Heterogeneous Paths of Structural Transformation †

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Abstract

I establish new facts and explanations on the heterogeneous paths of structural transformation across countries. First, many countries exhibit flat-manufacturing profiles without noticeable signs of deindustrialization, which differ from the conventional steep-manufacturing hump-shaped profiles in advanced economies. Second, substantial heterogeneity exists in the labor allocation within services sector as flat-manufacturing countries tend to allocate substantially more labor into low-skilled services compared to steep-manufacturing countries. Third, heterogeneous structural transformation paths are prevalent among both earlier and later developers and not subject to the timing of development. Using a standard model of structural transformation, I find that observed differences in sectoral productivity growth are not quantitatively sufficient to generate the heterogeneous paths of structural transformation across countries. Instead, differences in relative productivity levels between manufacturing and low-skilled services account for the majority of the heterogeneity, suggesting that country-specific factors are key. I show that the observed heterogeneous paths of structural transformation contribute substantially to economic growth outcomes across countries.

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.

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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 sector: rise at early stages of development (industrialization), reach a peak and then decline at later stages (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, referring to this phenomenon as "premature deindustrialization."

What are the driving forces of "premature deindustrialization"? Rodrik (2016) first 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 countries are running out of industrialization opportunities and consequently facing lower economic growth compared to earlier developers. Later work by Huneeus and Rogerson (2022) attributes the "premature deindustrialization" to the countries' rates of convergence to the frontier countries. In particular, they suggest that low growth in agricultural productivity is the main factor behind this phenomenon. Different from the conclusions of these two earlier papers, this paper uncovers new findings that provide novel insights on the sources behind the "premature deindustrialization" phenomenon. I find 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 the difference in relative productivity levels between manufacturing and low-skilled services which might reflect the difference in endowments and distortions specific to each individual country.

I start by 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 countries experience a flat profile of the manufacturing employment share without a noticeable peak over the course of development. This pattern of flat-manufacturing profiles is different from the conventional steep hump-shaped pattern in the manufacturing employment share documented in the United States and many other advanced countries. Second, there also exists much heterogeneity in the types of services expanded between advanced countries and the countries experiencing flat-manufacturing profiles. While the advanced countries tend to develop high-skilled services, the flat-manufacturing countries allocate much more labor into low-skilled services. Third, heterogeneous paths of structural transformation are prevalent among both early and late developers. The third fact provides evidence suggesting that the heterogeneous paths of structural transformation cannot be simply attributed to timing of development and explained by changes in global economy over time (such as technological changes and globalization trend) as suggested by Rodrik (2016). These three stylized facts motivate the two research questions of this paper. What are the key sources driving heterogeneous paths in structural transformation across countries? What are the aggregate implications of this heterogeneity on growth and development?

To address these questions, the paper develops a standard general equilibrium model of structural transformation that can account for the documented patterns. Following the standard literature, income effect and substitution effect are the two main forces driving structural transformation process. Similar to Gollin et al. (2002, 2007), labor reallocation out of agriculture in the model is driven by the income effect and determined by agricultural productivity. Following Duarte and Restuccia (2010) and Huneeus and Rogerson (2022), labor allocation between manufacturing and services sectors is driven by the substitution effect and determined by relative sectoral labor productivity between manufacturing and services sectors. The model consists of four sectors with the disaggregation of services into low-skilled and high-skilled services instead of the standard single services sector, and is calibrated to match the evolution of the sectoral employment shares in the United States during the early to middle stages of development. Following Duarte and Restuccia (2010), due to the lack of comparable sectoral output data across countries, the cross-country calibration involves the inference of sectoral productivity levels in the model to match sectoral employment shares at the initial sample period. For each country, based on the calibrated initial sectoral productivity levels and the 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 paths of structural transformation.

Through the lens of the benchmark model, I find that sectoral productivity profiles are driven by two forces: sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Huneeus and Rogerson (2022) emphasize the sectoral productivity growth rates (dynamic factors) in their analysis. The key novel contribution of this paper is to uncover the role of the initial sectoral productivity levels (static factors) in driving the structural transformation pattern. Using the calibrated model to the United States, I perform counterfactuals assuming the sectoral productivity growth rates of the United States but changing the initial relative productivity levels. By lowering the initial relative productivity level of low-skilled services relative to manufacturing, the counterfactuals generate structural transformation patterns very close to the patterns observed in most of the flat-manufacturing countries. The counterfactual result suggests that deviation in the sectoral productivity growth rates from the United States' growth rates are not large enough to quantitatively generate the patterns observed in the flat-manufacturing countries. Instead of the sectoral productivity growth rates, variation in the initial relative productivity levels is suggested to be the determinant factors driving cross-country differences in structural transformation paths. The initial sectoral productivity levels reflect country-specific components that are persistent over the course of development.

This finding raises a question of why the relative productivity level of low-skilled services to manufacturing is so much lower in the flat-manufacturing countries. I document cross-country evidence that the degree of informality has a dominant role in low-skilled services compared to manufacturing. Moreover, countries with the flat-manufacturing profile also tend to have a larger informal sector. The evidence suggests that country-specific distortions (such as business entry and operation costs) leading to a high degree of informality could be a potential source of low productivity level of low-skilled services relative to manufacturing in the flat-manufacturing countries. Differences in human capital (education or schooling) are found to have limited relationship with structural transformation patterns across countries.

I then use the model to assess the aggregate implications of the heterogeneous paths of structural transformation. During the period from 1965 to 2010, most steep-manufacturing countries experience substantial catch-up episodes in aggregate labor productivity relative to the United States, whereas the flat-manufacturing countries 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 the steep-manufacturing countries are mostly associated with the catch-up in manufacturing productivity. Stagnation experiences in the flat-manufacturing are mainly attributed to the low productivity growth and the dominant size of low-skilled services sector.

This paper is related to a broad literature studying structural transformation.[1] In particular, it directly links to the recent literature studying the heterogeneous patterns in the

[1] See Herrendorf et al. (2014) for overview of structural transformation literature. Examples of important contributions are 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).

industrialization and the deindustrialization. There are several important papers proposing alternative channels explaining the heterogeneity in the industrialization experiences across countries. Rodrik (2016) attributes the premature deindustrialization to the rise of globalization. Sposi et al. (2021) emphasize the role of open economy factors and find an important role of trade costs on explaining cross-country industrialization and deindustrialization patterns. My paper is different from Rodrik (2016) and Sposi et al. (2021) as I focus on driving forces in the context of a closed economy. In the model with trade and capital accumulation, Sposi et al. (2021) find that closed economy factors (sectoral productivity) are the most important drivers, though their study also highlights the importance of interaction of sectoral productivity and trade costs. Fujiwara and Matsuyama (2022) propose a theoretical channel suggesting that heterogeneous technology gaps between sectors across countries can qualitatively generate the "premature deindustrialization" phenomenon. However, they do not use the model to quantify the role of this channel in explaining the patterns in the data. The closest to my paper is Huneeus and Rogerson (2022) who also study the heterogeneity in structural transformation in the context of a closed economy. My theoretical framework builds upon the insights of Huneeus and Rogerson (2022) by focusing on two forces driving structural transformation: an income effect driving employment out of agriculture and a substitution effect between manufacturing and services. Besides agricultural productivity growth (income effect) and relative productivity growth between manufacturing and services (substitution effect) emphasized in Huneeus and Rogerson (2022), the main insight of my paper is to uncover a new driving factor of structural transformation via the substitution effect: differences in initial relative productivity levels between manufacturing and services. Quantitatively, this new factor accounts for most of the observed heterogeneous paths of structural transformation across countries. Overall, there are three major contributions of my paper to the literature. First, this paper documents a comprehensive set of facts on the heterogeneity in structural transformation patterns both in manufacturing and within services across countries. Second, through the lens of the benchmark structural transformation model, this paper uncovers a new driving factor (the initial relative productivity levels between manufacturing and services) and finds that this new factor is quantitatively important in capturing the heterogeneous patterns of structural transformation not just in manufacturing but also in services. Third, I investigate the aggregate implications of the heterogeneity in structural transformation and find that this phenomenon is critical to variation in cross-country aggregate outcomes.

