Heterogeneous Paths of Structural Transformation †

Duc Nguyen
University of Toronto

July 2022

Abstract

This paper establishes a new set of stylized facts and explanations on the heterogeneity in structural transformation across countries, hence shedding light on the “premature deindustrialization” phenomenon introduced by Rodrik (2016). I document a number of countries exhibiting flat manufacturing profiles without noticeable signs of deindustrialization. This pattern strikingly differs from the conventional steep manufacturing hump-shaped profiles in the United States and other developed economies. The heterogeneity is even more significant in the labor allocation within services sector: Flat manufacturing economies tend to allocate substantially more labor into low-skilled services compared to steep manufacturing economies. Heterogeneous patterns are prevalent among both earlier and later developers and not subject to the timing of development. Based on the benchmark model of structural transformation, I find that variation in sectoral productivity growth is not quantitatively sufficient to generate observed heterogeneity in structural transformation across countries. Instead, variation in relative productivity levels between manufacturing and low-skilled services accounts for the majority of the heterogeneity, suggesting that differences in country-specific factors are the key sources behind this phenomenon. Countries following different structural transformation paths are shown to experience significantly different outcomes on economic growth.

JEL classification: E1, E24, O11, O13, O14, O41, O50.
Keywords: employment, agriculture, manufacturing, low-skilled services, high-skilled services, productivity, structural transformation, industrialization, premature deindustrialization.

†I am extremely thankful for and indebted to my supervisor Diego Restuccia for his constant advice, support and encouragement throughout this project. I thank Loren Brandt, Magarida Duarte, Joseph Kaboski, Gueorgui Kambourov and Yongseok Shin for extensive feedback and discussion. I am also grateful to Stephen Ayerst, Benjamin Bridgman, Kevin Donovan, Murat Celik, Ying Feng, Gaelan MacKenzie, Serdar Ozkan, Florian Scheuer, Joseph Steinberg, Anson Zhou, Xiaodong Zhu as well as participants at Toronto Macro Brown Bag, ECO 4060 seminars, 2022 Annual Meeting of Canadian Economic Association and 2022 North American Summer Meeting of Econometric Society for useful comments and suggestions. All errors are my own. *Contact Information:* Department of Economics, University of Toronto, 150 St. George Street, Toronto, ON M5S 3G7, Canada. E-mail: ducm.nguyen@mail.utoronto.ca.

1 Introduction

Structural transformation—the reallocation of resources across broad economic sectors—is a prominent feature of economic development. One common pattern of structural transformation is the hump-shaped evolution of manufacturing[1] sector: rise at early stages of development (i.e., industrialization), reach a peak and then decline at later stages (i.e., deindustrialization). Rodrik (2016) observes that many recent developers experience a substantially lower value of the peak and attain the peak at a lower level of development compared to earlier developers. He refers to this phenomenon as ”premature industrialization.”

What are the driving forces behind this phenomenon? Rodrik (2016) suggests that deindustrialization has been rising on a global scale in recent decades due to the trend of globalization and labor-saving technological progress in manufacturing. This means recent emerging economies are running out of industrialization opportunities and consequently facing lower economic growth compared to earlier developers. Huneeus and Rogerson (2020) attribute the ”premature deindustrialization” to the countries' rates of convergence to the frontier economies. In particular, they discover the differences in agricultural productivity growth to drive the manufacturing peaks across economies. This paper shows that the heterogeneity in structural transformation patterns occurs among both earlier and later developers and is not simply subject to the timing of development. The heterogeneity is found to be mainly driven by cross-country variation in sectoral productivity levels between manufacturing and low-skilled services, indicating that the phenomenon results from the variation in country-specific factors and distortions. Implication from this paper's findings is that we need to conduct further investigation at individual country level to have a better understanding and appropriate policies on issues resulting from the phenomenon.

I start the paper with documenting a set of stylized facts on the heterogeneity in structural transformation across countries. Using data from the Groningen Growth and Development Centre (GGDC) 10-Sector Database and the Penn World Table (PWT) 10.0, I document the following stylized facts. First, a number of economies experience a flat profile of manufacturing share without noticeable peak over the course of development. This pattern of flat manufacturing profiles is different from the conventional pattern of steep evolution with significant rise followed by sharp fall in manufacturing share documented in the United States and many other advanced economies. Second, there also exists much heterogeneity in the types of services expanded between advanced economies and flat manufacturing ones. While

[1]Following the standard practice in the literature, the term manufacturing refers to the broad industry sector.

advanced economies tend to develop high-skilled services, flat manufacturing economies substantially allocate labor into low-skilled services. These two stylized facts motivate the two research questions of this paper. What factors drive these heterogeneous patterns in structural transformation across economies? What are the aggregate implications of these differences on growth and development?

To address these two questions, the paper develops a general equilibrium model of structural transformation that can account for the documented patterns. Similar to Gollin et al. (2002, 2007), labor allocation out of agriculture in the model is determined by agricultural productivity. Following Duarte and Restuccia (2010) and Huneeus and Rogerson (2020), relative sectoral labor productivity determines the labor allocation between manufacturing and services sectors. My model consists of four sectors with the disaggregation of services into low-skilled and high-skilled services instead of the standard single services sector. The model is calibrated to match sectoral employment share evolution in the United States during early to middle stages of development. Following Duarte and Restuccia (2010), due to lack of comparable sectoral output data across economies, the cross-country calibration exercise involves inference of sectoral productivity levels in the model to match sectoral employment shares at the initial sample period. For each economy, based on calibrated initial sectoral productivity levels and observed sectoral productivity growth rates, I derive sectoral productivity profiles which determine the sectoral labor allocation in the model. The model accounts very well for the heterogeneous patterns of structural transformation.

In the benchmark model, sectoral productivity profiles are driven by sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Using the calibrated model to the United States economy, I perform counterfactuals assuming sectoral productivity growth rates of the United States but changing initial relative productivity levels. By lowering initial relative productivity level of low-skilled services relative to manufacturing, the counterfactuals generate structural change patterns very close to the patterns in most of the flat manufacturing economies. The counterfactual result suggests that deviation in sectoral productivity growth rates from the United States' growth rates are not large enough to quantitatively generate the patterns observed in flat manufacturing economies. Instead of sectoral productivity growth rates, variation in initial relative productivity levels is suggested to be the determining forces driving cross-country differences in structural transformation. Initial sectoral productivity levels reflect country-specific components that are persistent over the course of development.

This finding raises a question of why relative productivity level of low-skilled services to manufacturing is substantially lower in flat manufacturing economies. The paper documents cross-country evidence that informal economy has dominant role in low-skilled services compared to manufacturing. Moreover, economies with flat manufacturing patterns also tend to have larger informal sector. The evidence suggests that country-specific distortions (such as business entry and operation costs) leading to large informal sector could be a potential source of low productivity level of low-skilled services relative to manufacturing in flat manufacturing economies. Human capital endowments are found to have limited correlation with structural transformation patterns across countries.

The paper employs the model to study aggregate implications of heterogeneous paths of structural transformation. During the period from 1965 to 2010, most steep manufacturing economies experience substantial catch-up episodes in aggregate labor productivity relative to the United States, whereas flat manufacturing economies experience stagnation and slowdown. To study the aggregate implications of heterogeneous sectoral productivity patterns, I perform four sets of counterfactuals by setting productivity growth rate to the United States rate for each sector among agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactuals indicate that productivity growth in agriculture and high-skilled services sectors have little impact on aggregate productivity. The catch-up experiences in steep manufacturing economies are mostly associated with the catch-up in manufacturing productivity. Stagnation experiences in flat manufacturing are mainly attributed to the low productivity growth and dominant size of low-skilled services sector.

This paper is related to literature studying structural transformation.[2] In particular, the paper is directly linked to the recent literature studying heterogeneous patterns in industrialization and deindustrialization experience. Rodrik (2016) attributes the premature deindustrialization to the rise of globalization. Sposi et al. (2021) emphasize the role of open economy factors and find that variation in trade costs can largely account for cross-country deindustrialization patterns. In a closed economy context, Huneeus and Rogerson (2020) provide a finding that variation in sectoral productivity growth, particularly in agriculture, can quantitatively explain the observed variation in the peak of manufacturing hump-shape patterns across countries. This paper is different from Rodrik (2016) and Huneeus and Rogerson (2020) in three major aspects. First, this paper shows that the manufacturing peak and the timing of the peak do not fully characterize heterogeneity in structural transformation. Two other important features of heterogeneity are the steepness of the industrialization and the allocation of labor into low-skilled services. Second, the analysis shows that variation in initial relative sectoral productivity levels accounts for the majority of variation in observed

[2]See Herrendorf et al. (2014) for overview of this literature. Important contributions include Kongsamut et al. (2001), Gollin et al. (2002, 2007), Ngai and Pissarides (2007), Buera and Kaboski (2009), Duarte and Restuccia (2010), Boppart (2014) and Comin et al. (2021).

structural transformation. Beyond the formal analysis, evidence on informality suggests that differences in cross-country sectoral productivity levels could potentially result from country-specific institutions and distortions. Third, this paper takes a further step in investigating aggregate implications of the phenomenon and finds that heterogeneity in structural transformation is critical to understanding variation in cross-country aggregate outcomes.

My work is also related to literature studying skill-biased structural change. Recent papers by Buera et al. (2021) and Ngai and Sevinc (2020) document skill-biased structural transformation patterns as the reallocation process from low skill intensive sectors to high skill intensive sectors. Buera et al. (2021) and Ngai and Sevinc (2020) find that skilled-biased structural change is crucial to explain the patterns of rising wages for high-skilled workers and stagnation in wages for low-skilled workers in developed economies. While these two papers concentrate on the two-sector disaggregation (high-skilled and low-skilled economic sectors) and its implications on labor market outcomes in high-income economies, my paper instead focuses on disaggregation within services sector (high-skilled and low-skilled services sectors) and its implications for aggregate growth in middle-income economies.

Several recent papers also suggest that disaggregation of services sector is useful in studying structural change and productivity. Duarte and Restuccia (2020) show that large heterogeneity between traditional and non-traditional services has substantial impact on aggregate productivity across countries. Duernecker et al. (2017) distinguish services by productivity growth to study the aggregate outcome in developed economies' context. The closest to my paper in this strand of the literature is Fang and Herrendorf (2021) which study the structural change towards high-skilled services sector in China and find that underdevelopment of high-skilled services due to distortions has a substantial negative aggregate impact. Different from Fang and Herrendorf (2021), my paper investigates heterogeneous structural change patterns in manufacturing and within services in a multi-country setting.

The paper is organized as follows. Section 2 describes the data and the data sources. In the section 3, I document a set of stylized facts on heterogeneous patterns in structural transformation across economies. Section 4 sets up a four-sector model of structural transformation and calibrates to the United States as a benchmark economy. Section 5 performs cross-country calibration and counterfactual analysis to assess the role of sectoral productivity factors in capturing the documented heterogeneity in cross-country structural transformation. In section 6, I document patterns in aggregate productivity growth and use the model to investigate the implications of sectoral productivity across economies. Section 7 provides suggestive evidence and discussion on potential sources of explanations. Section 8 concludes the paper.

2 Data

The main set of countries and periods in this analysis is from GGDC 10-Sector Database (Timmer et al., 2015). Among the 41 countries in the sample, I exclude 8 countries that only experience a rise in manufacturing throughout the sample periods (industrialization) and 5 other countries that mostly experience decline in manufacturing throughout the sample periods (deindustrialization). 6 countries are excluded due to data issues. The analysis in this paper focuses on the group of the remaining 22 countries consisting of Argentina, Bolivia, Botswana, Brazil, Chile, Colombia, Costa Rica, France, Ghana, Indonesia, Italy, Japan, Korea, Malaysia, Mauritius, Mexico, Peru, Philippines, South Africa, Spain, Taiwan, the United States.

I aggregate the ten sectors into four using the following method. Manufacturing comprises of Mining and Quarrying; Manufacturing; Electricity, Gas and Water supply; and Construction. Services sector is disaggregated into low-skilled and high-skilled services following the standard classification in Buera et al. (2021), Ngai and Sevinc (2020) and Fang and Herrendorf (2021). A sub-service sector is defined as low-skilled service if its hour share of skilled labor[3] is lower than the median of the broad services sector. From data on labor hours by skills, I compute hour share of high-skilled labor for each economic sector across 28 countries over 34 years included in KLEMS Database. Economic sectors in GGDC 10-Sector Database and KLEMS 2007 are defined based on the International Standard Industrial Classification, Revision 3.1 (ISIC Rev.3.1). The disaggregation results are impressively consistent across economies and over time (see Figure A.1). Classification using labor compensation by skills instead of hours also yields similar results (see Figure A.2). The final classification is determined based on the majority of countries in the sample:

- Low-skilled services: Trade Services (Wholesale and Retail Trade (G), Hotels and Restaurants (H)), Transport Services (Transport, Storage and Communications (I)), Personal Services (Other Community, Social and Personal Service Activities, Activities of Private Households (O,P))
- High-skilled services: Business Services (Financial Intermediation, Renting and Business Activities (excluding owner occupied rents) (J,K)), Government Services (Public Administration and Defense, Education, Health and Social work (L,M,N))

This classification is similar to Fang and Herrendorf (2021)'s classification reported for China. Based on this classification, I compute the employment shares for the four sectors

[3]Following standard literature practice, skilled labor is defined as labor with college degree or higher

in each economy and denote them as L_a, L_m, L_{ls}, L_{hs} for agriculture, manufacturing, low-skilled services and high-skilled services respectively. To analyze the trend of the series, I smooth sectoral employment shares by standard practice using Hodrick-Prescott filter with smoothing parameter value of 6.25 as in standard practice. The data are merged with data from Penn World Table (PWT) 10.0 (Feenstra et al., 2015) to study aggregate implications of structural change patterns in section 6. PPP-adjusted measure of real aggregate output and employment data are used to calculate real aggregate labor productivity.

For the structural transformation patterns in the United States, Groningen Growth and Development Centre (GGDC) 10-Sector Database only provides data after 1950 when the industrialization process in the United States was over. In order to fully capture both the industrialization and the deindustrialization phases in the United States, I combine data from 3 different sources: Carter et al. (2006) for 1880-1930 period, Bureau of Economic Analysis (BEA) data for 1929-1950 period and 10-sector Database for 1950-2010 period.

Other than GGDC 10-Sector Database and Penn World Table 10.0, I also employ three other datasets to document stylized facts in section 3 and to provide suggestive evidence and discussion in section 7. I use labor hours and compensation by sectors and skills data from KLEMS Database 2007 (Timmer et al., 2007) for the classification of services sectors into high-skilled and low-skilled services. The dataset consists of 26 European economies together with the United States and Japan during the period 1970-2004.

To document structural transformation patterns across recent (post-1990s) emerging economies, I employ the GGDC/UNU-WIDER Economic Transformation Database (ETD) (de Vries et al., 2021). The database covers a broader set of 51 developing African, Asian and Latin American countries during period 1990-2018. Sectoral employment data are aggregated into four sectors in a similar manner as with the GGDC 10-Sector Database described earlier. Even though the industry classification of GGDC/UNU-WIDER ETD is based on ISIC Rev.4 Code, twelve economic sectors are aggregated into agriculture, manufacturing, low-skilled services and high-skilled services using a similar method.[4] Agriculture comprises of agriculture (A); manufacturing comprises of mining (B), manufacturing (C), utilities (D,E) and construction (F); low-skilled services comprise of trade services (G,I), transport services (H) and other services (R,S,T,U); high-skilled services comprise of business services (J,M,N), financial services (K), real estate (L) and government services (O,P,Q).

