
  - The counterfactual matches the data well for peak MAN share as well as last-period sectoral EMP share for most countries
  - AGR productivity growth has limited role
  - For some countries, non-AGR growth rates have quantitative role

Colombia as an Example

Figure 1: USA Model and COL data

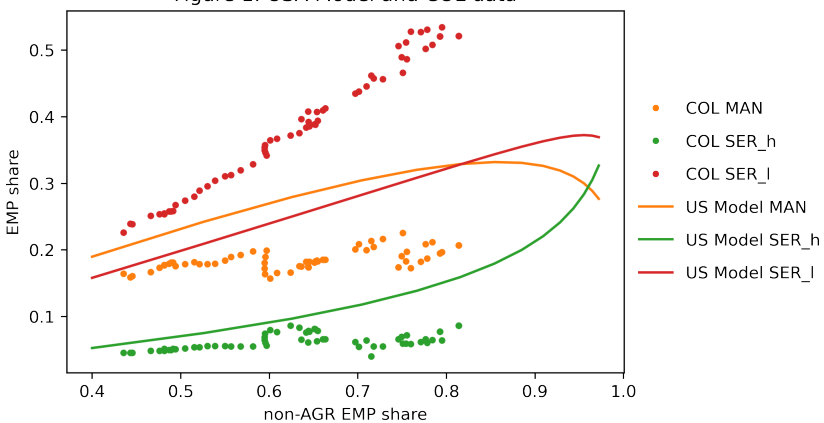
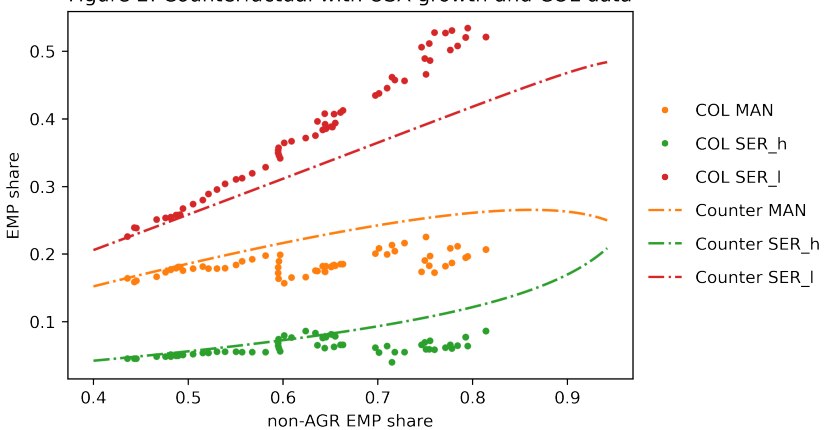


Figure 2: Counterfactual with USA growth and COL data



- Descriptions

	A_{i0}	g_a	g_i
Figure 1	US	US	US
Figure 2	COL	US	US

- Results
  - The counterfactual generates close pattern to data
  - The result indicates high explanatory power of the relative productivity level

Colombia as an Example

Figure 3: Model with USA AGR growth and COL data

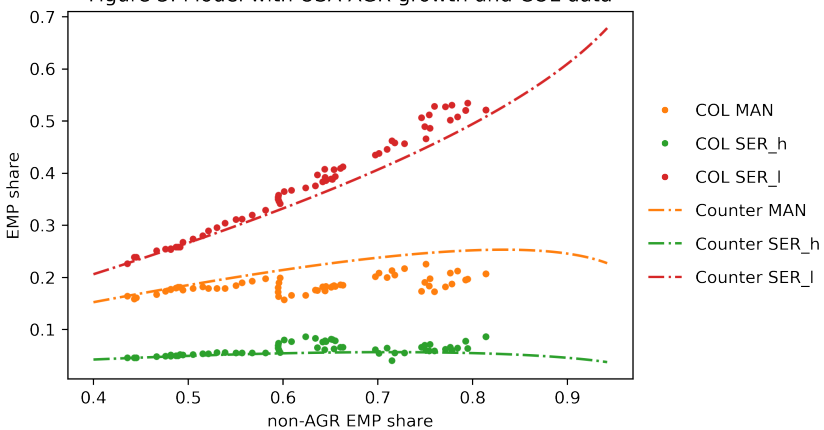
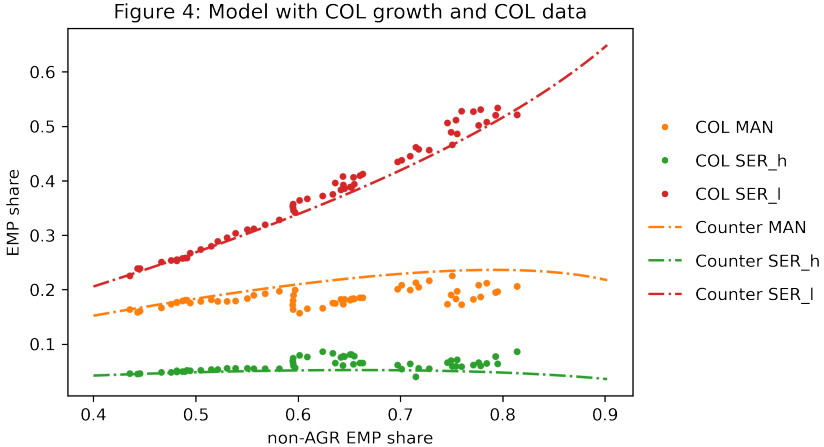