My paper is also related to the literature studying skill-biased structural transformation. 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 advanced 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 the aggregate growth in middle-income economies. My paper also contributes to the recent literature investigating the heterogeneity within services sector and its implications on structural transformation and economic growth. Duarte and Restuccia (2020) show that substantial heterogeneity between traditional and non-traditional services has a large role in explaining cross-country income differences. Duernecker et al. (2021) disaggregate services into progressive and stagnant services. They show that large heterogeneity in productivity growth within services is important in understanding the productivity growth slowdown in the United States. The closest to my paper in this strand of the literature is Fang and Herrendorf (2021) which study the structural transformation between goods, low-skilled services and high-skilled services sectors in the context of China. Fang and Herrendorf (2021) find that underdevelopment of high-skilled services results from large distortions in this sector and results in substantial loss in China's aggregate productivity. Different from Fang and Herrendorf (2021), my paper investigates the heterogeneous structural transformation 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 Section 3, I document a set of stylized facts on heterogeneous patterns in structural transformation across countries. 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 countries. Section 7 provides suggestive evidence and discussion on potential sources of explanations. Section 8 concludes.

2 Data

The main set of countries and periods in this analysis is from the 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 and 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 is lower than the median of the broad services sector.[2] From the data on labor hours by skills, I compute hour share of high-skilled labor for each economic sector across of 26 European countries together with the United States and Japan during the period 1970-2004 from the KLEMS 2007 Database (Timmer et al., 2007). Economic sectors in the GGDC 10-Sector Database and the KLEMS 2007 Database are defined based on the International Standard Industrial Classification, Revision 3.1 (ISIC Rev.3.1). The disaggregation results are impressively consistent across countries 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 in each country and denote them as L_a, L_m, L_{ls}, L_{hs} for agriculture, manufacturing, low-skilled

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

services and high-skilled services respectively. To analyze the trend of the series, I smooth the sectoral employment shares by standard practice using Hodrick-Prescott filter with a smoothing parameter value of 6.25 as in the standard practice. The data are merged with data from the Penn World Table (PWT) 10.0 (Feenstra et al., 2015) to study the aggregate implications of structural transformation patterns in Section 6. The PPP-adjusted measure of real aggregate output and the employment data are used to calculate real aggregate labor productivity.

For the structural transformation patterns in the United States, the 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 the 1880-1930 period, Bureau of Economic Analysis (BEA) data for the 1929-1950 period and the GGDC 10-Sector Database for the 1950-2010 period.

To document the structural transformation patterns across recent (post-1990s) emerging countries reported in Section 3, 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 the GGDC/UNU-WIDER ETD is based on International Standard Industrial Classification, Revision 4 (ISIC Rev.4 Code), twelve economic sectors are aggregated into agriculture, manufacturing, low-skilled services and high-skilled services using a similar method.[3] 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).

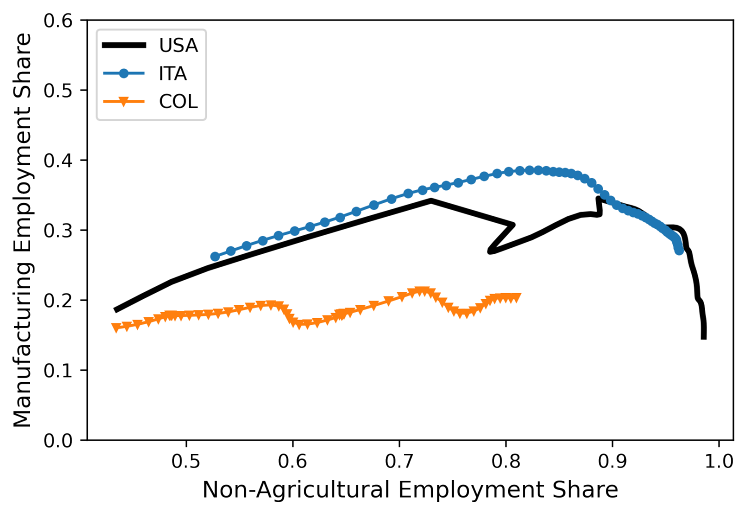
In Section 7, I use data on employment categorized by employment status and economic activity from International Labour Organization (ILO) Database. The dataset contains an unbalanced panel of 156 countries from 1976 to 2020. From the original dataset, I compute share of self-employed persons (serving as a proxy for degree of informality) by economic sector, country and year.

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

3 Heterogeneous Paths of Structural Transformation

Rodrik (2016) and Huneeus and Rogerson (2022) document large heterogeneity in the peak of the manufacturing hump-shaped patterns across countries. In this section, I document a more comprehensive set of facts uncovering new important features of heterogeneity in structural transformation. First, countries greatly differ in the whole profile of the manufacturing employment share: Some countries follow a steep rise and fall in the manufacturing employment share while many others follow a flatter manufacturing profile. Second, the heterogeneity is also substantial in the labor allocation within services. These two aspects of heterogeneity turn out to have an important role in understanding the explanatory sources as well as the implications on aggregate growth.

Figure 1: Heterogeneous Patterns of Structural Transformation



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

In order to compare the structural transformation patterns across countries, I employ a representation of plotting the sectoral employment shares over the 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, the non-agricultural employment share can serve as a proxy for the level of development. This representation of the sectoral employment shares over the non-agricultural employment share exhibits a very similar characterization to the conventional representation over GDP per capita.

Figure 1 plots the manufacturing employment share against the non-agricultural employment share of three countries: the United States, Italy and Colombia. The evolution profiles of the manufacturing employment shares are strikingly different between these countries. While the United States and Italy exhibit the steep inverted U-shaped pattern in manufacturing, Colombia shows the pattern of a 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: a steep-manufacturing group characterized by steep profile of manufacturing (similar to the United States and Italy) and a flat-manufacturing group characterized by a flat profile of manufacturing (similar to Colombia).

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

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

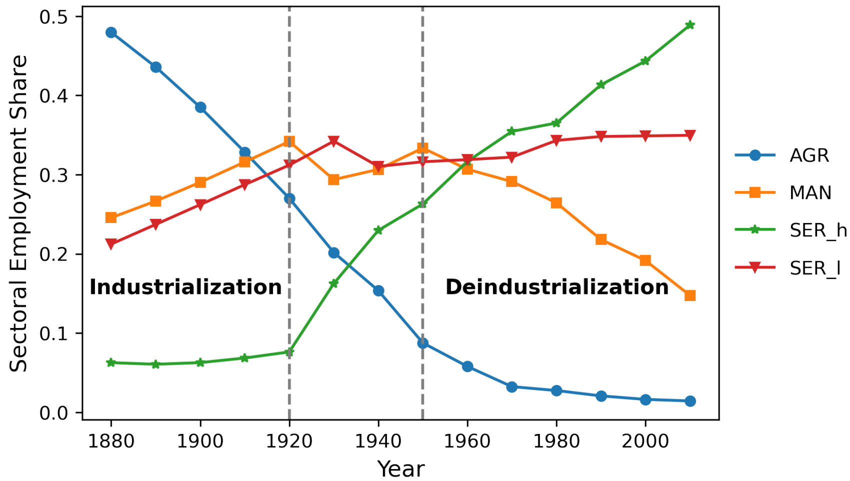
3.1 Pattern in Steep-Manufacturing Economies