In section 7, I use employment by status in employment and economic activity data from

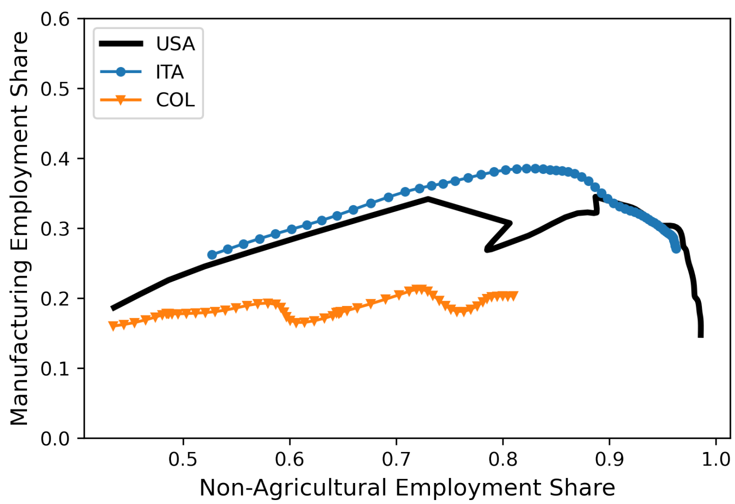
[4] The difference between ISIC Rev.3.1 Code and ISIC Rev.4 Code does not significantly affect the 4-sector classification into agriculture, manufacturing, low-skilled services and high-skilled services.

International Labour Organization (ILO) Database. The dataset contains an unbalanced panel of 156 countries from 1976 to 2020. From the original dataset, I compute share of self-employed persons (as a proxy for informality) by economic sector, country and year.

3 Heterogeneous Paths of Structural Transformation

Rodrik (2016) and Huneeus and Rogerson (2020) document large heterogeneity in the peak of manufacturing hump-shaped patterns across economies. In this section, I show that there are other important features of heterogeneity in structural transformation other than the manufacturing peak. First, countries greatly differ in the whole path of manufacturing evolution: Some countries follow a steep rise and fall in manufacturing share while many others follow a flatter manufacturing profile. Second, the heterogeneity is also substantial in labor allocation within services. These two aspects of heterogeneity turn out to have an important role in understanding the explanatory sources as well as implications on aggregate growth.

Figure 1: Heterogeneous Patterns of Structural Transformation



Notes: Sectoral Employment data for the United States are from Carter et al. (2006), Bureau of Economic Analysis and GGDC 10-Sector Database covering the period 1880-2010. Sectoral Employment data for Italy and Colombia are from GGDC 10-Sector Database covering the period 1950-2010.

In order to compare structural transformation patterns across economies, I employ the representation of plotting sectoral employment shares over non-agricultural employment share. This characterization yields an advantage of visualizing the labor reallocation process from agriculture towards manufacturing and services. As structural transformation out of agriculture is a robust feature of economic development, non-agricultural employment share can serve as a proxy for level of development. This representation of sectoral employment share over non-agricultural employment share exhibits very similar patterns to the conventional representation over GDP per capita.

Figure 1 plots manufacturing employment share against nonagricultural employment share of three economies: the United States, Italy and Colombia. The evolution profiles of manufacturing employment shares are strikingly different between these economies. While the United States and Italy exhibit the pattern of steep rise and decline in manufacturing, Colombia illustrates the pattern of flat hump-shaped profile in the manufacturing employment share. Next subsections present further cross-country evidence on this heterogeneity. To highlight the difference in the patterns of the manufacturing evolution, I classify countries into two groups of patterns: steep manufacturing group characterized with high peak and steep profile of manufacturing (similar to the United States and Italy) and flat manufacturing group characterized with low peak and flat profile of manufacturing (similar to Colombia).

During early to middle stages of development, flat manufacturing economies allocate substantially less employment into manufacturing sector compared to steep manufacturing economies. Instead, structural transformation in flat manufacturing economies is characterized with the reallocation of employment from agriculture into services. Do flat manufacturing economies allocate employment into the same types of services as steep manufacturing? As sectors within services are widely different, breakdown of service sector may reveal important implications about structural transformation process and growth experiences of flat manufacturing economies.

The following subsections present cross-country evidence that countries experience remarkably different patterns of structural transformation. Subsection 3.1 first exhibits the patterns in the United States as a benchmark and other economies in steep manufacturing group. Subsection 3.2 documents the patterns in flat manufacturing economies. Subsection 3.3 reports evidence that recent (post-1990s) emerging economies also exhibit substantial heterogeneity in structural transformation patterns.

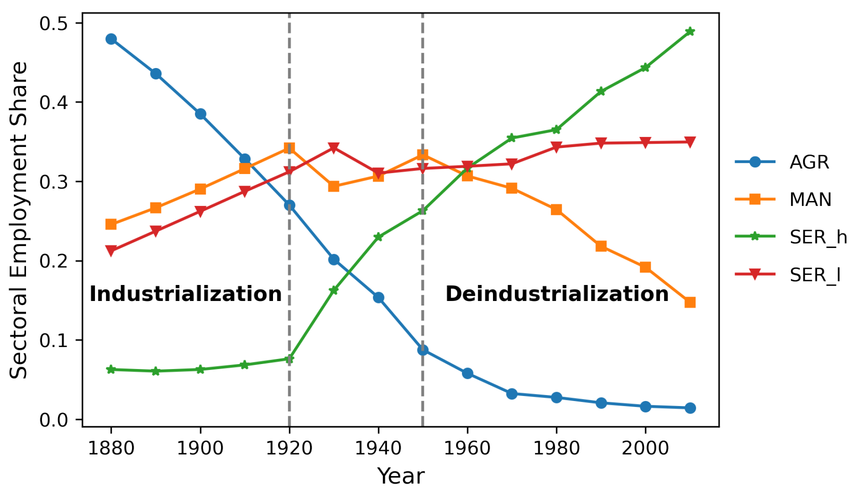
3.1 Structural Transformation Pattern in Steep Manufacturing Economies

This subsection presents stylized facts on structural transformation in the United States and many other economies following similar patterns. I classify this type of structural transformation pattern as steep manufacturing pattern.

Pattern in the United States

I first document structural transformation in the United States as a benchmark economy. Figure 2 displays the evolution of sectoral employment shares during the period from 1880 to 2010. The expansion of low-skilled and high-skilled services occurs at different stages of development.

Figure 2: Structural Transformation in the United States during 1880-2010



Notes: Industrialization and deindustrialization phase indicates the period observing significant rise and decline respectively in manufacturing employment share. The period between 1920 and 1950 (Great Depression and World War II period) observes fluctuation in manufacturing share.

- Industrialization Phase (1880-1920): Labor out of agriculture is mostly reallocated towards manufacturing and low-skilled services. High-skilled services sector accounts for a minor share.
- Great Depression and World War II period (1920-1950): Manufacturing starts reaching the peak and high-skilled services employment share starts rising.
- Deindustrialization Phase (1950-2010): Agricultural employment share becomes very

small. Labor out of manufacturing is mostly reallocated towards high-skilled services. Employment share in low-skilled services does not vary significantly. High-skilled services sector eventually takes over the economy.

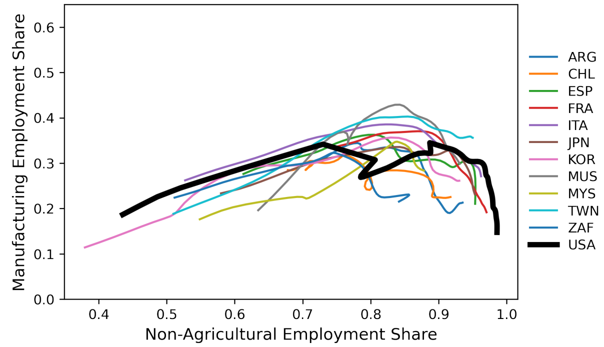
Pattern across Steep Manufacturing Economies

The structural change patterns are quite similar in other developed economies such as the United Kingdom, Canada, Italy and Japan (see Figure B.1). These developed economies experience qualitatively similar patterns to the United States in the industrialization and the deindustrialization phases. Figure 3 documents the structural change patterns in steep manufacturing economies. The patterns are characterized with steep rise and fall in evolution of manufacturing employment share over the course of development. Low-skilled services rise along with manufacturing at earlier stage when high-skilled services mostly develop and dominate the economy at later stage. The structural change patterns differ significantly before and after the peak of manufacturing.

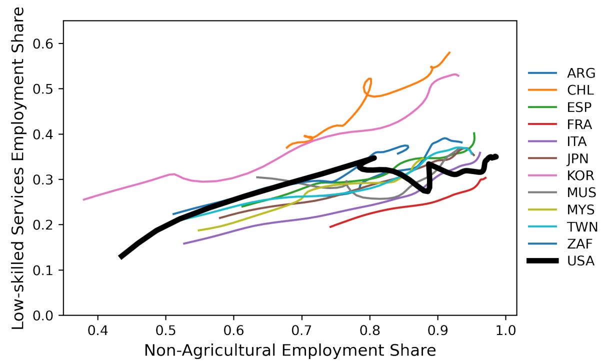
To better visualize the structural change patterns, I separate the sample period of all steep manufacturing economies into two phases: industrialization (before the manufacturing peak) and deindustrialization (after the manufacturing peak). Manufacturing, low-skilled services and high-skilled services employment shares are plotted against non-agricultural employment share. Figure 4 and 5 present the evolution of manufacturing, low-skilled services and high-skilled services during the industrialization and the deindustrialization phases respectively. These figures exhibit stark differences in the patterns of structural change between the industrialization and the deindustrialization phases.

Figure 3: Structural Transformation in Steep Manufacturing Economies

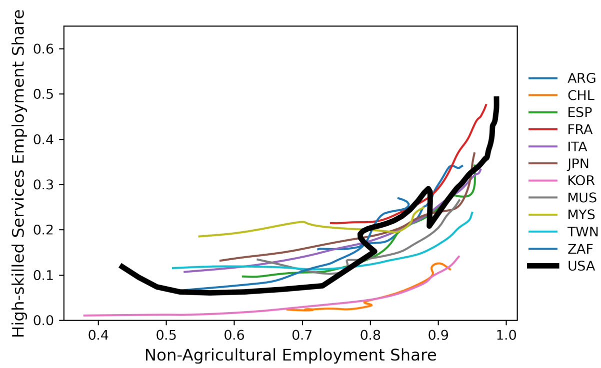
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

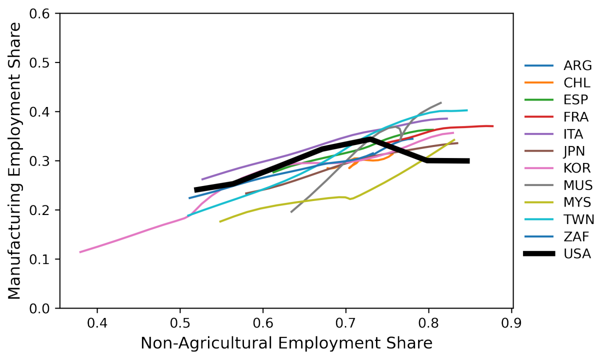


Notes: Black lines represent evolution of manufacturing, low-skilled services and high-skilled services employment shares over non-agricultural employment share in the United States as a benchmark economy. The slope of each line represent the percentage of employment share reallocated towards each sector given 1% employment share leaving agriculture. These slopes are quite similar for other steep manufacturing economies in the figure, suggesting similar pattern to the structural transformation in the United States.

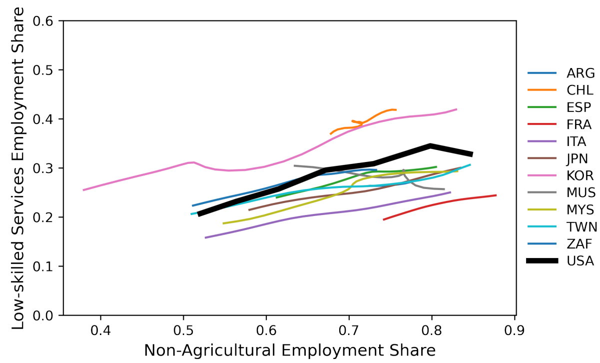
The industrialization phase is characterized by a reallocation of employment out of agriculture to manufacturing and low-skilled services. The sizes of manufacturing and low-skilled services sectors are comparable on average in this phase. The high-skilled services sector is smaller on average and exhibits larger variation across economies. During the industrialization phase (between 0.4% and 0.8% non-agricultural employment share) in the United States, out of 1% employment share out of agriculture, around 0.4%, 0.4% and 0.2% employment shares are reallocated towards manufacturing, low-skilled services and high-skilled services respectively. The values of these slopes are quite similar in other steep manufacturing economies.

Figure 4: Industrialization Phase of Steep Manufacturing Economies

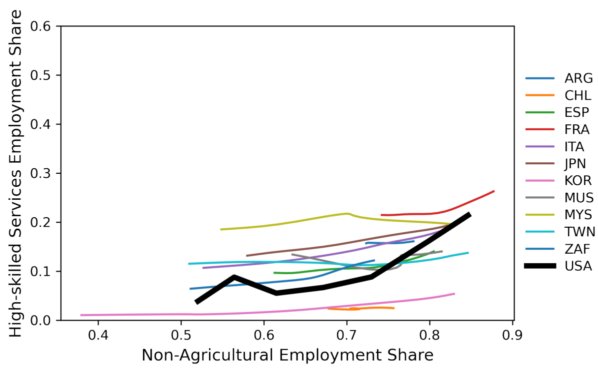
(a) Manufacturing



(b) Low-skilled Services



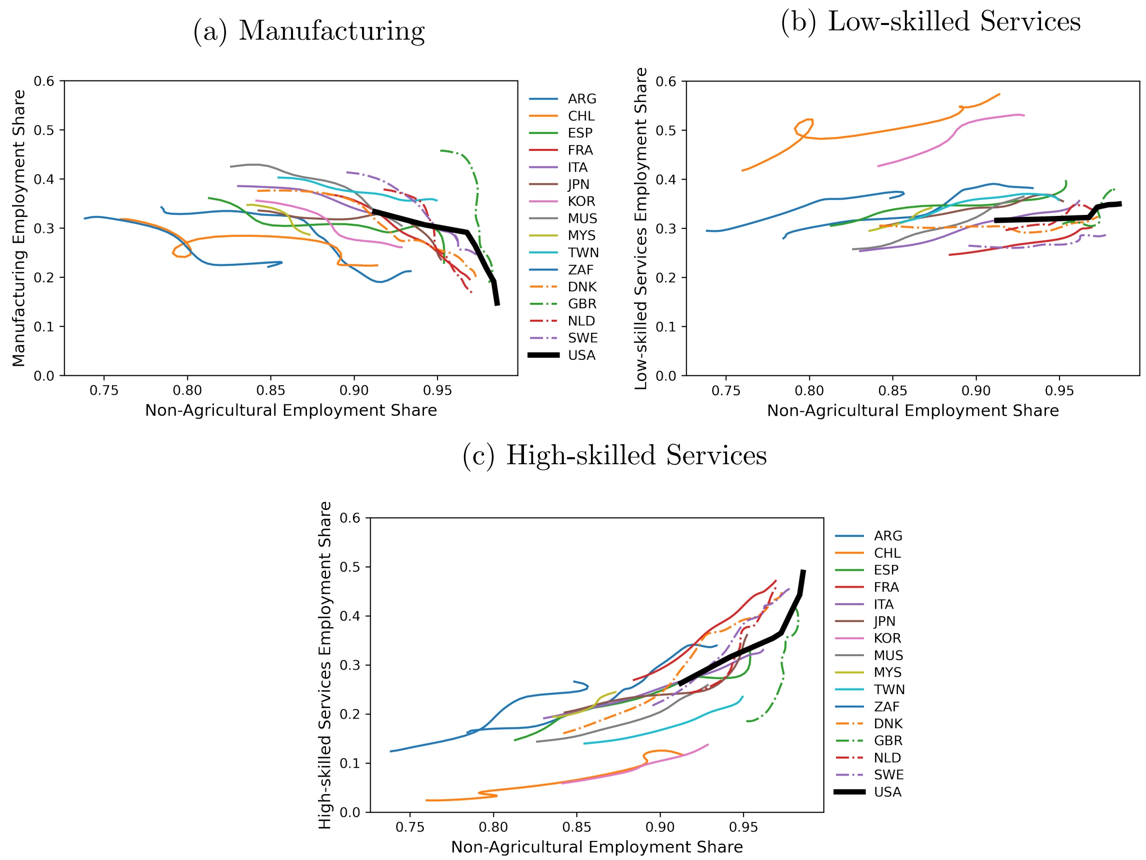
(c) High-skilled Services



Notes: Industrialization phase for each country is marked as the period before the peak of manufacturing employment share. For the United States, due to the period 1920-1950 with fluctuation in manufacturing employment share, the industrialization phase is chosen to be the period 1880-1950 before the decline of manufacturing employment share. The slope and evolution profile in each plot is similar between the steep manufacturing economies and the United States during industrialization phase: While manufacturing and low-skilled services exhibit significant and approximately equal rise in employment share, high-skilled services employment share show less change.