Figure 4: Model with COL growth and COL data

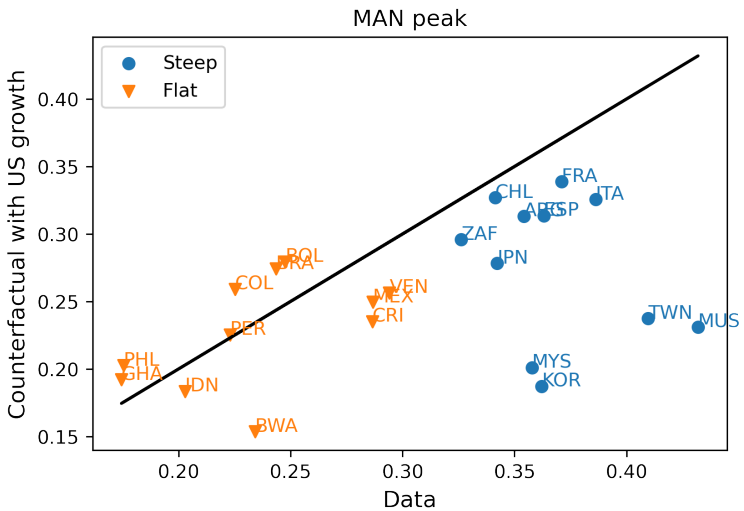


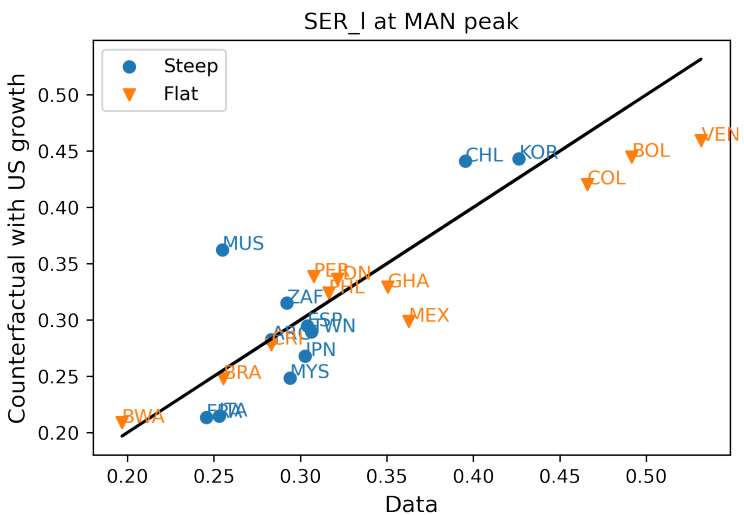
- Descriptions

	A_{i0}	g_a	g_i
Figure 3	COL	US	COL
Figure 4	COL	COL	COL

- Results
  - Using growth from data improves the fit
  - AGR productivity growth has limited role