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

Pattern in the United States

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

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



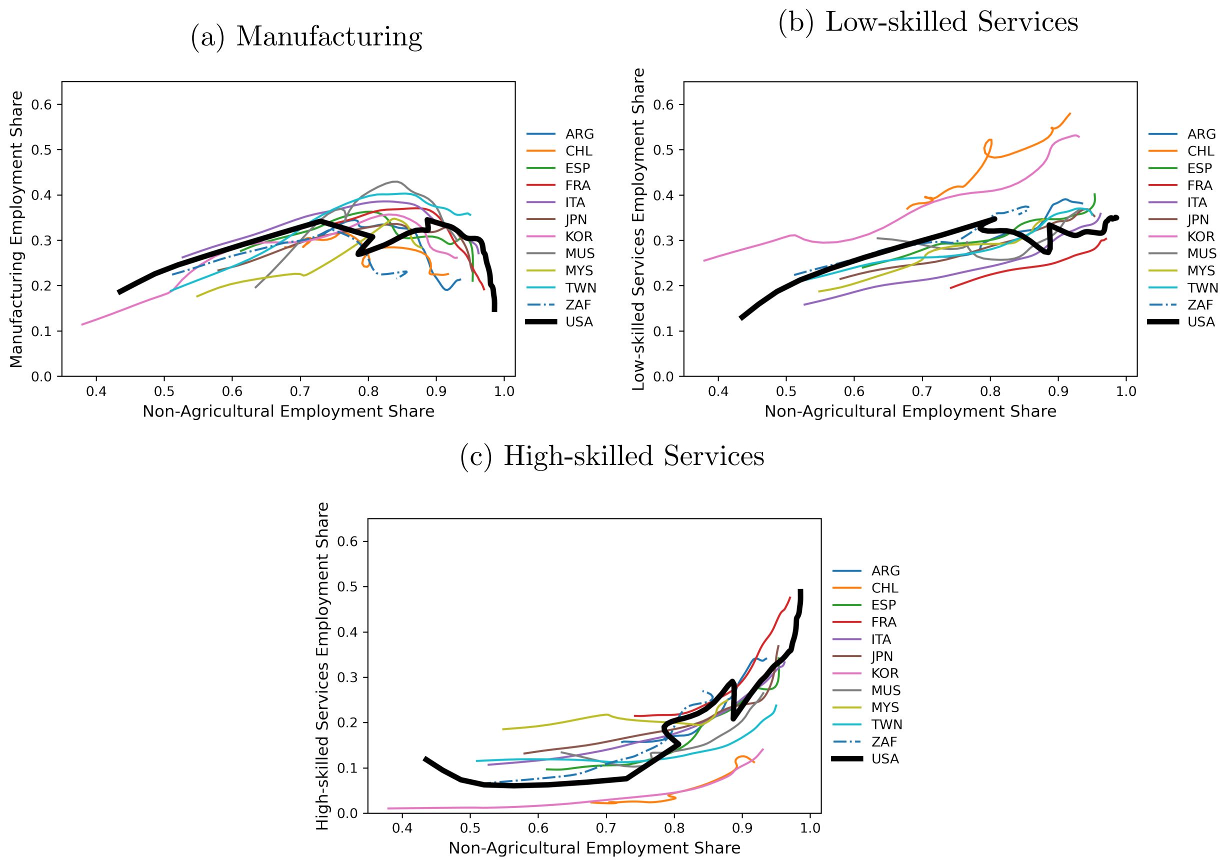
Notes: The industrialization and the deindustrialization phase indicates the period observing significant rise and decline respectively in the manufacturing employment share. The period between 1920 and 1950 (Great Depression and World War II period) observes fluctuation in the manufacturing employment 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): The manufacturing employment share starts reaching the peak and the high-skilled services employment share starts rising.
- Deindustrialization Phase (1950-2010): The agricultural employment share becomes very small. Labor out of manufacturing is mostly reallocated towards high-skilled services. The 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 a qualitatively similar pattern to the United States in the industrialization and the deindustrialization phases. Figure 3 documents the structural change pattern in the steep-manufacturing countries. The pattern is characterized by a steep hump-shaped evolution of the 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 transformation patterns differ significantly before and after the peak of manufacturing.

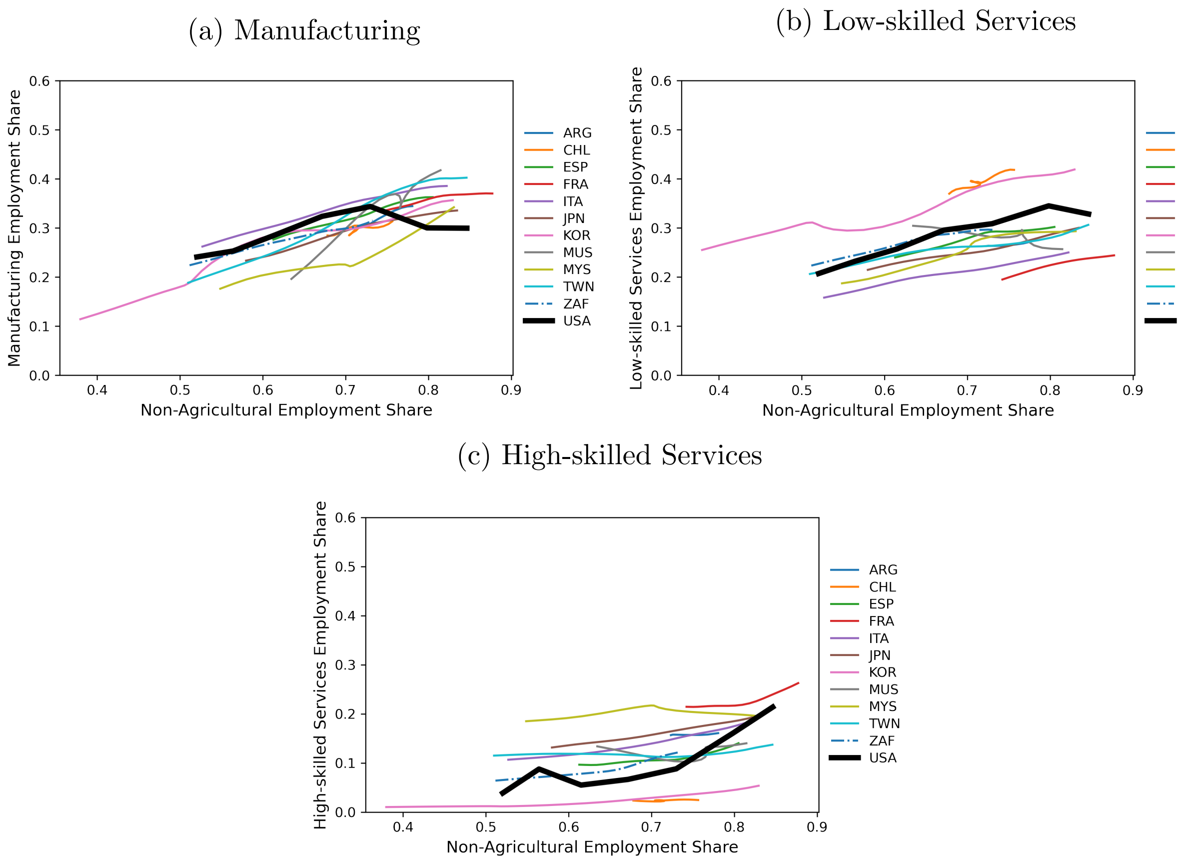
Figure 3: Structural Transformation in Steep-Manufacturing Economies



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

To better visualize the structural transformation patterns, I separate the sample period of all steep-manufacturing countries into two phases: the industrialization (before the manufacturing peak) and the deindustrialization (after the manufacturing peak). The employment shares in manufacturing, low-skilled services and high-skilled services are plotted against the non-agricultural employment share. Figure 4 and 5 present the evolution of the employment share in 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 transformation between the industrialization and the deindustrialization phases.