During the deindustrialization phase, employment share in agriculture becomes minor. As discussed above, significantly different from the industrialization phase, the deindustrialization phase is marked with a sharp decline in the manufacturing sector. Labor is reallocated towards high-skilled services, making this sector eventually the largest sector in most of the economies. Low-skilled services employment share experiences fewer changes during this phase.

Figure 5: Deindustrialization Phase of Steep Manufacturing Economies



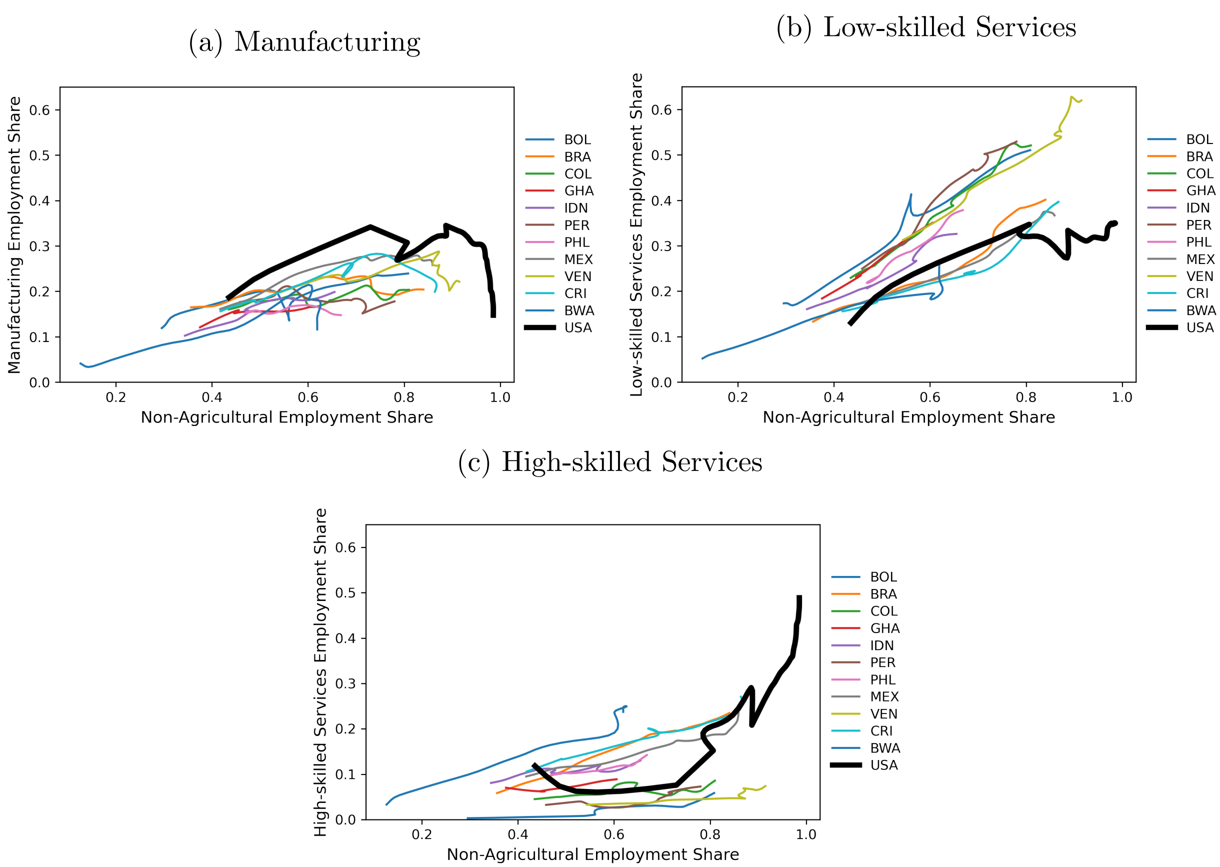
Notes: Deindustrialization phase for each country is marked as the period after the peak of manufacturing employment share. For the United States, due to the period 1920-1950 with fluctuation in manufacturing employment share, the deindustrialization phase is chosen to be the period 1950-2010 during the decline of manufacturing employment share. The slope and evolution profile in each plot is similar between the steep manufacturing economies and the United States during deindustrialization phase: Decline in manufacturing employment share, little change in low-skilled services and significant rise in high-skilled services.

3.2 Pattern in Flat Manufacturing Economies

Flat manufacturing economies do not observe significant deviation in structural change patterns before and after the manufacturing peak. I find that the evolution in the shares of low-skilled and high-skilled services exhibits similar trends before and after the manufacturing peak. Examples of economies which exhibit flat manufacturing profile include Brazil, Peru, Philippines and Ghana (see Figure B.2). Unlike the United States and other steep manufacturing economies, flat manufacturing economies experience a large low-skilled services sector and a small manufacturing sector. The patterns before and after the peak of manufacturing are quite similar: Manufacturing employment share changes little and low-skilled services sector substantially expands.

Figure 6 presents structural change patterns across flat manufacturing economies. We can observe that the paths of manufacturing share are relatively flat and remains at the lower levels in flat manufacturing economies compared to the United States. The low-skilled services sector is considerably larger and expands at steeper rate compared to the United States. High-skilled services sector remains insignificant throughout the sample period for most economies in the group.

Figure 6: Structural Transformation in Flat Manufacturing Economies



Notes: Black lines represent evolution of manufacturing, low-skilled services and high-skilled services employment shares over non-agricultural employment share in the United States as a benchmark economy. The slopes are remarkably different for flat manufacturing economies in each plot, suggesting different pattern to the structural transformation in the United States. In particular, the flat manufacturing economies exhibit lower slope of labor reallocation towards manufacturing and substantially higher slope of labor reallocation towards low-skilled services compared to the United States.

3.3 Heterogeneous Patterns Across Recent Developing Economies

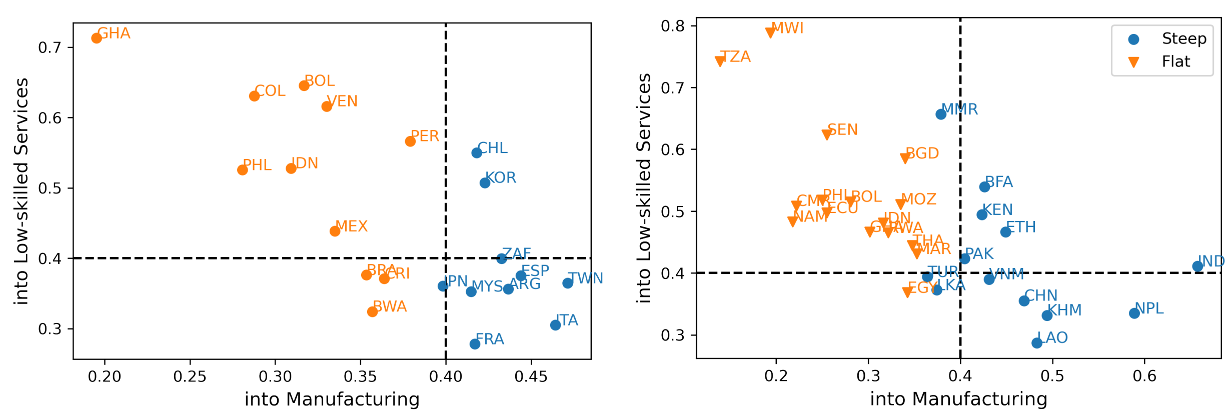
A natural question raised is whether a region or period is associated with the pattern of steep or flat manufacturing. Rodrik (2016) suggests that economies tend to attain lower manufacturing peak after 1990s due to the rise of globalization. However, there are two major limitations with Rodrik (2016)'s analysis. First, his analysis employs the GGDC 10-Sector Database which consists a few number of post-1990s industrializers. Second, as previous studies (including Rodrik (2016) and Huneeus and Rogerson (2020)) focus on the peak as the key feature of manufacturing hump-shaped patterns, their analysis is restricted to include only economies which have attained the manufacturing peak.

This paper overcomes these two limitations by using data from a broad set of recent emerging economies and focusing on the evolution of labor allocation into manufacturing and services. Using data from GGDC/UNU-WIDER Economic Transformation Database (ETD) (de Vries et al., 2021), I document the structural transformation patterns across recent developing economies. Among 51 countries in the sample, there are 29 countries that have observed significant industrialization (at least 10 years) during the sample period.

Figure 7: Percentage of Labor Reallocation from Agriculture into Manufacturing vs. into Low-skilled Services

(a) GGDC 10-Sector Database

(b) GGDC/UNU-WIDER Economic Transformation Database



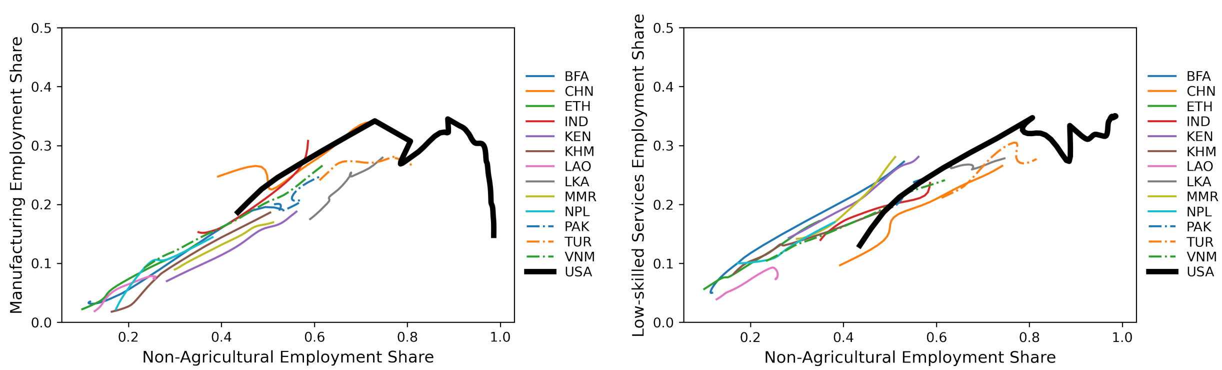
Notes: Figure (a) reports the variables for earlier (post-1950s) economies from GGDC 10-Sector Database. Figure (b) reports the variables for later developers (post-1990s) from Economic Transformation Database. The dash line presents the labor allocation into manufacturing and low-skilled services in the United States during the industrialization: Out of 1% employment share leaving agriculture, around 0.4% employment share is reallocated towards manufacturing and low-skilled services.

Figure 7 shows cross-country patterns of labor reallocation out of agriculture into manufacturing and low-skilled services. Figure 7a and 7b plot the labor reallocation into manufacturing and low-skilled services of earlier developers during 1950-2010 (GGDC 10-Sector Database) and later developers during 1990-2018 (Economic Transformation Database) respectively. There are two major similar structural transformation patterns between the two samples. First, the economies in both samples reallocate employment out of agriculture mostly towards manufacturing and low-skilled services. Economies that allocate less employment share into manufacturing (flat manufacturing) tend to allocate more employment share into low-skilled services and vice versa. Second, different from Rodrik (2016)'s finding that post-1990 economies tend to attain lower manufacturing peak or follow flat manufacturing pattern, figure 7b shows that 13 recent developers out of 29 allocate similar or even more labor into manufacturing compared to the United States during the industrialization phase. Moreover, both steep and flat manufacturing patterns occur in all the three regions: Africa, Asia and Latin America. This evidence suggests that heterogeneous structural transformation patterns of steep and flat manufacturing are prevalent across economies and not subject to a specific time period or a geographical region.

Figure 8: Structural Transformation Patterns in Recent Steep Manufacturing

(a) Manufacturing Employment Share

(b) Low-skilled Services Employment Share

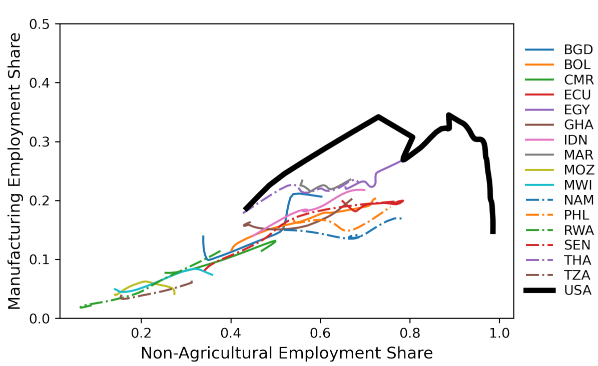


Notes: The slopes of manufacturing and low-skilled services employment shares with respect to non-agricultural employment share in these recent steep manufacturing economies are close to the United States during the industrialization phase. Even though these recent developing economies have not reached the manufacturing peak yet, they exhibit quite similar slopes and evolution profiles of employment share in manufacturing and low-skilled services plots to the United States.

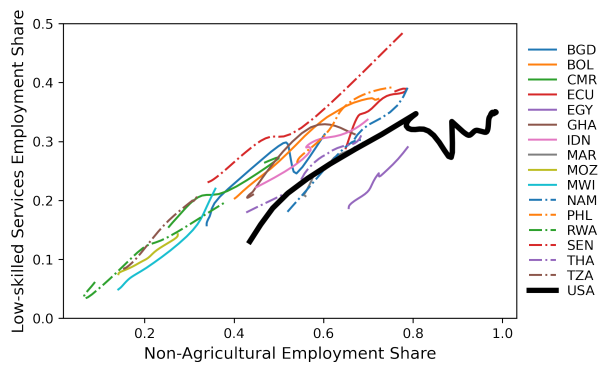
Figure 8 and 9 illustrate the structural transformation patterns of recent steep manufacturing economies along with economies exhibiting the flat manufacturing pattern. In Figure 8a and 9a, while many recent emerging economies follow similar patterns to the United States with steep evolution of manufacturing, many others follow flat manufacturing patterns with less labor reallocation towards manufacturing. Figure 8b and 9b show that compared to the United States and other recent steep manufacturing economies, recent flat manufacturing economies also tend to allocate substantially more labor towards low-skilled services.

Figure 9: Structural Transformation Patterns in Recent Flat Manufacturing

(a) Manufacturing Employment Share



(b) Low-skilled Services Employment Share



Notes: The slopes of manufacturing and low-skilled services employment shares with respect to non-agricultural employment share in these recent flat manufacturing economies differ remarkably from the United States during the industrialization phase. Even though these recent developing economies have not reached the manufacturing peak yet, they exhibit significantly lower slopes of labor allocation to manufacturing and low-skilled compared to the United States.

In summary, structural transformation patterns are remarkably different across countries. While many countries follow steep manufacturing profile and moderate rise of low-skilled services similar to the United States, many other countries exhibit a pattern of flat manufacturing evolution and substantial rise of low-skilled services. These two heterogeneous patterns of structural transformation are observed among both earlier (pre-1990s) and later (post-1990s) developers, suggesting that the heterogeneity in structural change cannot be simply explained by the timing of development as suggested by Rodrik (2016).

4 Model

In this section, I lay out a model of structural transformation as a framework to investigate sources behind the heterogeneity in structural transformation across countries presented in the earlier section. In the model, sectoral labor productivity are the key driving forces behind labor reallocation across sectors. I also present the calibration strategy for the key parameters in the model and provide theoretical insights on potential sources driving the phenomenon of cross-country heterogeneity in structural transformation.

4.1 Model Description

I consider a standard benchmark model of structural transformation following Rogerson (2008) and Duarte and Restuccia (2010). In each period, four different types of goods are produced using linear technology in labor: Agriculture (a), manufacturing (m), low-skilled services (ls) and high-skilled services (hs).