Counterfactual vs. Data





Counterfactual: For any country c,

A_{i0}	g_a	g_i
c	US	US

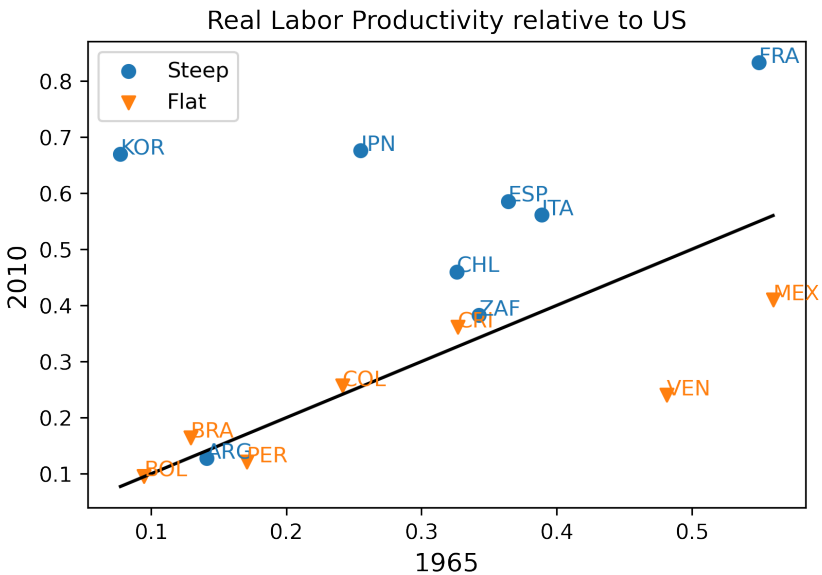
Results:

- The counterfactual can generate MAN peak and SER_I patterns close to the data
- For several steep manufacturing economies, sectoral productivity growth rates are important factors

Implications:

- Heterogeneous patterns of low *MAN* and high SER_I shares are driven by low relative productivity of SER_I to *MAN*

Quantitative Role of Sectoral Productivity Growth

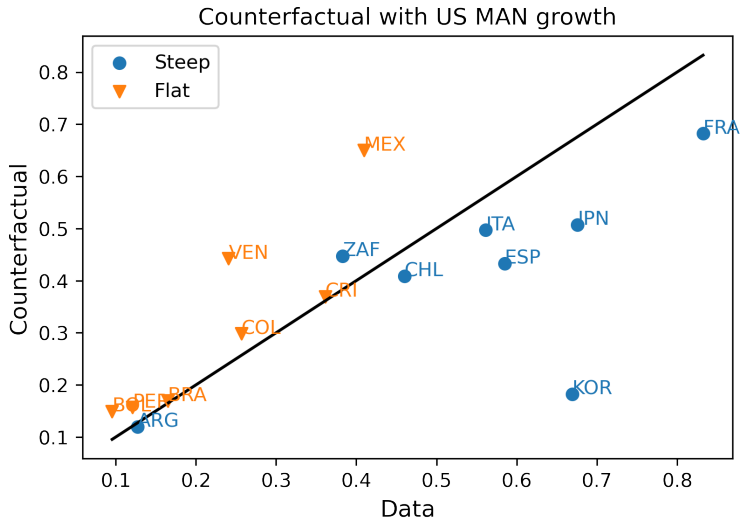


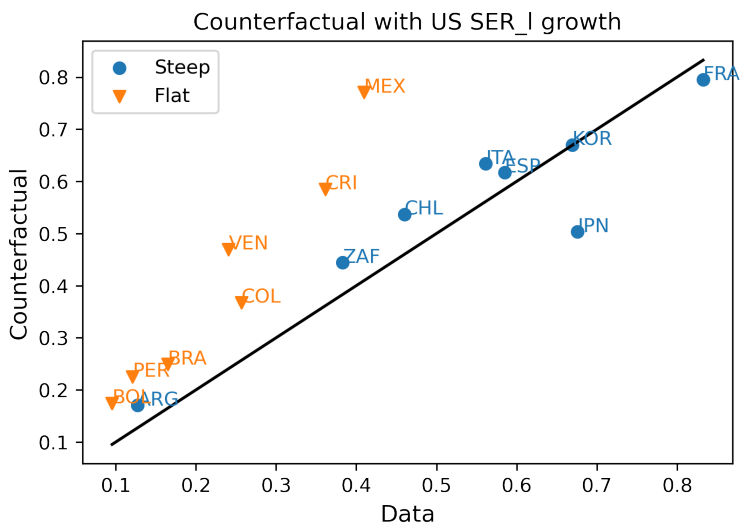
- During the period 1965-2010, relative to the US (frontier economy),
  - Steep Manufacturing: fast catch up
  - Flat Manufacturing economies: stagnation or decline
- What are quantitative contributions of sectoral productivity growth rates?