Figure 4: Industrialization Phase of Steep-Manufacturing Economies

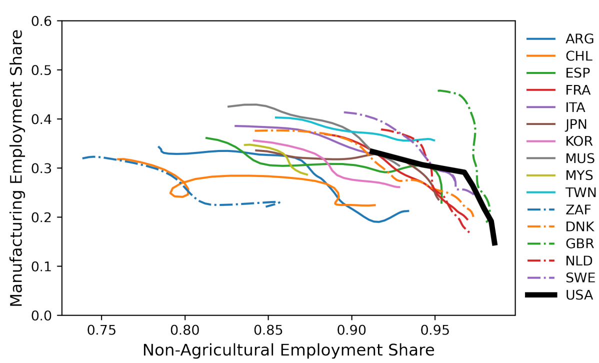


Notes: The industrialization phase for each country is marked as the period before the peak of the manufacturing employment share. For the United States, due to the period 1920-1950 with fluctuation in manufacturing employment share, the industrialization phase is chosen to be the period 1880-1950 before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

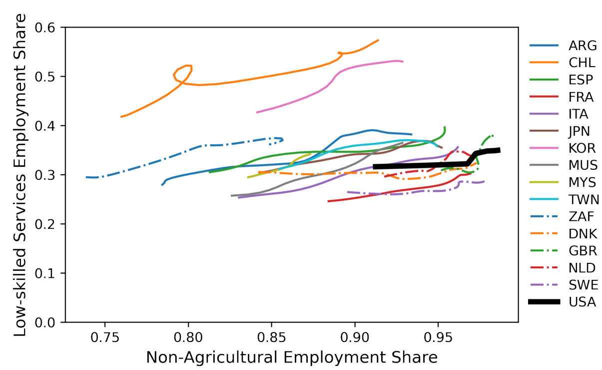
The industrialization phase is characterized by a reallocation of employment out of agriculture to manufacturing and low-skilled services. The sizes of manufacturing and low-skilled services sectors are comparable on average in this phase. The high-skilled services sector is smaller on average and exhibits larger variation across countries. During the industrialization phase (between 40% and 80% employment share in non-agricultural sector) in the United States, out of 1% employment share leaving agriculture, around 0.4%, 0.4% and 0.2% employment shares are reallocated to manufacturing, low-skilled services and high-skilled services respectively. The values of these slopes are quite similar in the other steep-manufacturing countries.

Figure 5: Deindustrialization Phase of Steep-Manufacturing Economies

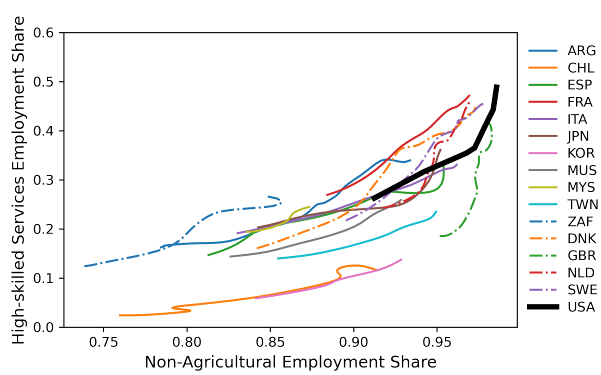
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



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

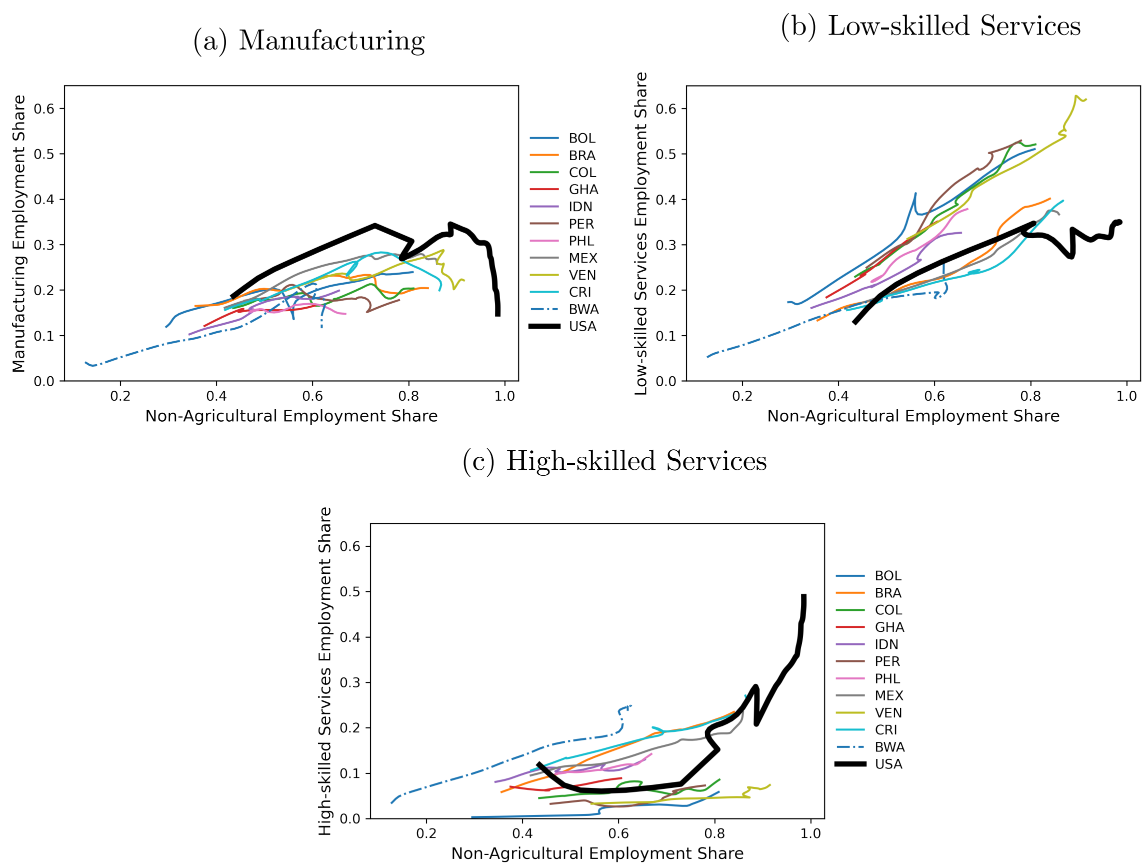
During the deindustrialization phase, the employment share in agriculture becomes minor. As discussed above, significantly different from the industrialization phase, the deindustrialization phase is marked with a sharp decline in the manufacturing employment share. Labor is reallocated towards high-skilled services, turning this sector to eventually become the largest sector in most developed countries. The low-skilled services employment share displays fewer changes during this phase.

3.2 Pattern in Flat-Manufacturing Economies

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

Figure 6 presents structural transformation patterns across the flat-manufacturing countries. We can observe that the flat-manufacturing countries exhibit flatter and lower-level profiles of the manufacturing employment share compared to the United States. The low-skilled services employment share is strikingly larger and expands at a steeper rate compared to the United States. The high-skilled services employment share remains insignificant throughout the sample period for most countries in the group.