Production. Technology

$$Y_i = A_i L_i, \qquad i \in \{a, m, ls, hs\} \tag{1}$$

where Y_i is output, L_i is labor input and A_i is labor productivity in sector i.

Households. Representative household is endowed with 1 unit of time and have preferences over four consumption goods. Following Gollin et al. (2002), the model assumes a subsistence constraint in agricultural consumption: Households are assumed to only receive utility from consuming non-agricultural goods when agricultural consumption satisfies subsistence constraint ($c_a > \bar{a}$).

Conditional on $c_a > \bar{a}$, preference over non-agricultural goods follows a homothetic CES preference given by

$$v(c_m, c_{ls}, c_{hs}) = \left(\varphi_m^{\frac{1}{\sigma}} c_m^{\frac{\sigma-1}{\sigma}} + \varphi_{ls}^{\frac{1}{\sigma}} c_{ls}^{\frac{\sigma-1}{\sigma}} + \varphi_{hs}^{\frac{1}{\sigma}} c_{hs}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

The literature emphasizes on two forces behind structural change between manufacturing and services: income effect and substitution effect. However, similar to Huneeus and Rogerson (2020), I also find limited role of income effect in allocating labor between manufacturing and services sectors during early to middle stage of development across economies. The assumption of homothetic CES preference across manufacturing and services serves to generate tractability and transparency.

Market structure. Firms are competitive in output and labor markets. Given market prices $\{p_i\}$ and wage w, a representative firm chooses labor input to maximize profit and the representative household chooses consumption allocations to maximize utility subject to budget constraint. Population size is normalized to 1.

Competitive Equilibrium. The equilibrium consists of a set of allocations $\{c_a, c_m, c_{ls}, c_{hs}\}$, $\{L_a, L_m, L_{ls}, L_{hs}\}$ and a set of prices $\{p_a, p_m, p_{ls}, p_{hs}\}$ (wage w is normalized to 1) such that

1. Given set of prices $\{p_i\}$, $\{c_i\}$ solves household's problem

$$\max_{\{c_i\}_{i=a,m,ls,hs}} \quad u(c_a, c_m, c_{ls}, c_{hs}) \quad \text{s.t.} \quad \sum_{i=a,m,ls,hs} p_i c_i = 1 \tag{3}$$

2. Given set of prices $\{p_i\}$, $\{L_i\}$ solves firm's problem

$$\max_{L_i} \quad p_i A_i L_i - L_i \tag{4}$$

3. Goods markets clear

$$c_i = Y_i, \quad i \in \{a, m, ls, hs\} \tag{5}$$

4. Labor market clears

$$L_a + L_m + L_{ls} + L_{hs} = 1 \tag{6}$$

Given linear production technology, from the firm's problem, sectoral price is the inverse of sectoral labor productivity:

$$p_i = \frac{1}{A_i}, \quad i \in \{a, m, ls, hs\} \tag{7}$$

Combining with goods market clearing conditions, expenditure share and employment share are equal for each sector

$$p_i c_i = p_i Y_i = L_i \tag{8}$$

Household's problem and market clearing conditions will then determine sectoral expenditure and employment shares.

If $A_a \leq \bar{a}$, household will allocate all income to agricultural goods and consequently all expenditure and labor are in agriculture. The case $A_a > \bar{a}$ will be more relevant and be focused in the analysis. In this case, household will spend only $c_a = \bar{a}$ on agricultural goods, implying agricultural employment share

$$L_a = \frac{\bar{a}}{A_a} \tag{9}$$

The remaining income ($E = 1 - \bar{c_a}$) is allocated towards c_m, c_{ls} and c_{hs}. From household's problem, expenditure for each sector $i = m, ls, hs$ can be derived as

$$\frac{p_i c_i}{E} = \frac{\varphi_i p_i^{1-\sigma}}{\sum_{j=m,ls,hs} \varphi_j p_j^{1-\sigma}} \tag{10}$$

Substituting conditions (7) and (8) yields

$$L_i = \frac{\varphi_i A_i^{\sigma-1}}{\sum_{j=m,ls,hs} \varphi_j A_j^{\sigma-1}} \left(1 - \frac{\bar{a}}{A_a}\right) \tag{11}$$

4.2 Productivity Dynamics

Following the standard practice in literature, I focus on the case assuming constant technological progress in each of the four sectors

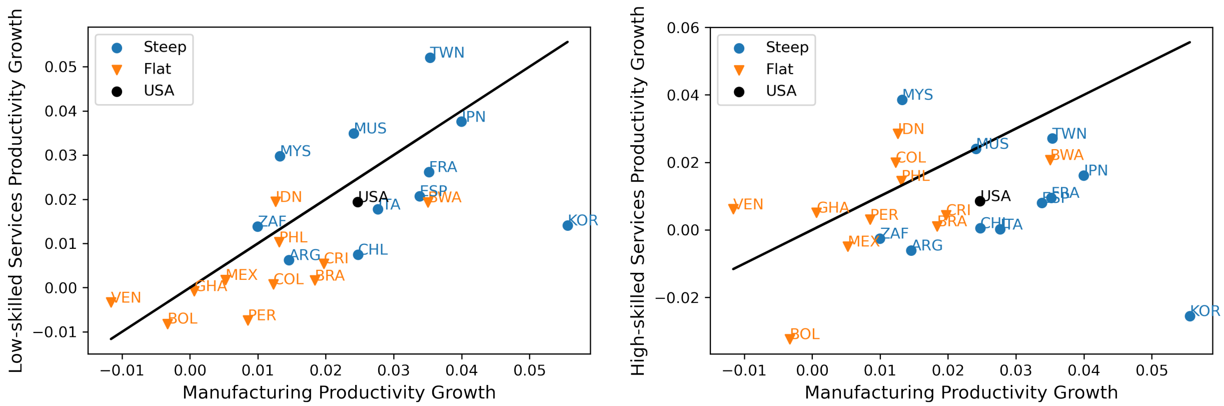
$$A_{it} = A_{i0} e^{g_i t}$$

The structural transformation patterns are driven by relative sectoral productivity growth rate $\{g_i\}$ and relative labor productivity level $\{A_{i0}\}$. Huneeus and Rogerson (2020) find that the hump-shaped pattern of manufacturing is driven by positive agricultural productivity growth ($g_i > 0$) and larger productivity growth in manufacturing relative to services ($g_m > g_s$).

Figure 10 reports the annualized growth rates of labor productivity in low-skilled services and high-skilled services against manufacturing sectors. Empirical evidence generally indicates that manufacturing has higher productivity growth than both high- and low-skilled services in most of the sample countries. Compared to high-skilled services, productivity growth rates in both manufacturing and low-skilled services are subject to larger variation across countries. Steep manufacturing economies tend to observe higher productivity growth rates in both manufacturing and low-skilled services than flat manufacturing economies. High-skilled services productivity growth rates, on the other hand, are quite similar across economies.

Figure 10: Sectoral Labor Productivity Growth Rates

(a) Manufacturing vs. Low-skilled Services (b) Manufacturing vs. High-skilled Services



Notes: Solid line represents 45-degree line. Point above the line indicates that annualized productivity growth rate in low/high-skilled services is higher than in manufacturing. Black dots represent annualized sectoral productivity growth rates in the United States.

4.3 Benchmark Calibration to the United States

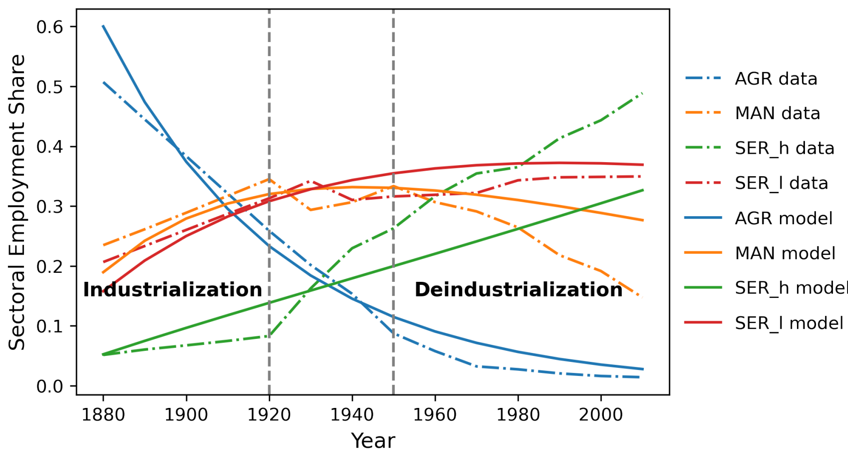
I calibrate the model parameters to capture the evolution of sectoral employment shares in the United States during the industrialization phase 1880-1950. Due to the lack of data on US sectoral productivity for the period 1880-1950, I follow Huneeus and Rogerson (2020) to assume agricultural productivity growth (g_a) to be 2.39% to match the observed trend in agricultural employment share. Other sectoral growth rates (g_m, g_{ls}, g_{hs}) during 1880-1950 are assumed to be the growth rates between 1950 and 1970.

All sectoral productivity levels in the initial period (A_{i0}) are normalized to 1. The economy is assumed to start at 60% employment in agriculture, implying that $\bar{a} = 0.60$. Elasticity of substitution for non-agricultural goods, σ, is set to be 0.30 following estimates using micro-data in Comin et al. (2021). My calibration strategy is to pick values for φ_m, φ_{ls} and φ_{hs} to match United States sectoral employment share evolution. Table 1 presents calibrated values.

Table 1: Benchmark Calibration

Parameters	σ	$\bar{a}$	φ_m	φ_{ls}	φ_{hs}
Value	0.30	0.60	0.47	0.40	0.13

Figure 11: Structural Transformation in the United States: Model vs. Data



Notes: The figure plots sectoral employment shares inferred by the model and in the data of the United States. The dashed lines represent the data and the solid lines represent the model. The model fits the data quite well.

Figure 11 shows the fit of the calibrated model to the data in the United States. The model can generate the hump shape of manufacturing with the peak close to observed data. The model generates employment shares very close to data during the industrialization phase. However, the model doesn't generate very close fit to the employment shares for manufacturing and high-skilled services during the deindustrialization phase. The reasons are potentially the simplification assumptions of constant sectoral labor productivity growth and no income effect for labor allocations between manufacturing and services sectors in the model. During late stage of development, sectoral productivity growth rates could greatly differ from previous stages and income effect becomes more important in leading to the decline of manufacturing and the expansion of high-skilled services. As this paper focuses more on early and middle stages of development across economies, abstraction from changes in growth and income effect does not significantly affect the results presented in the next sections while having an advantage of yielding better transparency to the analysis.

4.4 Sources of Structural Transformation

The above theoretical model suggests that heterogeneity in structural change patterns arises from deviations in sectoral productivity profiles. Two forces behind these departures are sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Detailed analysis on the role of sectoral productivity growth factors can be found in Huneeus and Rogerson (2020). They report finding that agricultural productivity growth largely accounts for the variation in the manufacturing peak compared to the relative productivity growth between manufacturing and services sectors.

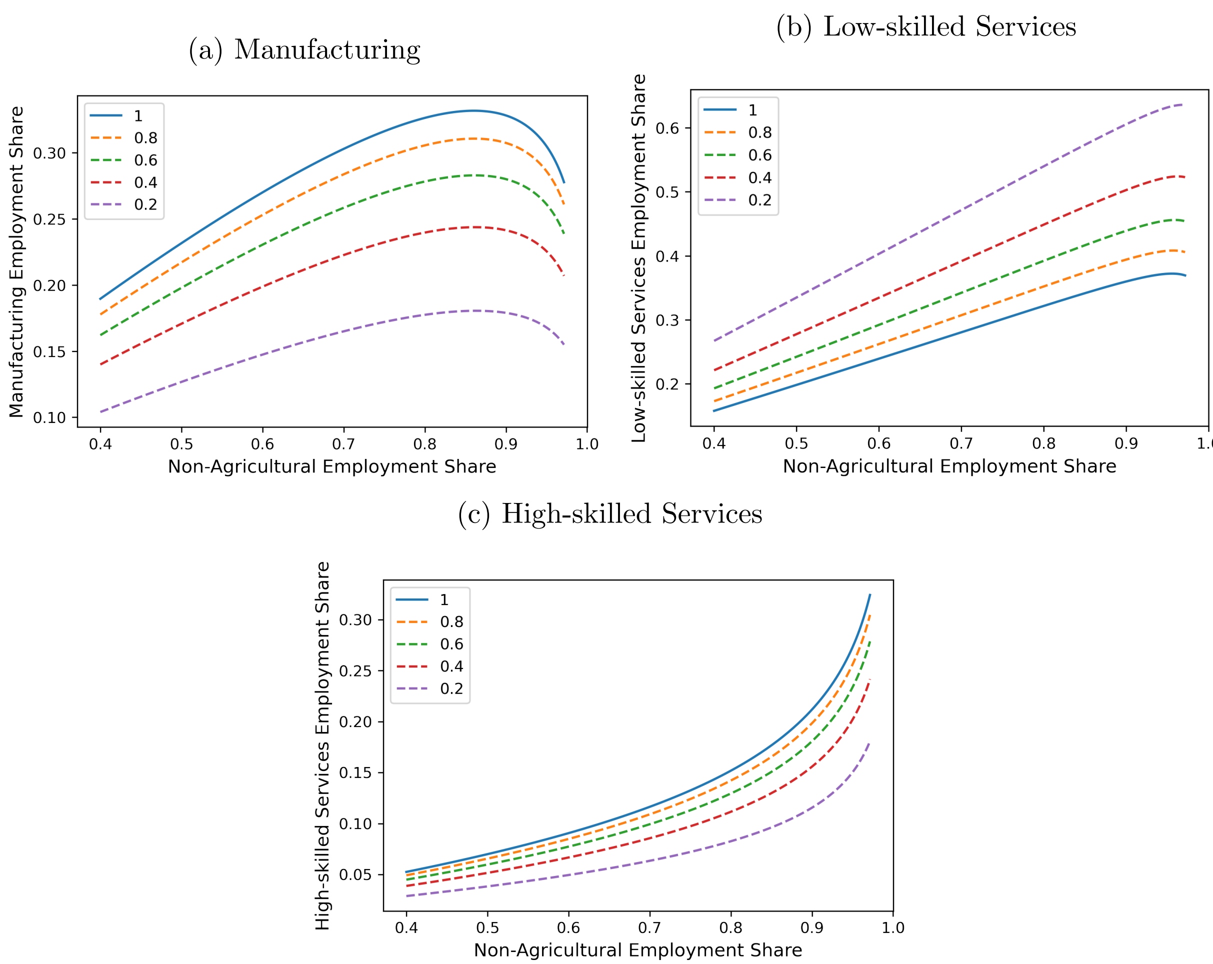
This paper introduces and investigates initial sectoral productivity levels as another channel in shaping the observed patterns in section 3. The model suggests that two economies with similar sectoral productivity growth rates can still experience different relative productivity profiles if the initial relative productivity levels in non-agricultural sectors are different. Consider a simple illustration of the United States as a benchmark economy and an economy c. Assume both countries have same productivity growth rates in all sectors $g_i^c = g_i^{US} = g_i \quad \forall i \in \{a, m, ls, hs\}$ and initial agricultural productivity level $A_{a0}^c = A_{a0}^{US}$. The only difference between the two economies is in initial relative sectoral productivity levels among non-agricultural sectors $\frac{A_{i0}^c}{A_{m0}^c} \neq \frac{A_{i0}^{US}}{A_{m0}^{US}} \quad \forall i \in \{ls, hs\}$. As sectoral productivity grows at the same rate in both countries, relative productivity levels among non-agricultural sectors are different between country c and the United States at any period t $\frac{A_{it}^c}{A_{mt}^c} \neq \frac{A_{it}^{US}}{A_{mt}^{US}} \quad \forall i \in \{ls, hs\}$ and the differences remain the same as the initial differences

$$\frac{A_{it}^c/A_{mt}^c}{A_{it}^{US}/A_{mt}^{US}} = \frac{A_{i0}^c/A_{m0}^c}{A_{it}^{US}/A_m^{US}} \frac{e^{(g_i-g_m)t}}{e^{(g_i-g_m)t}} = \frac{A_{i0}^c/A_{m0}^c}{A_{it}^{US}/A_m^{US}} \quad \forall i \in \{ls, hs\} \tag{12}$$

The difference in initial relative productivity levels represents a persistent gap in relative sectoral productivity levels between the two economies over the course of development. This gap can be resulted from country-specific static factors such as past growth rates, institutions, distortions, human capital endowments. The gap in initial relative productivity will persist over time and result in different patterns of labor allocation. As the key feature of heterogeneity in structural change patterns is that flat manufacturing economies experience lower manufacturing shares and higher low-skilled services, a flat manufacturing economy is expected to have lower relative labor productivity of low-skilled services to manufacturing than in the United States: $\frac{A_{ls0}^c}{A_{m0}^c} < \frac{A_{ls0}^{US}}{A_{m0}^{US}}$.