Counterfactuals with US Sectoral Growth Rates

- Start an economy c with the sectoral productivity levels in 1965
- Set the growth rate in 1 sector to the US growth rate ($g_i = g_i^{US}$) and keep the others as the data ($g_j = g_i^c, j \neq i$)
- Calculate counterfactual aggregate productivity relative to the US in 2010 and compare with the data
- The counterfactual presents the quantitative role of each sectoral productivity growth in accounting for growth experience in each economy

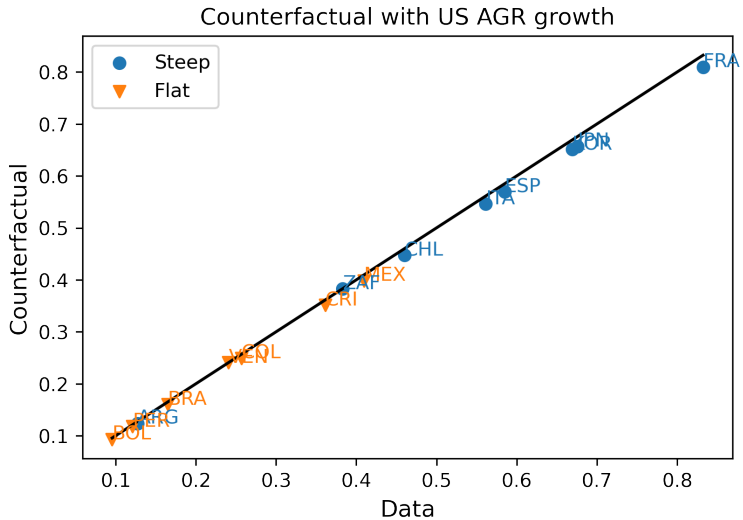
Labor Productivity Relative to US: Counterfactuals

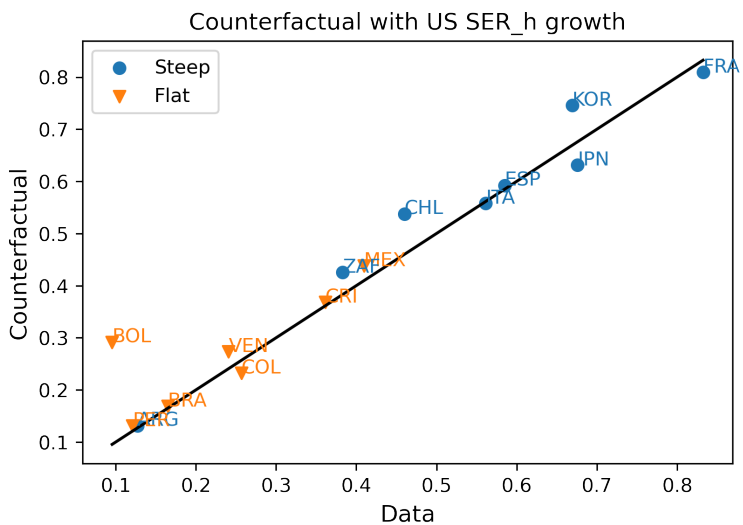




- Counterfactual with US *MAN* productivity growth rates:
  - Steep Manufacturing: substantially lower than the model
  - Flat Manufacturing: close to the model
- Counterfactual with US SER_I productivity growth rates:
  - Steep Manufacturing: close to the model
  - Flat Manufacturing: substantially lower than the model

Labor Productivity Relative to US: Counterfactuals





- Counterfactuals with US growth rates in AGR and SER_h do not generate significant difference
- Implications: Growth rates in AGR and SER_h do not account for different growth experience across economies

Aggregate Implications

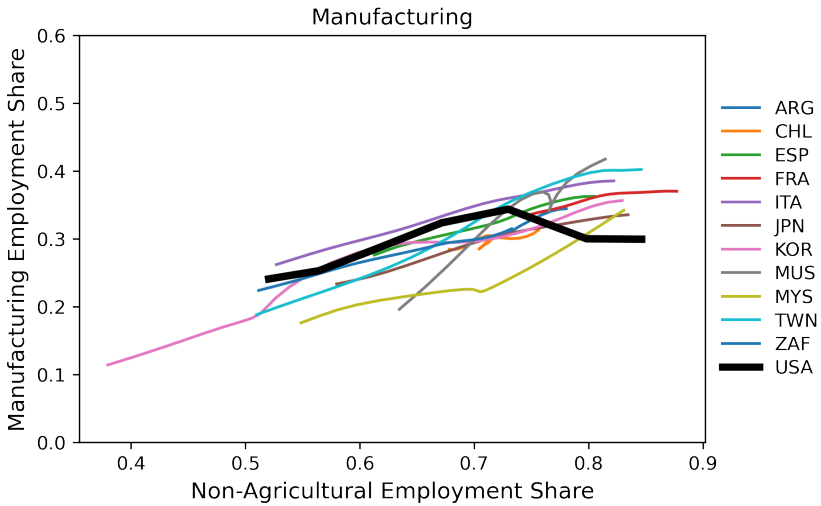
- Steep Manufacturing:
  - Fast catch-up with the US
  - High productivity growth rate in *MAN* mainly accounts for the catch-up
- Flat Manufacturing:
  - Stagnation experience with slow or no catch-up
  - Lack of catch-up in SER_I productivity mainly contributes to stagnation