Figure 6: Structural Transformation in Flat-Manufacturing Economies



Notes: The solid black lines represent the evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark. The slopes are remarkably different for the flat-manufacturing countries in each plot compared to the United States. In particular, the flat-manufacturing countries exhibit lower slopes of labor reallocation towards manufacturing and substantially higher slopes 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 countries tend to attain a lower manufacturing peak after 1990s. He conjectures from this finding that change in global sources such as the rise of globalization or labor-saving technology are main reason behind this phenomenon. 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

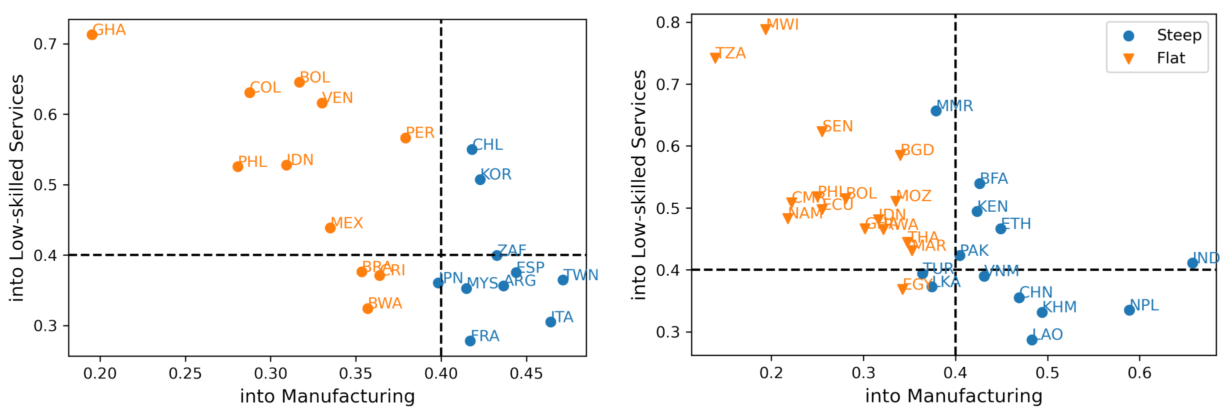
(2022)) focus on the peak as the key feature of manufacturing hump-shaped patterns, their analysis is restricted to include only countries which have attained the manufacturing peak.

This paper overcomes these two limitations by using data from a broad set of recent emerging countries and focusing on the evolution of the 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 the recent developing countries. Among the 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



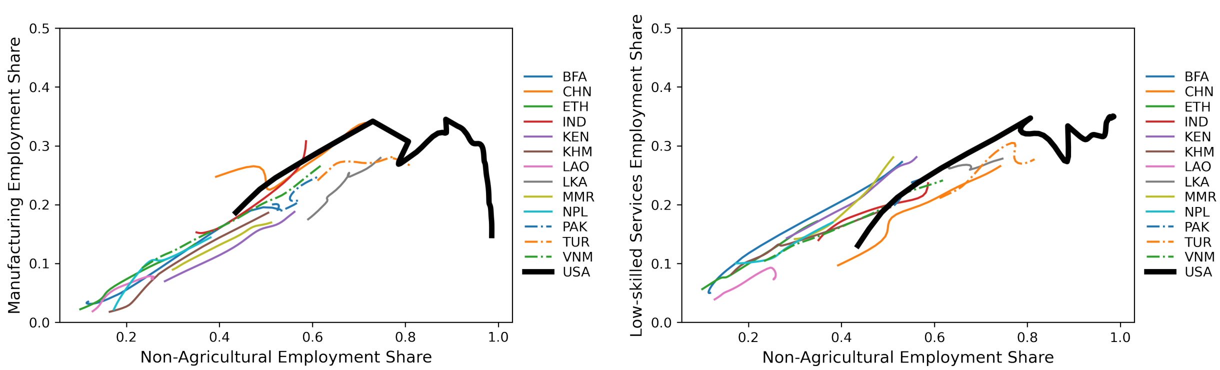
Notes: Figure (a) reports the variables for the earlier (post-1950s) developers from the GGDC 10-Sector Database. Figure (b) reports the variables for the later (post-1990s) developers from the Economic Transformation Database. The black dashed line presents the labor allocation process into manufacturing 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 the cross-country patterns of the 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 the earlier developers during 1950-2010 (from the GGDC 10-Sector Database) and the later developers during 1990-2018 (from the Economic Transformation Database) respectively. There are two major similar structural transformation patterns between the two samples. First, most countries in both samples reallocate employment out of agriculture mostly towards manufacturing and low-skilled services during early to middle stage of development. 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 developers tend to attain a lower manufacturing peak and follow a 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 the steep and the flat-manufacturing patterns occur in all the three regions: Africa, Asia and Latin America. This evidence suggests that the heterogeneous paths of structural transformation are prevalent across countries 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

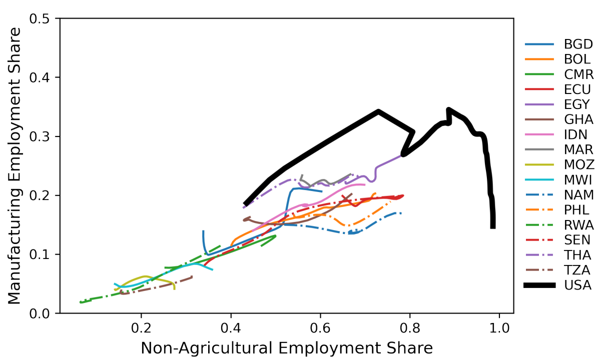


Notes: The solid black lines represent evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark. The slopes of the manufacturing and the low-skilled services employment shares with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

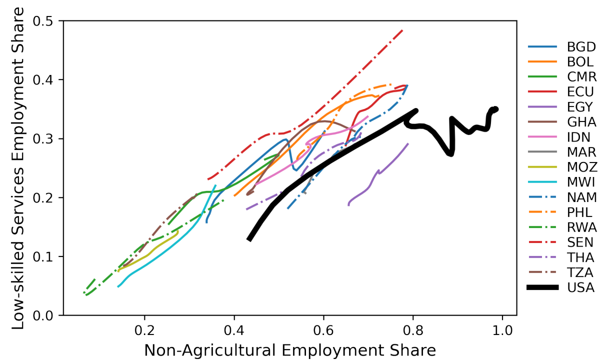
Figure 8 and 9 illustrate the structural transformation patterns of the recent steep-manufacturing countries along with the countries exhibiting the flat-manufacturing pattern. In Figure 8a and 9a, while many recent emerging countries follow similar patterns to the United States with the steep evolution of the manufacturing employment share, many others follow the flat-manufacturing pattern with less labor reallocation towards manufacturing. Figure 8b and 9b show that compared to the United States and other recent steep-manufacturing countries, the recent flat-manufacturing countries 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 solid black lines represent evolution of the employment shares in manufacturing, low-skilled services and high-skilled services over the non-agricultural employment share in the United States as a benchmark. The slopes of the manufacturing and the low-skilled services employment shares with respect to the non-agricultural employment share in these recent flat-manufacturing countries differ remarkably from the United States during the industrialization phase. Even though these recent developing countries have not reached the manufacturing peak yet, they exhibit significantly lower slopes of the labor allocation to manufacturing and low-skilled compared to the United States.

In summary, the structural transformation patterns are remarkably different across countries. While many countries follow a steep-manufacturing profile and a moderate rise of low-skilled services similar to the United States, many other countries exhibit a pattern of flat-manufacturing evolution and a 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 transformation 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 the sources behind the heterogeneity in structural transformation across countries presented in the earlier section. In the model, sectoral labor productivities 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 a technology linear 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. A 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 $c_a > \bar{a}$, preferences over non-agricultural goods follow homothetic CES preferences 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 transformation between manufacturing and services: income effect and substitution effect. However, similar to Huneeus and Rogerson (2022), I also find a limited role of income effect in allocating labor between manufacturing and services sectors during early to middle stage of development across countries. The assumption of homothetic CES preferences 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 the 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 a set of prices $\{p_i\}$, $\{c_i\}$ solves the representative 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 a set of prices $\{p_i\}$, $\{L_i\}$ solves the representative 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 the linear production technology, from the representative firm's problem, the sectoral prices can be derived as the inverse of the sectoral labor productivity:

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

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

$$p_i c_i = p_i Y_i = L_i, \quad i \in \{a, m, ls, hs\} \tag{8}$$

The representative household's problem and the market clearing conditions will then determine the sectoral expenditure and the employment shares.