To illustrate quantitative impact of initial relative productivity channel, I consider four economies similar to the United States in sectoral labor productivity growth but with lower values of initial relative labor productivity of low-skilled services to manufacturing. Figure 12 presents the evolution of sectoral employment shares in these four counterfactual economies where initial relative labor productivity levels of low-skilled services to manufacturing are set to be 0.8, 0.6, 0.4 and 0.2 of the benchmark economy (the United States). Blue connected lines present the structural transformation pattern of the United States, whereas the dashed lines exhibit the patterns in the four counterfactual economies. This departure where initial relative productivity levels are the only source of variation generates similar patterns to flat manufacturing economies: lower manufacturing peaks and flatter manufacturing hump shapes. Low-skilled services employment share also rises at steeper rate. The counterfactuals suggest that static factors leading to lower initial productivity of low-skilled services relative to manufacturing can qualitatively characterize the deviations in structural change patterns of flat manufacturing from the United States.

Figure 12: Static Factors and Structural Change Patterns



Notes: Solid line represent the sectoral employment share in the benchmark economy following the structural transformation in the United States. Dash lines represent four counterfactual economies which only differ from the benchmark economy due to lower initial productivity levels of low-skilled services (equal to $0.8, 0.6, 0.4$ and 0.2 of the benchmark economy).

5 Cross-country Analysis

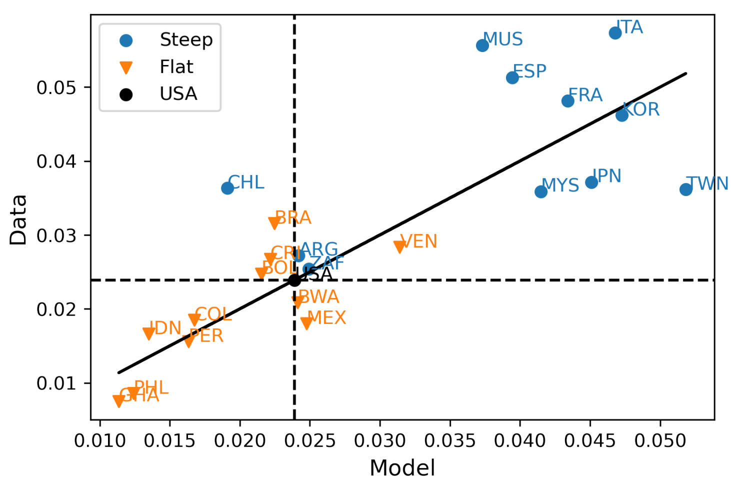
Based on the model calibrated to the United States as a benchmark economy, this section extends the analysis to study forces driving heterogeneity in cross-country structural transformation patterns. The section first starts with the calibration of sectoral productivity growth and levels across countries. I next present a set of counterfactuals showing the decomposition of sources behind the cross-country heterogeneous structural transformation paths.

5.1 Cross-country Calibration

Agricultural Sector Calibration

Based on the model's assumption on subsistence constraint in terms of agricultural consumption, I calibrate the growth rate of agricultural labor productivity implied by model to fit the observed employment share of agriculture. Figure 13 plots the agricultural labor productivity growth rates from the data and those inferred by the model. The growth rates inferred by the model track the data quite well for most economies. The result suggests a good fit of model for explaining the evolution of employment share in xagricultural sector.

Figure 13: Agricultural Productivity Growth: Model vs. Data



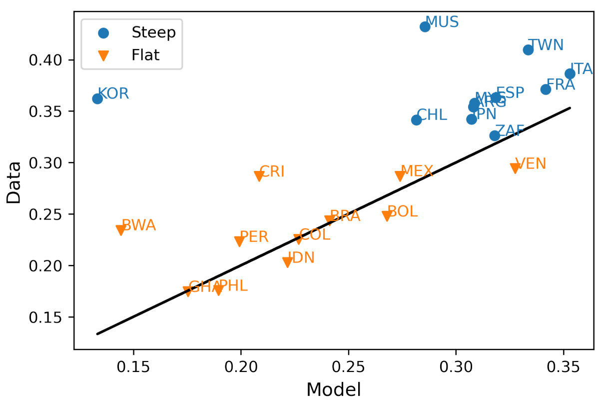
Notes: The plot reports the value in the last period for the model and the data. Solid line represents the 45-degree line on which the model perfectly fits the data. The agricultural productivity growth rates inferred from the model are quite close to the data.

Manufacturing and Services Sectors Calibration

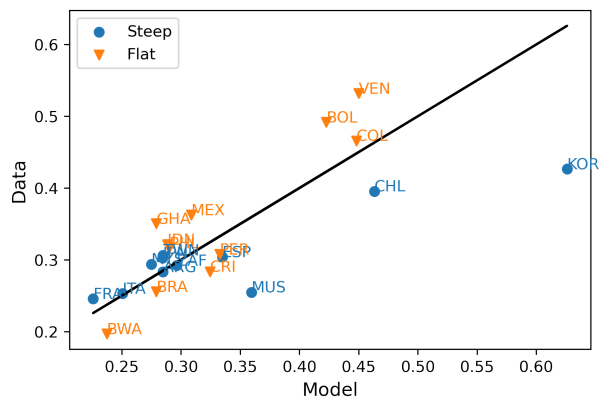
For labor allocation in manufacturing and services sectors, I follow the calibration strategy described in Duarte and Restuccia (2010). Due to the lack of comparable sectoral value-added data across large set of countries, I employ the model to restrict sectoral labor productivity levels in initial sample period. For each country, sectoral labor productivity levels in manufacturing, low-skilled services and high-skilled services are calibrated to match sectoral employment shares and aggregate labor productivity relative to the United States for the first year in the sample.

Figure 14: Sectoral Employment Share at Manufacturing Peak Year: Model vs. Data

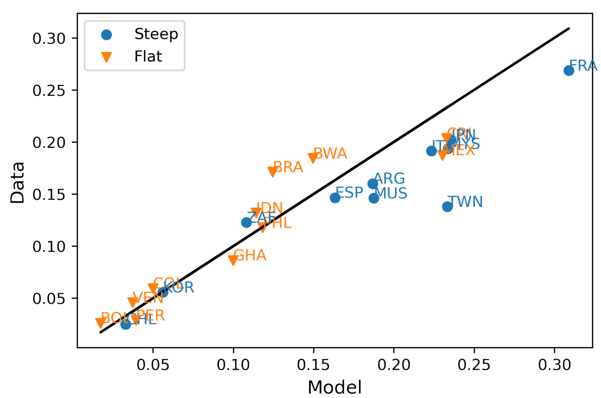
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

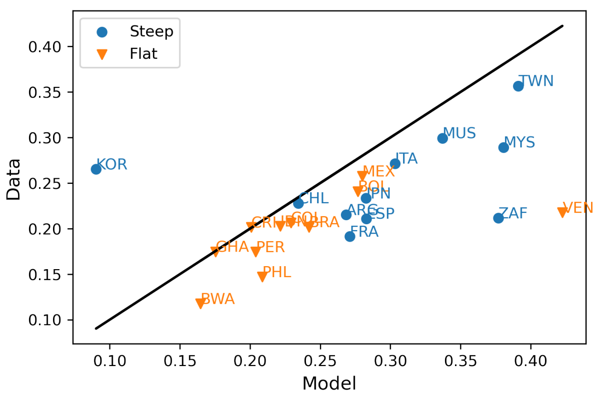


Notes: Each plot reports the value for each variable in the period when manufacturing reaches the peak for the model and the data. Solid line represents the 45-degree line on which the model perfectly fits the data. The sectoral employment shares at the peak of manufacturing inffered by the model are quite close to the data.

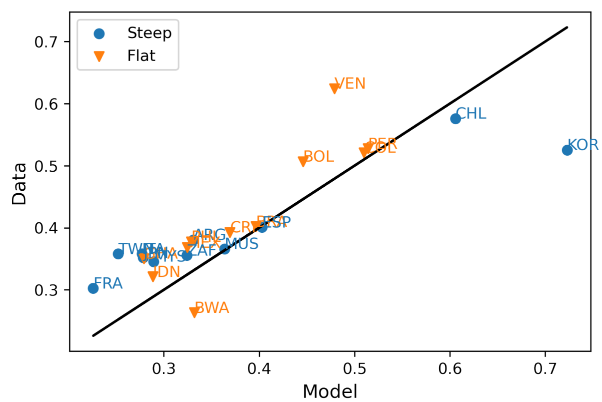
Figure 14 reports the shares of employment for each sector in the peak year of manufacturing employment share in the model and in the data. Figure 15 plots the shares of employment in each sector in the last sample period in the model and in the data. The model can generate quite good fit in sectoral employment shares in the peak year as well as in the last year. The overall fit of the structural change paths is quite impressive for a simple model.

Figure 15: Last-year Sectoral Employment Share: Model vs. Data

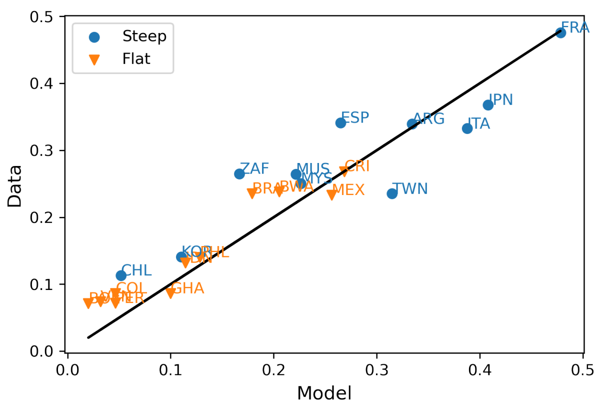
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



Notes: Each plot reports the value for each variable in the last period for the model and the data. Solid line represents the 45-degree line on which the model perfectly fits the data. The sectoral employment shares in the last sample period inferred by the model are quite close to the data.

5.2 Counterfactual Analysis

I perform counterfactual analysis to decompose the quantitative importance of initial sectoral productivity levels (static factors) and sectoral productivity growth rates (dynamic factors) in generating the heterogeneous patterns across countries. As discussed in section 4, static and dynamic factors are the two forces driving heterogeneous sectoral productivity profiles across economies. The counterfactuals are conducted by setting the growth rates of labor productivity in all sectors to the rates of the United States, leaving the initial sectoral productivity levels the same as calibrated values. These counterfactuals illustrate the importance of initial sectoral productivity levels for cross-country patterns in sectoral labor allocation. The counterfactual results indicate that differences in initial sectoral productivity levels are found to be the main drivers of heterogeneity in structural change patterns between steep and flat manufacturing economies.

Illustrating Example of Colombia

I first present the findings of the counterfactual exercise through an illustration of Colombia (COL). Figure 16 exhibits the evolution of manufacturing, low-skilled services and high-skilled services employment shares over non-agricultural employment share in the counterfactuals with Colombia data.

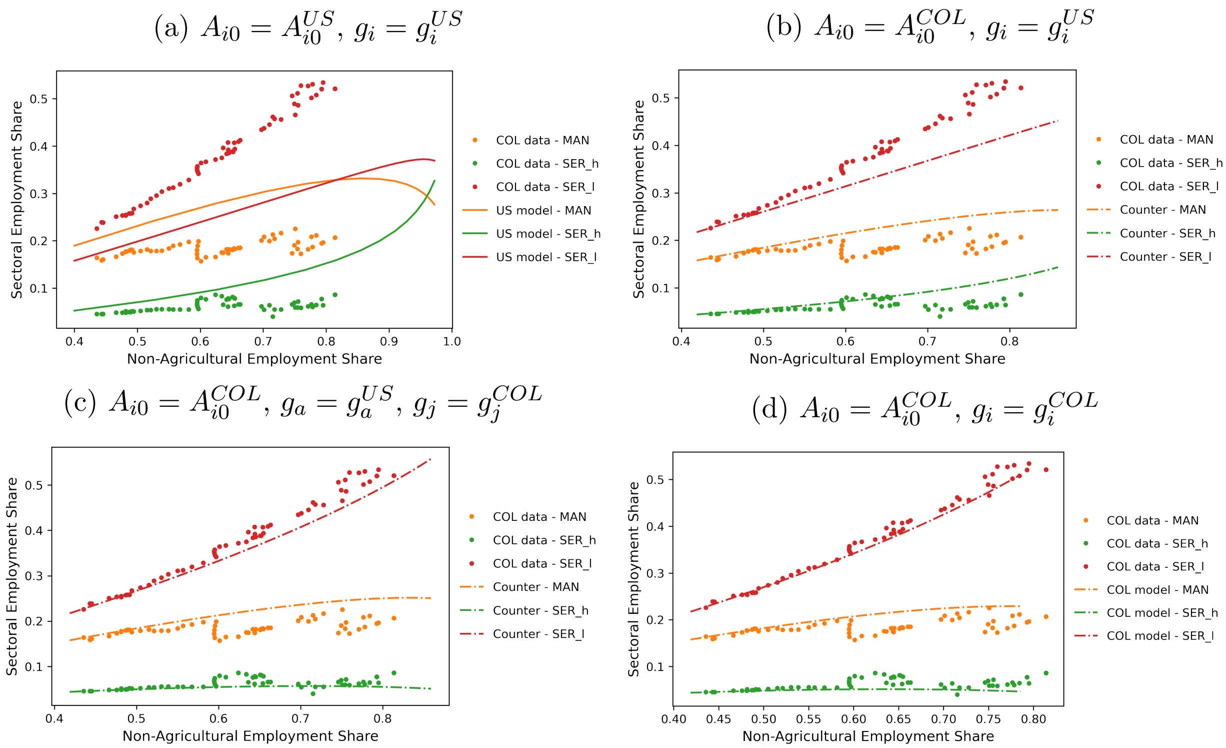
Figure 16a plots the United States modeled sectoral employment shares (which is close to the shares in the United States data presented earlier in Figure 11) and Colombia's shares in the data. Manufacturing employment share in the United States experience a steep hump shape with significantly higher values than Colombia during the industrialization phase. Low-skilled services employment share is substantially higher in Colombia compared to the United States over the whole sample period. The economic structures between the United States and Colombia are substantially different. At 80% non-agricultural employment share, while the United States has approximately 32% employment share in manufacturing and 32% employment share in low-skilled services, Colombia economy comprises of approximately 20% employment share in manufacturing and 50% employment share in low-skilled services.

Figure 16b exhibits sectoral employment shares in Colombia data and the first counterfactual using Colombia's initial sectoral labor productivity and the United States's productivity growth rates in agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactual can generate structural change patterns closer to the data with a steeper rise in low-skilled services and a flatter hump shape of manufacturing. This result indicates that initial relative productivity levels have important implications for heterogeneous structural change patterns between Colombia and the United States. The remaining gaps in structural change patterns between this counterfactual and the data are attributed to dynamic factors (sectoral productivity growth rates).

Figure 16d shows that incorporating both sectoral initial productivity levels and sectoral productivity growth rates of Colombia generates structural change patterns very close to the data. Figure 16c shows sectoral employment shares by the counterfactual using Colombia's initial sectoral labor productivity with the United States's agricultural productivity growth and Colombia's productivity growth rates in the other three sectors. The sectoral employment shares by this counterfactual are also close to the data, suggesting limited explanatory power of productivity growth in agriculture.