Conclusions

- Large heterogeneity in labor allocation between *MAN* and *SER*
- Relative productivity between *MAN* and SER_I accounts for majority of the heterogeneity
- Important aggregate impacts on growth
- Future research:
  - understand sources driving the heterogeneity in relative productivity between *MAN* and *SER*
  - country-specific distortions, frictions, policies
  - role of other key features of heterogeneity within services sector

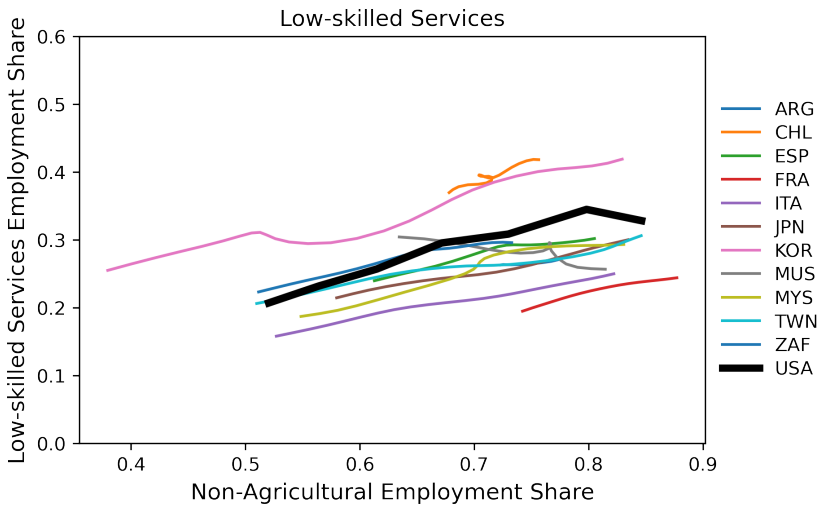
▸ Suggestive Explanations

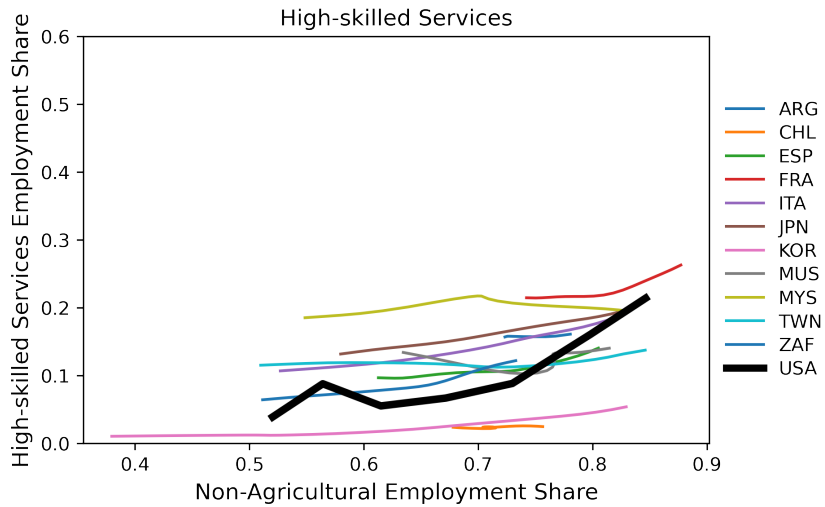
Steep Manufacturing: Industrialization Phase