If $A_a \leq \bar{a}$, the representative 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, the representative household will spend only $c_a = \bar{a}$ on agricultural goods, implying the 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 the representative household's problem, the expenditure for each sector $i = m, ls, hs$ can be derived as

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

Substituting the conditions (7) and (8) yields

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

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

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

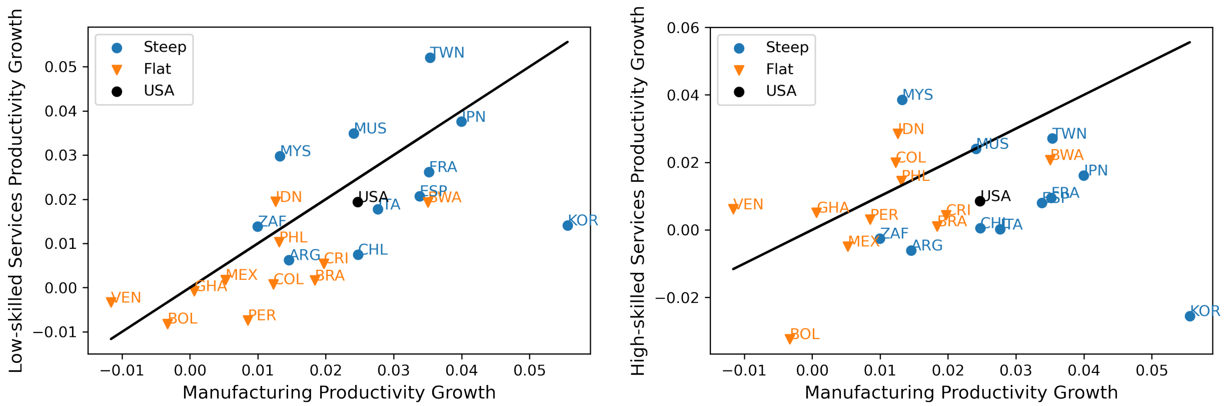
The structural transformation patterns are driven by relative sectoral productivity growth rate $\{g_i\}$ and relative labor productivity level $\{A_{i0}\}$. Huneeus and Rogerson (2022) find that the hump-shaped pattern of manufacturing is driven by a positive agricultural productivity growth ($g_i > 0$) and a 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 a larger variation across countries. The steep-manufacturing countries tend to experience higher productivity growth rates in both manufacturing and low-skilled services than the flat-manufacturing countries. High-skilled services productivity growth rates, on the other hand, are quite similar across countries.

Figure 10: Sectoral Labor Productivity Growth Rates

(a) Manufacturing vs. Low-skilled Services

(b) Manufacturing vs. High-skilled Services



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

4.3 Benchmark Calibration to the United States

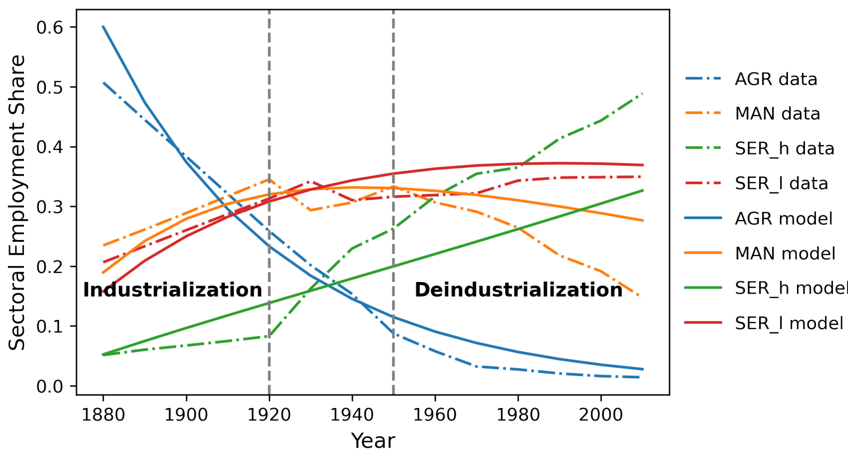
I calibrate the model parameters to capture the evolution of the sectoral employment shares in the United States during the industrialization phase 1880-1950. Due to the lack of data on the sectoral productivity in the United States for the period 1880-1950, I follow Huneeus and Rogerson (2022) to assume the agricultural productivity growth (g_a) to be 2.39% to match the observed trend in the agricultural employment share. Other sectoral productivity growth rates (g_m, g_{ls}, g_{hs}) during the period 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 share in agriculture, implying that $\bar{a} = 0.60$. The elasticity of substitution for non-agricultural goods, σ, is set to be 0.30 following the 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 the sectoral employment share evolution in the United States. Table 1 presents the calibrated value for each parameter.

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 the 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 steep hump-shaped profile of manufacturing employment share close to the 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 of manufacturing and high-skilled services during the deindustrialization phase. The reasons are potentially the simplifying assumptions of constant sectoral labor productivity growth and no income effect for labor allocations between manufacturing and services sectors in the model. During the 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 countries, 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 the heterogeneity in structural transformation patterns arises from the deviations in the sectoral productivity profiles. Two forces behind these departures are the sectoral productivity growth rates (dynamic factors) and the initial sectoral productivity levels (static factors). Detailed analysis on the role of the sectoral productivity growth factors can be found in Huneeus and Rogerson (2022). They report finding that the 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 uncovers and investigates initial sectoral productivity levels as a new 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 the same productivity growth rates in all sectors $g_i^c = g_i^{US} = g_i \quad \forall i \in \{a, m, ls, hs\}$ and the same initial agricultural productivity level $A_{a0}^c = A_{a0}^{US}$. The only difference between the two economies is in the 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 the sectoral productivity grows at the same rate in both countries, the 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

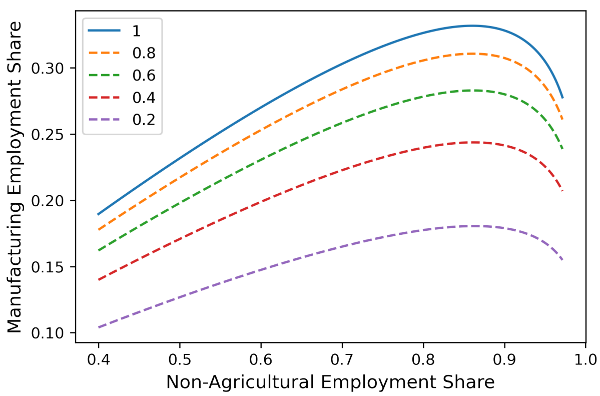
$$\frac{A_{it}^c/A_{mt}^c}{A_{it}^{US}/A_{mt}^{US}} = \frac{A_{i0}^c/A_{m0}^c}{A_{i0}^{US}/A_{m0}^{US}} \frac{e^{(g_i-g_m)t}}{e^{(g_i-g_m)t}} = \frac{A_{i0}^c/A_{m0}^c}{A_{i0}^{US}/A_{m0}^{US}} \quad \forall i \in \{ls, hs\} \tag{12}$$