At 80% non-agricultural employment share, initial relative labor productivity contributes around 74% and 52% to the differences in manufacturing and low-skilled services employment shares between the United States and Colombia. Sectoral productivity growth rates explain around 26% and 48% respectively to the observed difference in manufacturing and low-skilled services share. Among the four sectors, agricultural productivity growth contributes only 9% and 12% to the observed differences in manufacturing and low-skilled services employment shares.

Figure 16: Sectoral Employment Shares: Counterfactual vs. Colombia data



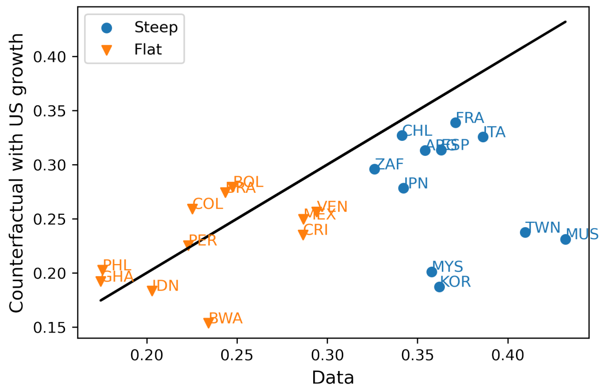
Notes: Each plot presents sectoral employment share of the data in Colombia along with the benchmark model or counterfactuals. Figure (a) shows the sectoral employment shares in the benchmark model of the United States. Figure (b) shows the sectoral employment shares in the counterfactual assuming Colombia's initial sectoral relative productivity levels and the United States' sectoral productivity growth rates. Figure (c) shows the sectoral employment shares in the counterfactual assuming Colombia's initial sectoral relative productivity levels, Colombia's sectoral productivity growth rates in non-agricultural sectors and the United States' agricultural productivity growth rates. Figure (d) shows the the sectoral employment shares in the counterfactual using initial sectoral productivity levels and growth rates in Colombia.

Cross-country Counterfactual Results

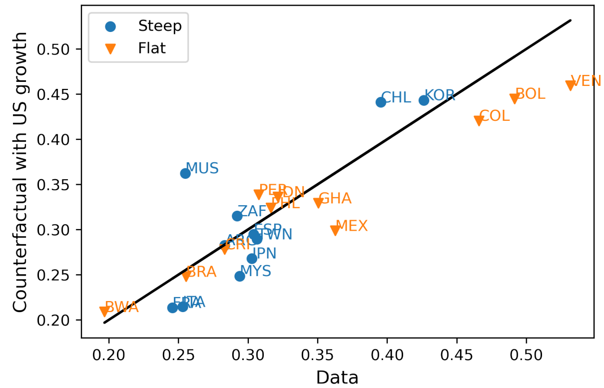
The counterfactual exercise is conducted for other economies in the sample. For each economy, the counterfactual sectoral productivity and employment profiles are generated assuming the economy's initial conditions and the United States sectoral productivity growth rates.

Figure 17: Sectoral Employment Share at Manufacturing Peak Year: Counterfactual with the United States growth vs. Data

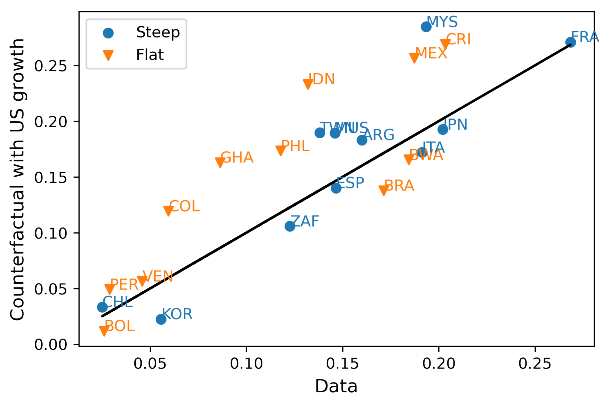
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



Notes: The counterfactual assumes each country's initial sectoral productivity level and the United States' sectoral productivity growth rates. Each plot reports the value for each variable in the period when manufacturing reaches the peak for the counterfactual and the data. Solid line represents the 45-degree line on which the counterfactual perfectly fits the data. The counterfactual generates sectoral employment shares close to the data, suggesting that variation in initial sectoral productivity levels can account for the observed heterogeneity in structural transformation.

Figure 14 plots the sectoral employment shares in the peak year of manufacturing share in this counterfactual against the data. The counterfactual generates structural change patterns very close to the data, suggesting that the differences in initial relative productivity levels are quantitatively sufficient in driving observed heterogeneous patterns between steep and flat manufacturing economies.

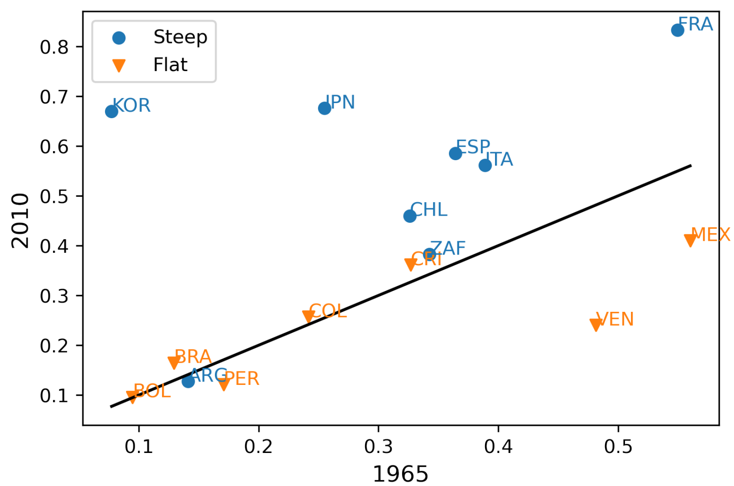
6 Aggregate Implications

In this section, I document cross-country patterns in aggregate labor productivity and investigate the quantitative importance of sectoral labor productivity in explaining cross-country growth experiences during the period 1965-2010. Due to sample limitation, only 15 among 22 countries are included in the analysis.

6.1 Aggregate and Sectoral Productivity Patterns

I first document patterns in aggregate productivity growth across countries. The data for aggregate productivity are derived as follows. Aggregate labor productivity relative to the United States in 1965 is calculated based on PPP-adjusted real output and labor data from Penn World Table (PWT) 10.0. Combining with real aggregate productivity growth measured from the data in GGDC 10-Sector Database, I then compute aggregate labor productivity relative to the United States in 2010 for each country.

Figure 18: Aggregate Labor Productivity Relative to the United States: 1965-2010

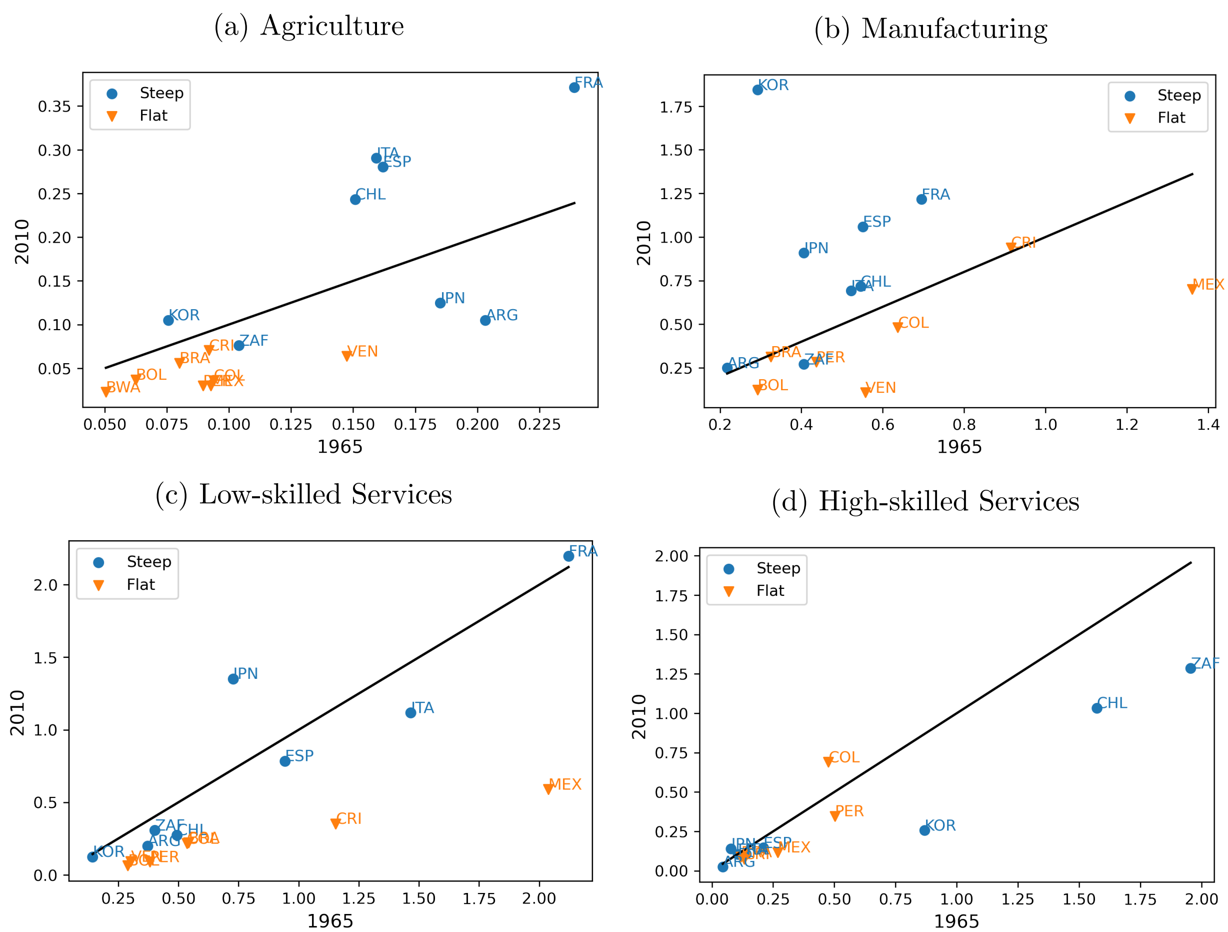


Notes: Data on aggregate labor productivity levels are from Penn World Table 10.0. The plot reports aggregate labor productivity level relative to the United States in 1965 and 2010. Solid line represents the 45-degree line on which the aggregate labor productivity levels relative to the United States in 1965 and 2010 are the same, indicating no catch-up in labor productivity with the United States.

Figure 18 plots real aggregate labor productivity relative to the United States in 2010 against values in 1965 as well as a 45-degree line to facilitate comparison. Most steep manufacturing countries lie very far above the 45-degree line, indicating episodes of substantial catch-up in aggregate productivity relative to the United States. Most economies in flat manufacturing group lie very close to or below 45-degree line, suggesting experiences of no catch-up or stagnation relative to the United States.

Figure 19 next reports productivity levels in agriculture, manufacturing, low-skilled services and high-skilled services relative to the United States for each country in 2010 against 1965 along with a 45-degree line. There has been considerable variation in labor productivity growth experiences across sectors and economies. In Figure 19a, while only four economies experience significant catch-up in agricultural productivity to the United States, the majority of countries in the sample have lower agricultural productivity growth relative to the United States. Figure 19b shows that while there has been substantial manufacturing productivity catch-up in steep manufacturing group, most flat manufacturing economies experience a decline in manufacturing productivity relative to the United States. Figure 19c presents patterns of little catch-up or decline in low-skilled services productivity compared to the United States for most countries. While most steep manufacturing economies experience little change in low-skilled services productivity relative to the United States, flat manufacturing countries have substantial fall in low-skilled services productivity compared to the United States. In Figure 19d, there has been little change in high-skilled services productivity relative to the United States for most economies in the sample.

Figure 19: Sectoral Productivity Relative to the United States: 1965-2010



Notes: Data on sectoral labor productivity levels are inferred by the model. Each plot reports labor productivity level relative to the United States for each sector in 1965 and 2010. Solid line represents the 45-degree line on which the sectoral labor productivity levels relative to the United States in 1965 and 2010 are the same, indicating no catch-up in sectoral labor productivity with the United States.

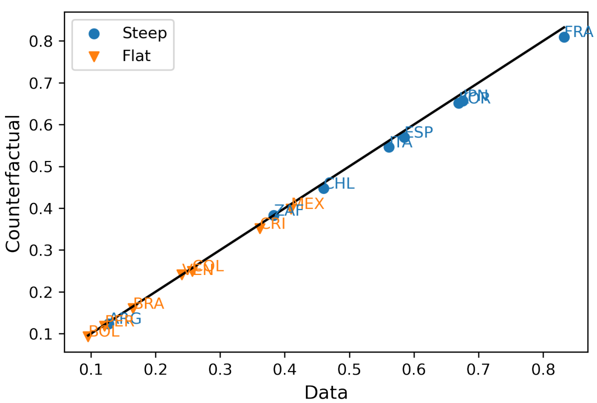
6.2 Role of Sectoral Productivity in Aggregate Productivity

I next turn to the set of counterfactuals where productivity growth rate in one sector is set to the growth rate of the United States. These counterfactuals illustrate the quantitative importance of sectoral productivity growth in explaining cross-country growth experiences. Figure 20 reports the counterfactual results for aggregate productivity relative to the United States.

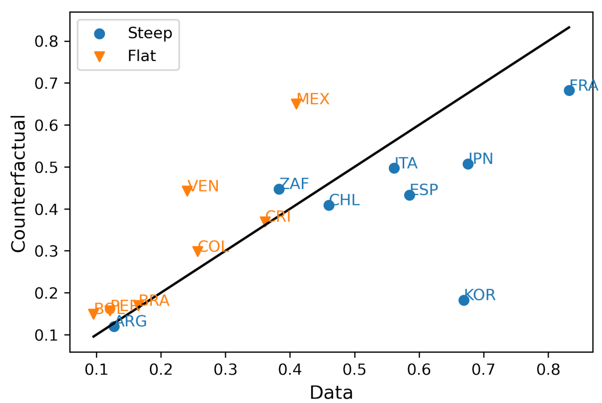
For most economies, setting sectoral productivity growth rates in agriculture and high-skilled services to the United States growth rates generate very small impacts on relative aggregate productivity. These two counterfactual results, reported in Figure 20a and 20d, indicate a small role of agriculture and high-skilled services sectors in explaining cross-country growth experiences.

Figure 20: Aggregate Productivity Relative to the United States: Counterfactual vs. Data

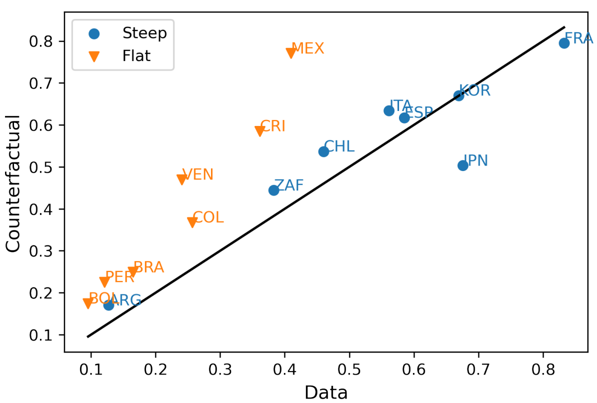
(a) Agriculture: $g_a = g_a^{US}$



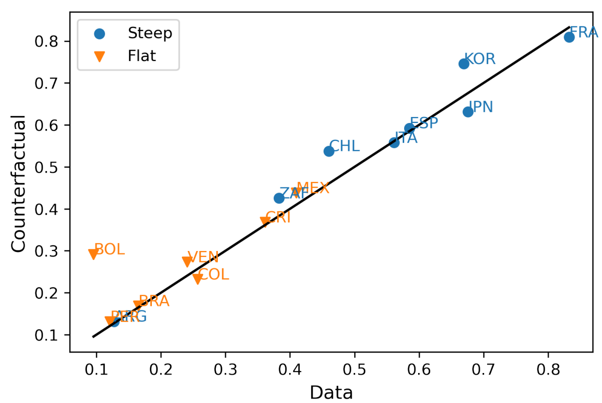
(b) Manufacturing: $g_m = g_m^{US}$



(c) Low-skilled Services: $g_{ls} = g_{ls}^{US}$



(d) High-skilled Services: $g_{hs} = g_{hs}^{US}$



Notes: Each counterfactual sets the productivity growth rate in each sector to the growth rate in the United States while keeping the other three sectors' growth rates the same as the data. Each plot reports aggregate labor productivity levels relative to the United States in 2010 in the data and in each of the counterfactual. Solid line represents the 45-degree line on which the sectoral labor productivity levels relative to the United States in the data and the counterfactual are the same.