1% decline in *AGR* EMP share results in

	MAN	SER_l	SER_h
US	0.4%	0.4%	0.2%
Average	0.4%	0.4%	0.2%





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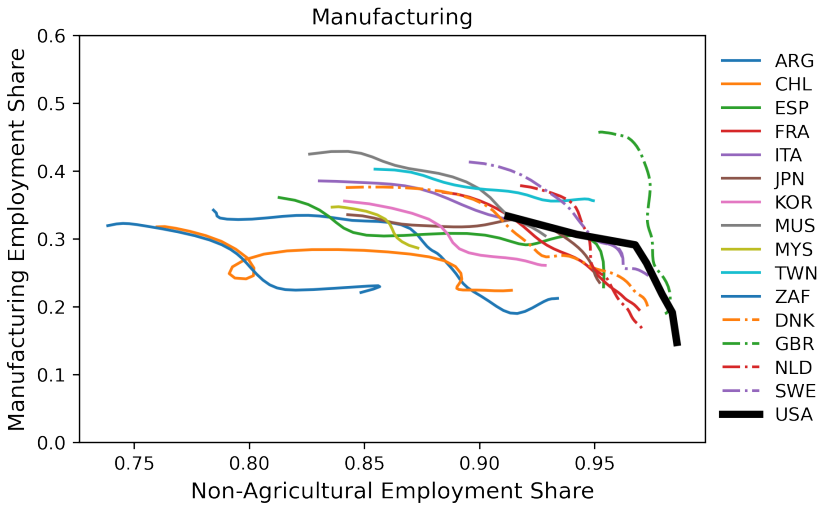
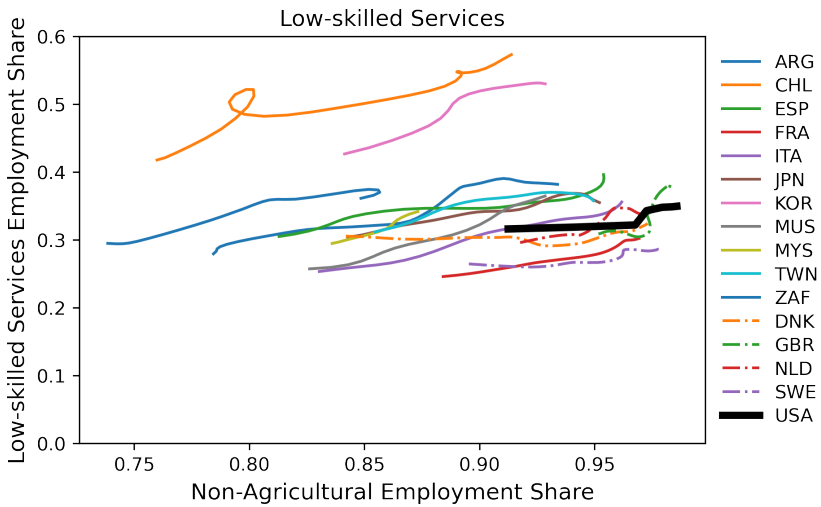
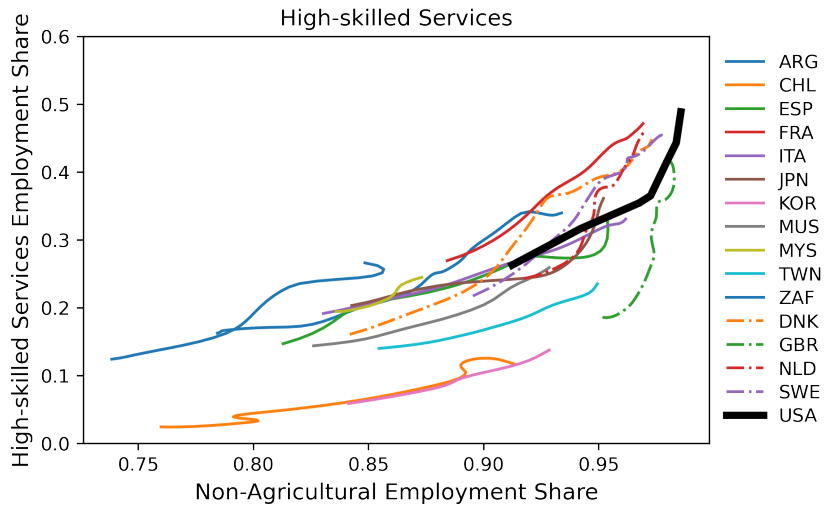
Steep Manufacturing: Deindustrialization Phase



Deindustrialization Phase:

- *MAN* share decline is largely associated with the rise of SER_h
- SER_l share is relatively flat