The difference in the initial relative productivity levels represents a persistent gap in the 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 the past growth rates, institutions, distortions, human capital endowments. The gap in the initial relative productivity levels will persist over time and result in different patterns of labor allocation. As the key feature of the heterogeneity in structural transformation patterns is that flat-manufacturing economies experience lower manufacturing employment shares and higher low-skilled services employment share, a flat-manufacturing economy is expected to have a lower relative labor productivity of low-skilled services to manufacturing than in the

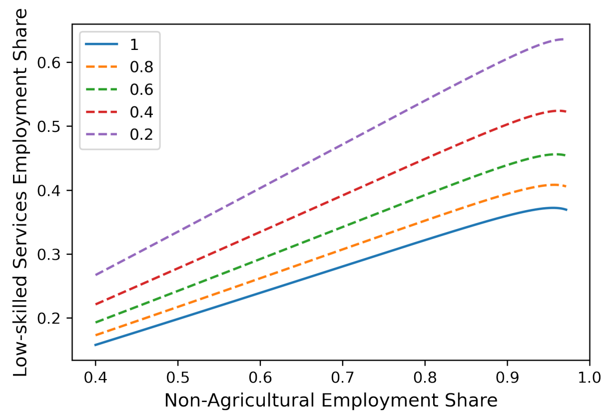
United States: $\frac{A^c_{ls0}}{A^c_{m0}} < \frac{A^{US}_{ls0}}{A^{US}_{m0}}$.

Figure 12: Initial Relative Productivity Levels and Structural Change Patterns

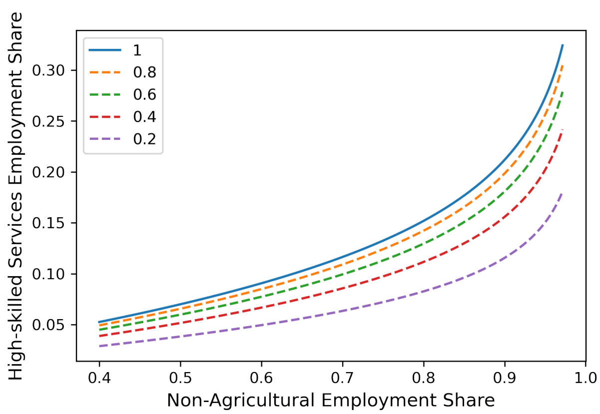
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



Notes: The solid blue lines represent the sectoral employment shares in the United States as a benchmark. The dashed lines represent four counterfactual economies which only differ from the benchmark economy in the initial productivity levels of low-skilled services (equal to $0.8, 0.6, 0.4$ and 0.2 of the benchmark economy).

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

5 Cross-country Analysis

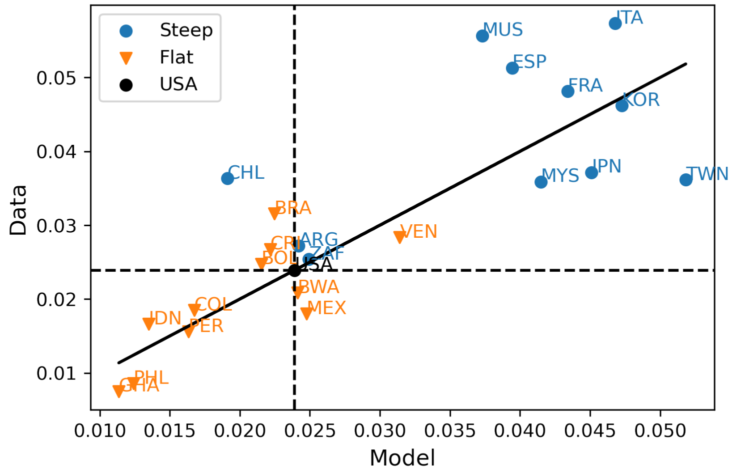
Based on the model calibrated to the United States as a benchmark economy, this section extends the analysis to study forces driving the heterogeneity in structural transformation patterns across countries. The section first starts with the calibration of sectoral productivity growth and initial levels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

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 agricultural 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. The solid black 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

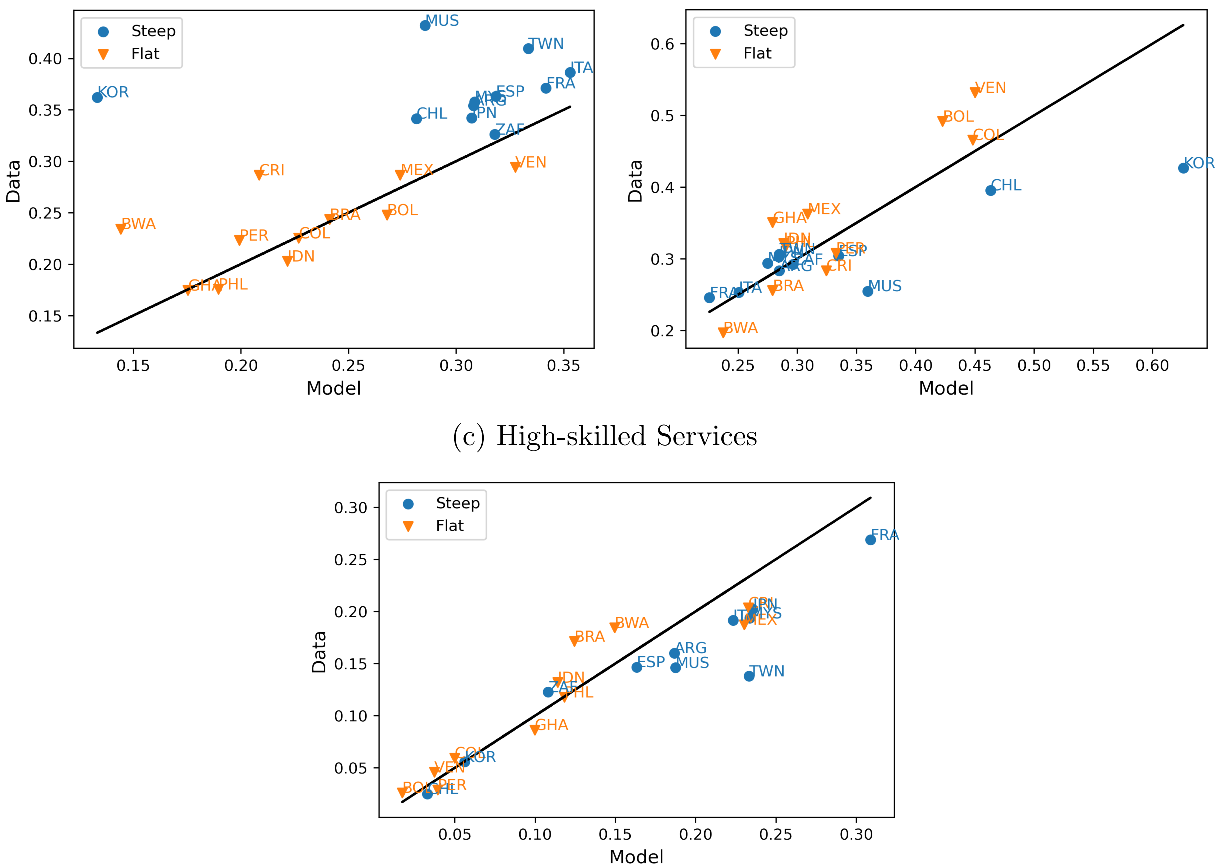
For labor allocation in manufacturing and services sectors, I follow the calibration strategy described in Duarte and Restuccia (2010). Due to the lack of comparable sectoral value-added data across a large set of countries, I employ the model to restrict the sectoral labor productivity levels in initial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