Figure 20b presents results of the counterfactual using the United States manufacturing productivity growth rate. The counterfactual generates much lower relative aggregate productivity for most steep manufacturing economies. For flat manufacturing group, the counterfactual generates very small differences. In Figure 20c, the counterfactual for low-skilled services sector illustrates a significantly large aggregate impact for most flat manufacturing economies. Low-skilled services productivity growth contributes little to the catch-up experiences in most steep manufacturing economies (except Japan).

In summary, manufacturing and low-skilled services sectors are the two major sectors greatly contributing to the variation in cross-country growth experiences. Substantial catch-up in manufacturing productivity together with large manufacturing sector mostly accounts for aggregate catch-up experiences in steep manufacturing group of economies. In flat manufacturing economies, lack of productivity growth in low-skilled services sector and a large low-skilled services sector are the important factors leading to episodes of decline in aggregate productivity relative to the United States.

7 Discussion

In this section, I discuss potential sources of cross-country variation in initial relative productivity levels (static factors) between manufacturing and low-skilled services. I show that informality has a dominant role in low-skilled services sector especially in economies with flat manufacturing patterns and that human capital is weakly correlated with the structural transformation.

7.1 Informal Economy

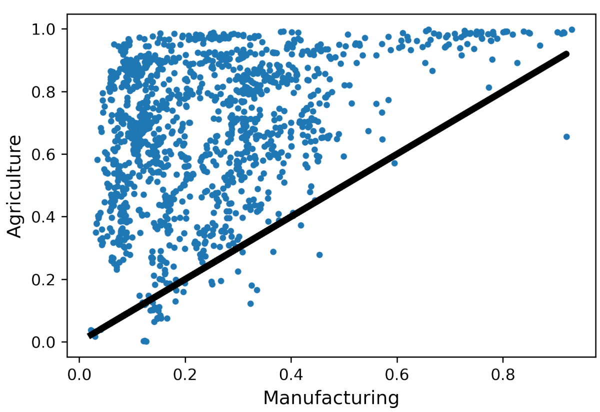
Informal economy has been considered an important aspect of developing economies. Informal sector is associated with small-scaled production, lack of physical and human capital and low productivity. Main driving sources of informality include weak institutions regarding tax, social security, bureaucracy, corruption, rule of law, etc. (Ulyssea, 2020).

There are different definitions and measures of informality depending on specific context. For this paper's purpose of documenting cross-country patterns involving both developed and developing economies, I use self-employment which is the mostly commonly used proxy for informality (Elgin et al., 2021). The data are from International Labour Organization (ILO) Database covering employment by sector and status in employment. Employment data are aggregated into 4 sectors: agriculture, manufacturing, low-skilled services and high-skilled services. For each sector, self-employment share at sectoral level is computed by dividing number of workers with self-employed status over total number of workers within that sector.

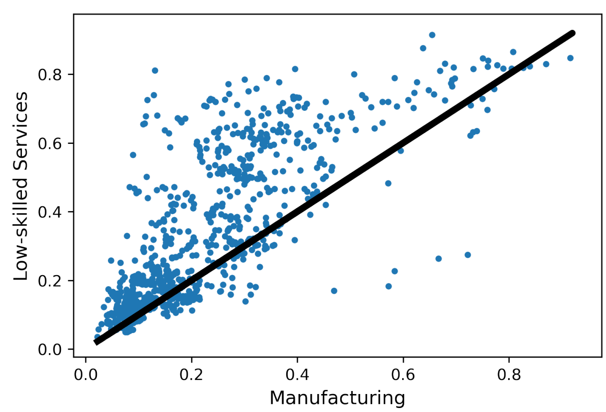
Figure 21 plots self-employment share in agriculture, low-skilled services and high-skilled services against manufacturing respectively. The black line in the figures represents 45-degree line. Figure 21a and 21b show that self-employment share in agriculture and low-skilled services is higher than in manufacturing (lie above 45 degree line) for most of the countries. High-skilled services sector is found to have less self-employment share than manufacturing in Figure 21c. This evidence suggests that self-employment share or informality differs significantly across sectors. While agriculture and low-skilled services tend to have larger informal sector, manufacturing and high-skilled services are generally more formal.

Figure 21: Share of Self-Employment by Sector

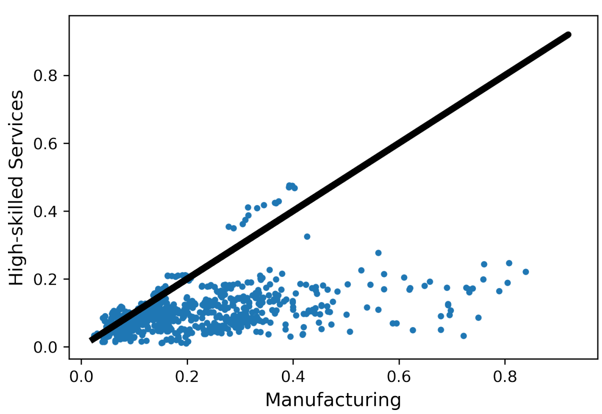
(a) Agriculture vs. Manufacturing



(b) Low-skilled Services vs. Manufacturing



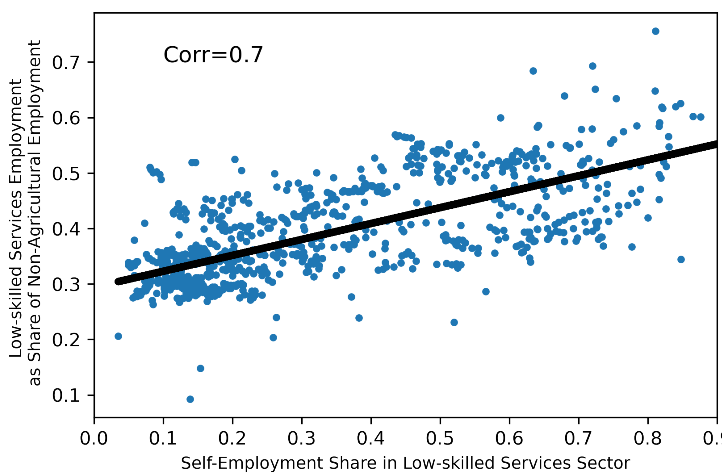
(c) High-skilled services vs. Manufacturing



Notes: Data on self-employment share are from International Labour Organization (ILO) Database. Solid line represents the 45-degree line on which the self-employment share in agriculture/low-skilled services/high-skilled services are the same as in manufacturing.

Figure 22 exhibits the relationship between employment share of low-skilled services in non-agriculture and self-employment share in low-skilled services across countries. Share of low-skilled services in non-agriculture is computed by dividing employment in low-skilled services by non-agricultural employment. This measure serves as a proxy for the structural transformation pattern: Higher value indicates higher share of labor leaving agriculture reallocating towards low-skilled services (closer to flat manufacturing patterns). The reason for using low-skilled services share instead of manufacturing is that manufacturing share with respect to non-agriculture differs significantly in the industrialization and the deindustrialization due to the hump-shaped evolution. Instead, share of low-skilled services rises over the course of development and exhibit a robust relationship respect to non-agriculture. Considering the sample consisting of 156 economies at various income levels, share of low-skilled services with respect to non-agriculture consequently better captures heterogeneity in cross-country structural change patterns.

Figure 22: Low-skilled Services - Employment Share vs. Informality



Notes: The plot reports the employment of low-skilled services as share of non-agricultural employment and the self-employment share in low-skilled services sector across countries. Solid line represents the fitted regression line between the two variables.

Figure 22 highlights a strong correlation (around 0.7) between informality of low-skilled services sector and employment share of low-skilled services. Countries with higher self-employment share (larger informal sector) tend to allocate more labor towards low-skilled services. This evidence suggests that in economies with large informal sectors due to weak institutions and high distortions, low-skilled services sector is more subject to absorb informal workers out of agriculture and consequently results in low productivity level due to dominance of small-scaled informal production.

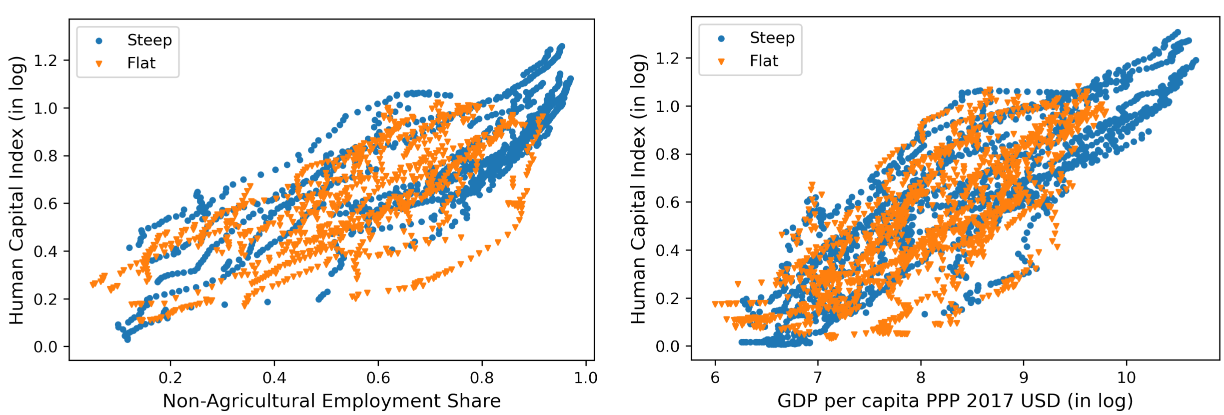
High barrier to entry and/or high cost of business operation is an example of distortions that could contribute to high informality and low relative productivity in low-skilled services relative to manufacturing. In an economy with high fixed cost of starting and operating business, only a limited number of high-productivity firms can cover the fixed costs and operate with profits. Among those existing firms, more firms will operate in manufacturing sector as manufacturing normally requires larger scale of operation compared to low-skilled services. Most production units in low-skilled services will be informal small-scaled households with low productivity. This channel is an illustration of how distortions could contribute to a wide gap in productivity between manufacturing and low-skilled services in flat manufacturing economies.

7.2 Human Capital

Human capital endowment or supply of skilled labor is a potential candidate for explaining the large heterogeneity in employment allocation between manufacturing and low-skilled services. Are flat manufacturing economies with substantially large low-skilled services sector subject to low human capital level or lack of skilled labor? My findings, however, suggest that there is little correlation between human capital and heterogeneity in structural change patterns.

Figure 23: Human Capital Index across Economies

(a) Non-AGR Employment Share (b) Real GDP per capita PPP 2017 USD (in log)



Notes: Data on Human Capital Index are from provided by Penn World Table 10.0, based on years of schooling and returns to education.

Figure 23 plots the logarithm of Human Capital Index (HCI) against measures of development, non-agricultural employment share and logarithm of GDP per capita (PPP 2017 USD). Human capital tends to rise with development. There's no systematic difference in human capital index between steep manufacturing and flat manufacturing economies: Flat manufacturing economies do not exhibit systematic patterns of lower human capital. At different levels of development, there's little relationship between human capital and the share of manufacturing. These results suggest little evidence for the role of human capital endowment in explaining the substantial heterogeneity in structural change patterns across economies.

8 Conclusions

This paper documents significant heterogeneous features in structural transformation patterns across countries. In particular, while some countries experience steep hump-shaped patterns in manufacturing sector, others experience flat hump shape with small changes in manufacturing employment share. Steep manufacturing economies experience substantial reallocation of employment from agriculture to manufacturing during the industrialization phase and substantial reallocation from manufacturing to high-skilled services during the deindustrialization phase. Flat manufacturing economies attain lower peak of manufacturing shares and experience little distinction between the industrialization and the deindustrialization. Structural transformation patterns in flat manufacturing economies can be characterized by substantial reallocation of employment from agriculture to low-skilled services and little change in manufacturing sector.

Based on a standard model of structural change, my analysis highlights the role of heterogeneous sectoral labor productivity profiles in capturing the cross-country differences in structural transformation and aggregate productivity. Among factors driving sectoral labor productivity, initial sectoral productivity levels can account for the majority of variation in structural change patterns. Country-specific institutions and distortions related to the size of informal sector are potential sources explaining low productivity and consequently large size in low-skilled services relative to manufacturing in flat manufacturing economies.

I also derive the aggregate implications of structural transformation patterns. While steep manufacturing countries experience substantial aggregate productivity catch-up, flat manufacturing economies tend to experience no catch-up or decline in aggregate productivity relative to the United States. The substantial catch-up episodes in steep manufacturing economies mainly result from catch-up in manufacturing productivity. Lack of aggregate growth in flat manufacturing economies can be largely explained by the low growth in low-skilled services sector. Differences in agricultural and high-skilled services productivity growth contribute little to aggregate growth experiences across countries.

These findings suggest that understanding country-specific sources of institutions and distortions driving sectoral productivity is crucial to understanding heterogeneous patterns of structural change and aggregate growth across countries. An important question is why flat manufacturing economies have substantially low productivity level in low-skilled services relative to manufacturing. It will be valuable to further investigate and quantify the importance of various sources of country-specific frictions and distortions in driving the substantial productivity gap between manufacturing and low-skilled services in flat manufacturing economies. It will be also important to extend the analysis to open economy framework to understand how trade interacts with country-specific factors in driving structural change and growth experiences.

References

Boppart, T. (2014). Structural Change and the Kaldor Facts in a Growth Model with Relative Price Effects and non-Gorman Preferences. *Econometrica*, 82(6):2167–2196.

Buera, F. J. and Kaboski, J. P. (2009). Can Traditional Theories of Structural Change Fit the Data? *Journal of the European Economic Association*, 7(2-3):469–477.

Buera, F. J., Kaboski, J. P., Rogerson, R., and Vizcaino, J. I. (2021). Skill-Biased Structural Change. *The Review of Economic Studies*.

Carter, S., Gartner, S., Haines, M., Olmstead, A., and Sutch, R. (2006). Historical Statistics of the United States, Earliest Times to the Present: Millennial Edition.

Comin, D., Lashkari, D., and Mestieri, M. (2021). Structural Change with Long-run Income and Price Effects. *Econometrica*, 89(1):311–374.

de Vries, G., Arfelt, L., Drees, D., Godemann, M., Hamilton, C., Jessen-Thiesen, B., Kaya, A., Kruse, H., Mensah, E., and Woltjer, P. (2021). The Economic Transformation Database (ETD): Content, Sources, and Methods. Technical report, WIDER Technical Note 2/2021.

Duarte, M. and Restuccia, D. (2010). The Role of the Structural Transformation in Aggregate Productivity. *The Quarterly Journal of Economics*, 125(1):129–173.

Duarte, M. and Restuccia, D. (2020). Relative Prices and Sectoral Productivity. *Journal of the European Economic Association*, 18(3):1400–1443.

Duernecker, G., Herrendorf, B., and Valentinyi, A. (2017). Structural Change within the Service Sector and the Future of Baumol's Cost Disease. CEPR Discussion Paper 12467.

Elgin, C., Kose, M. A., Ohnsorge, F., and Yu, S. (2021). Understanding Informality. Technical report.

Fang, L. and Herrendorf, B. (2021). High-Skilled Services and Development in China. *Journal of Development Economics*, 151:102671.

Feenstra, R. C., Inklaar, R., and Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10):3150–82.

Gollin, D., Parente, S., and Rogerson, R. (2002). The Role of Agriculture in Development. *American Economic Review*, 92(2):160–164.

Gollin, D., Parente, S. L., and Rogerson, R. (2007). The Food Problem and the Evolution of International Income Levels. *Journal of Monetary Economics*, 54(4):1230–1255.