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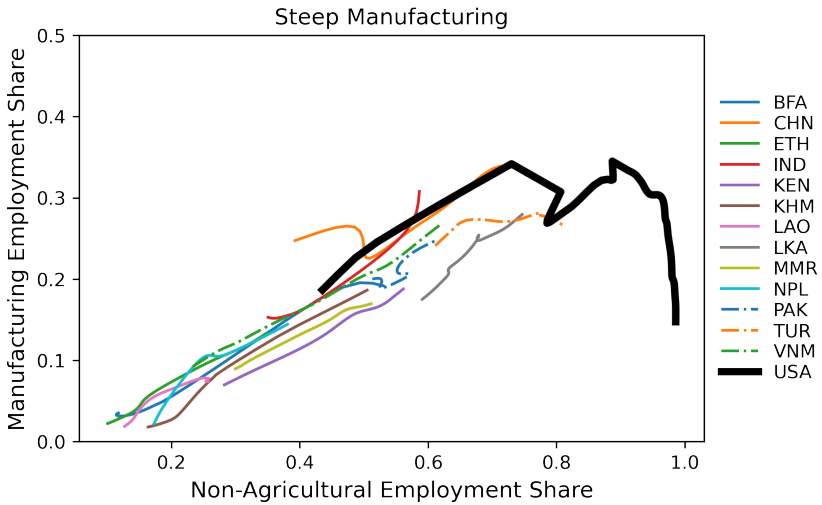
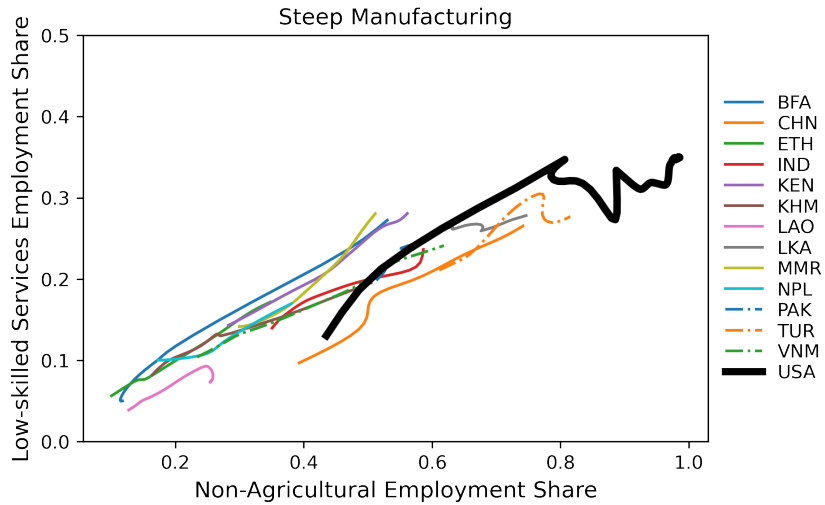
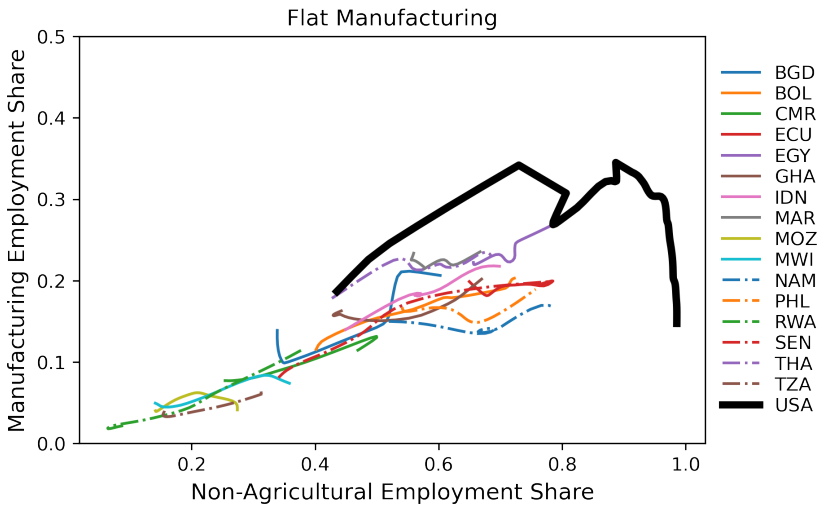
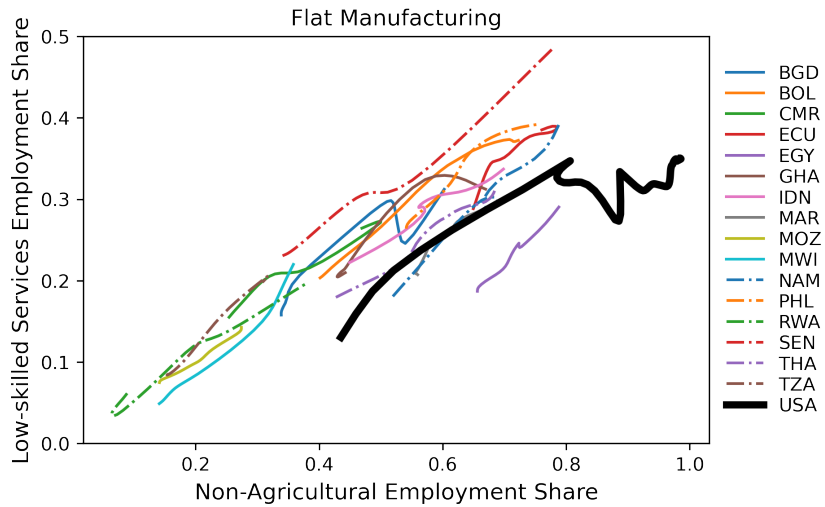
Recent Developing Economies