Herrendorf, B., Rogerson, R., and Valentinyi, A. (2014). Growth and Structural Transformation. In *Handbook of Economic Growth*, volume 2, pages 855–941. Elsevier.

Huneeus, F. and Rogerson, R. (2020). Heterogeneous paths of industrialization. Working Paper 27580, National Bureau of Economic Research.

Kongsamut, P., Rebelo, S., and Xie, D. (2001). Beyond Balanced Growth. *The Review of Economic Studies*, 68(4):869–882.

Ngai, L. R. and Pissarides, C. A. (2007). Structural change in a multisector model of growth. *American Economic Review*, 97(1):429–443.

Ngai, R. and Sevinc, O. (2020). A Multisector Perspective on Wage Stagnation. CEPR Discussion Paper No. DP14855.

Rodrik, D. (2016). Premature Deindustrialization. *Journal of Economic Growth*, 21(1):1–33.

Rogerson, R. (2008). Structural Transformation and the Deterioration of European Labor Market Outcomes. *Journal of Political Economy*, 116(2):235–259.

Sposi, M., Yi, K.-M., and Zhang, J. (2021). Deindustrialization and industry polarization. Working Paper 29483, National Bureau of Economic Research.

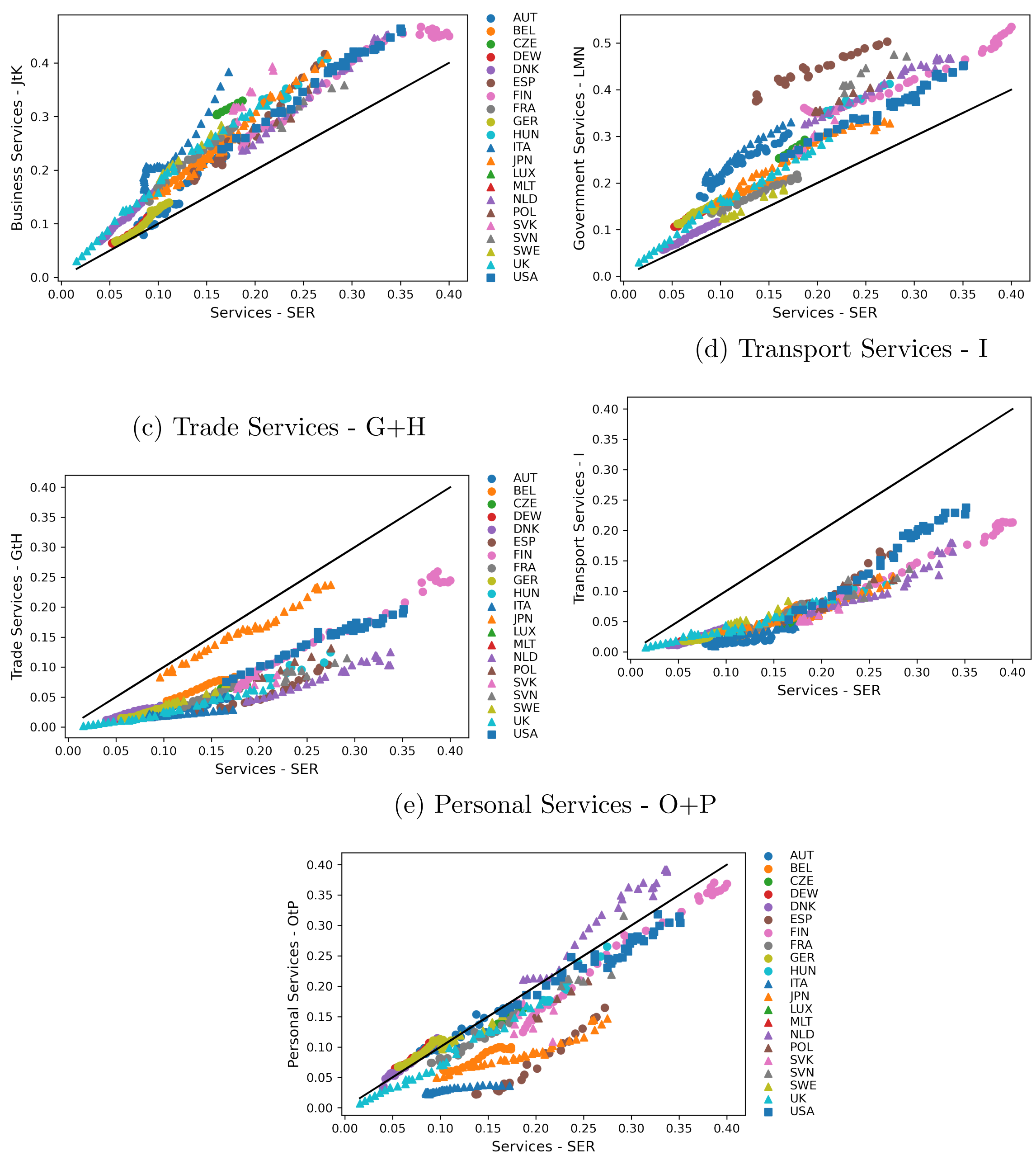
Timmer, M., de Vries, G. J., and De Vries, K. (2015). *Patterns of Structural Change in Developing Countries*. Routledge.

Timmer, M. P., O Mahony, M., Van Ark, B., et al. (2007). EU KLEMS Growth and Productivity Accounts: An Overview. *International Productivity Monitor*, 14:71.

Ulyssea, G. (2020). Informality: Causes and Consequences for Development. *Annual Review of Economics*, 12:525–546.

A Services Classifications - KLEMS

Figure A.1: High-skilled Labor Hour Share



(a) Business Services - J+K

(b) Government Services - L,M,N

(c) Trade Services - G+H

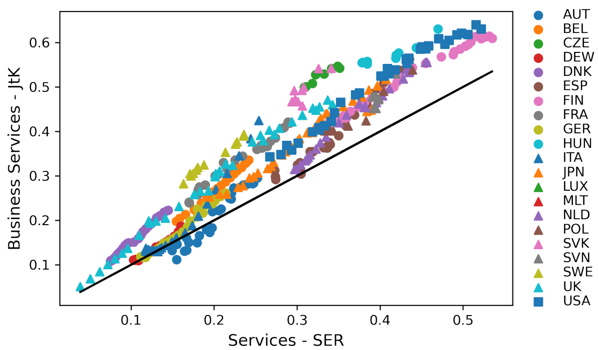
(d) Transport Services - I

(e) Personal Services - O+P

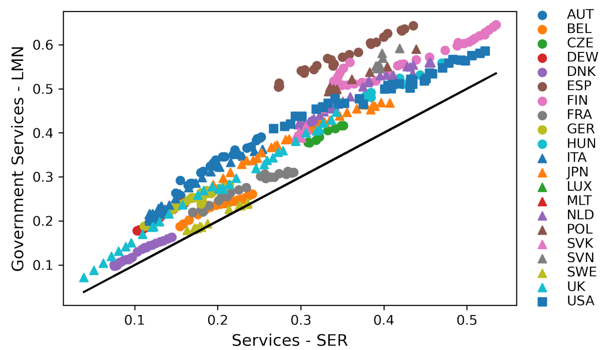
Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on share of hours worked by high-skilled workers for each sector are from KLEMS Database. Solid line represent 45-degree line on which hour share of high-skilled labor in the sector is the same as the median of broad services sector.

Figure A.2: High-skilled Labor Compensation Share

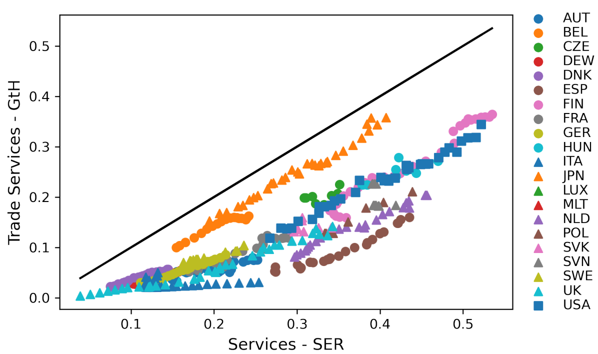
(a) Business Services - J+K



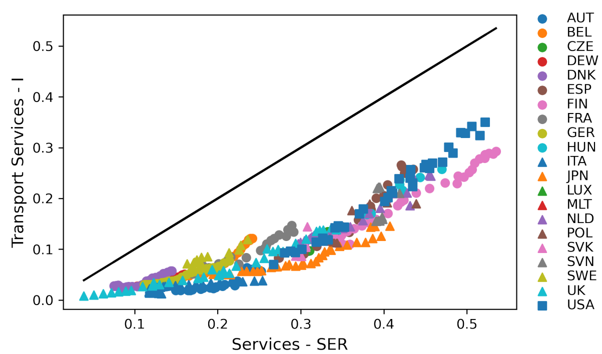
(b) Government Services - L,M,N



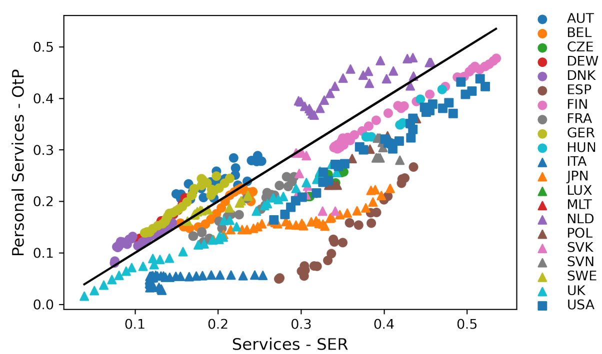
(c) Trade Services - G+H



(d) Transport Services - I



(e) Personal Services - O+P

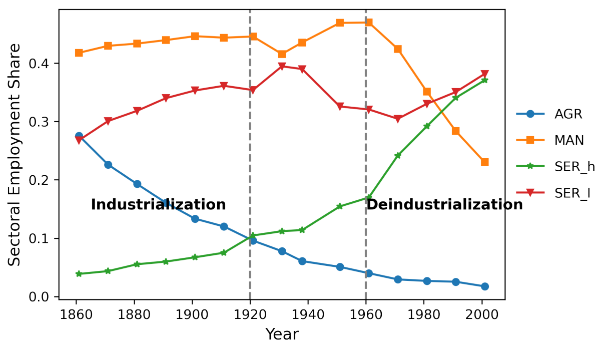


Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on share of labor compensation worked by high-skilled workers for each sector are from KLEMS Database. Solid line represent 45-degree line on which labor compensation share of high-skilled labor in the sector is the same as the median of broad services sector.

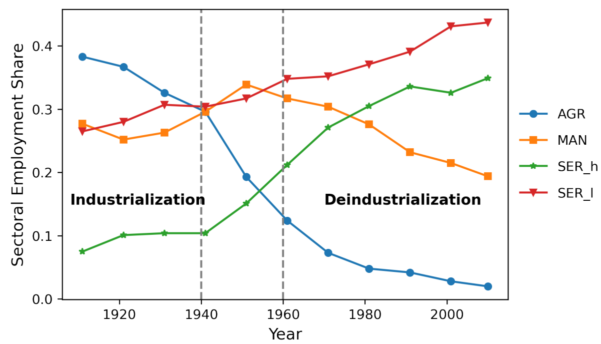
B Examples of Structural Transformation Patterns

Figure B.1: Examples of Structural Transformation in Steep Manufacturing Economies

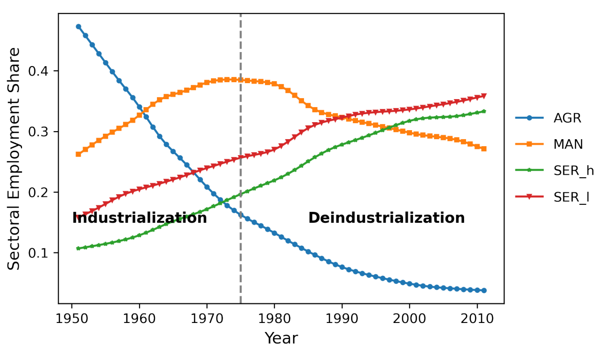
(a) United Kingdom



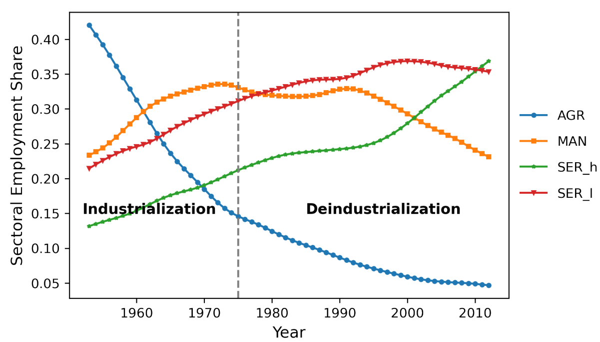
(b) Canada



(c) Italy



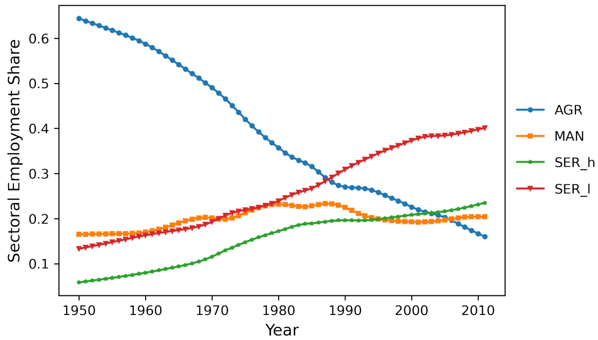
(d) Japan



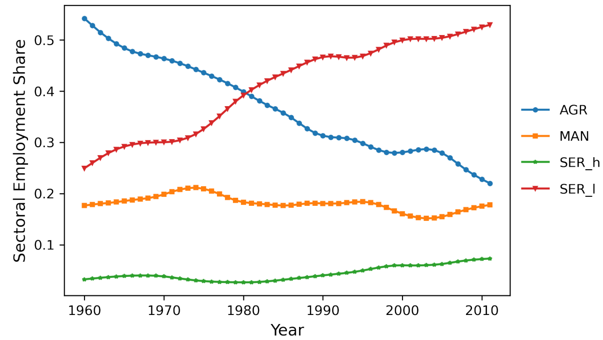
Notes: Data on sectoral employment shares for United Kingdom are from Professor Charles Feinstein's (1972) National Income, Output And Expenditure Of The United Kingdom 1855-1965 and from the GDDC 10-Sector Database. Data for Canada are from Statistics Canada. Data for Italy and Japan are from the GDDC 10-Sector Database.

Figure B.2: Examples of Structural Transformation in Flat Manufacturing Economies

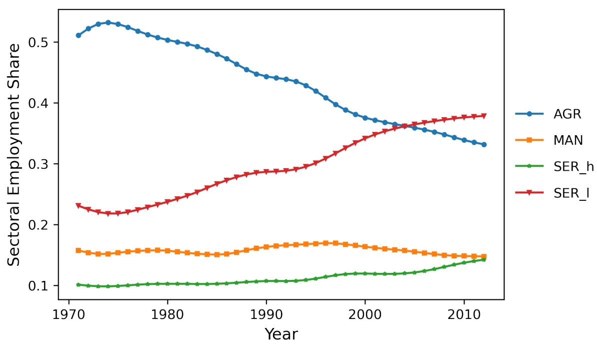
(a) Brazil



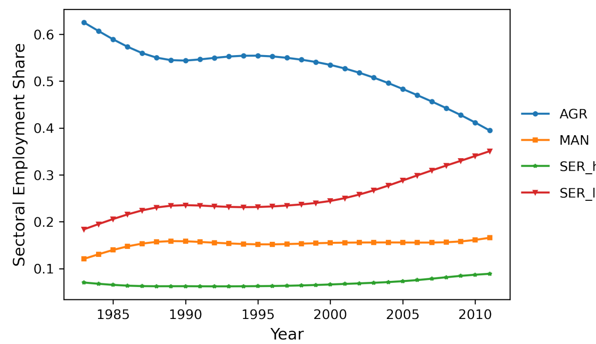
(b) Peru



(c) Philippines



(d) Ghana



Notes: Data on sectoral employment shares are from the GDDC 10-Sector Database.