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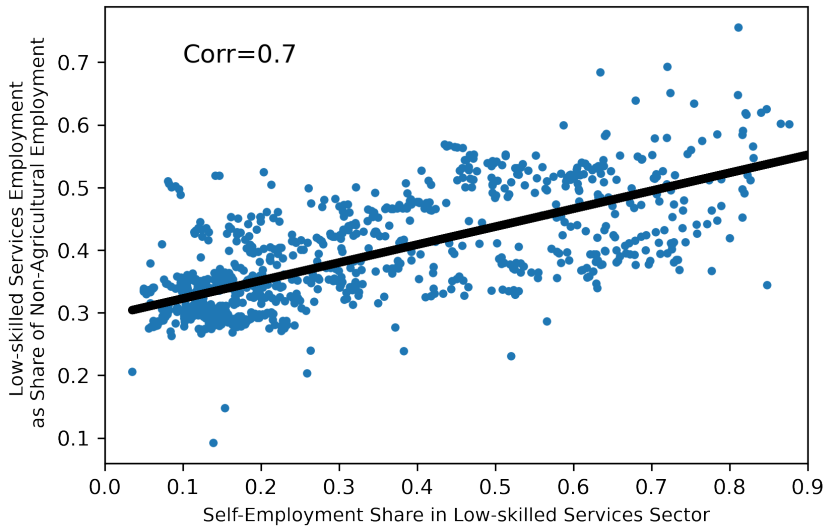
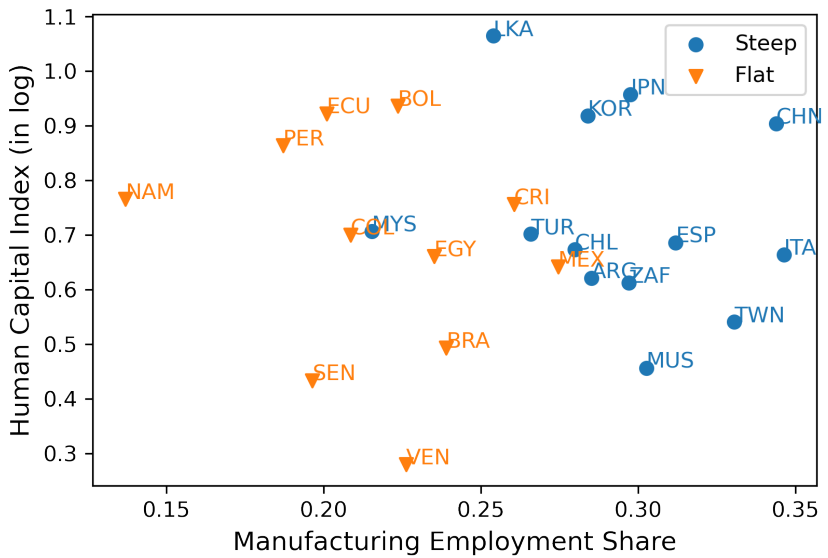
Potential Explanatory Sources





- Strong correlation between informality in low-skilled services and the patterns of steep/flat manufacturing $\rightarrow$ Suggest that distortions leading to the large size of informal economies are potential forces explaining heterogeneity
- Little correlation between human capital and structural change patterns

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