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

(a) Manufacturing

(b) Low-skilled Services

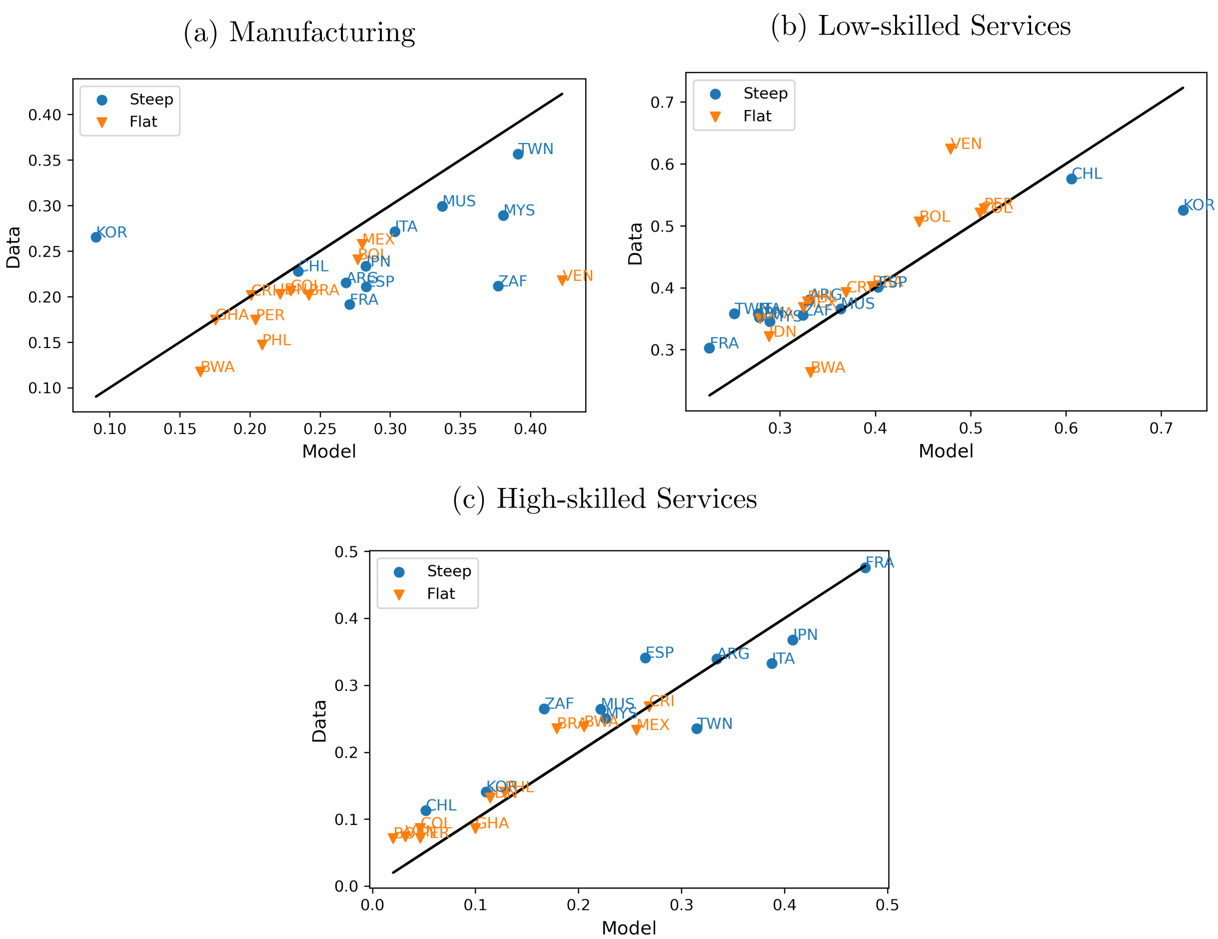
(c) High-skilled Services



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

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

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



Notes: Each plot reports the value for each variable in the last period for the model and the data. The solid black 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 the initial sectoral productivity levels (static factors) and the sectoral productivity growth rates (dynamic factors) in generating the heterogeneous patterns across countries. As discussed in section 4, the static and the dynamic factors are the two forces driving the 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 the initial sectoral productivity levels for the cross-country patterns in the sectoral labor allocation. The counterfactual results indicate that differences in the initial sectoral productivity levels are found to be the main drivers of the heterogeneity in structural transformation patterns between the steep- and the flat-manufacturing countries.

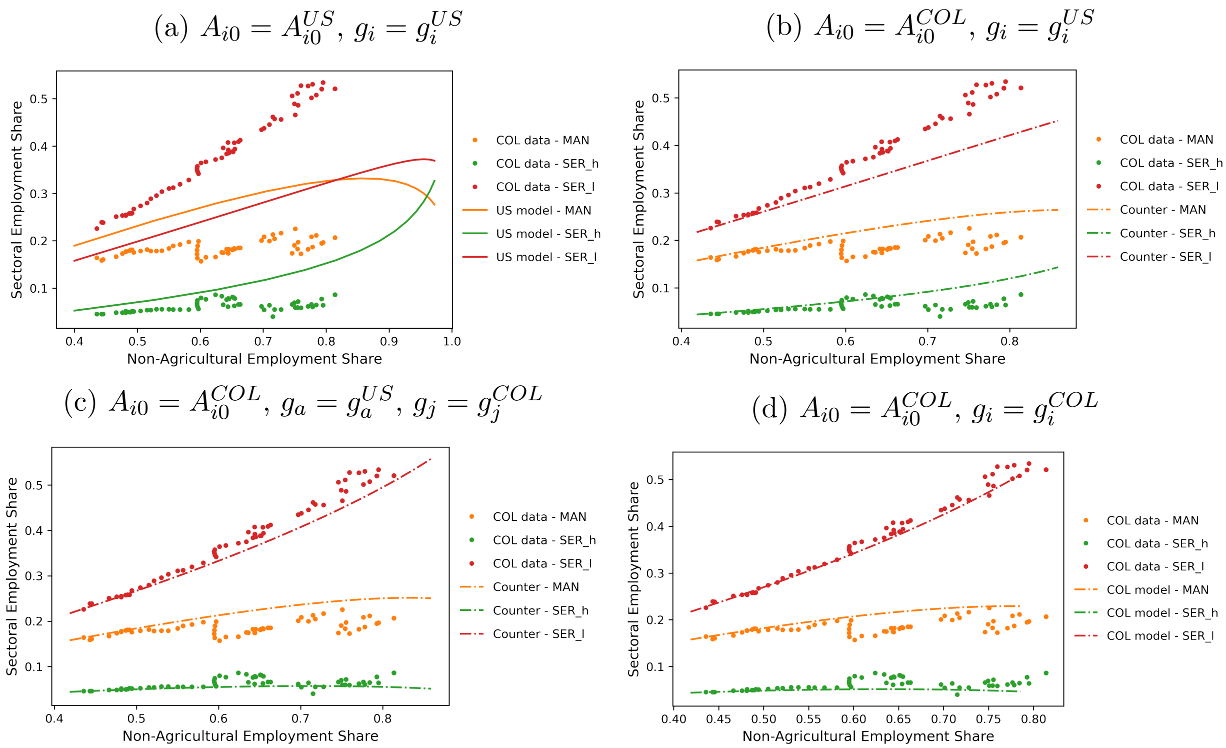
Illustrating Example of Colombia

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

Figure 16a plots the United States' sectoral employment shares from the model (which is close to the shares in the United States data presented earlier in Figure 11) and Colombia's sectoral employment shares from the data. The 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 has approximately 20% employment share in manufacturing and 50% employment share in low-skilled services.

Figure 16b exhibits the sectoral employment shares in Colombia data and the first counterfactual using Colombia's initial sectoral labor productivity levels together with the United States's productivity growth rates in agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactual can generate structural transformation patterns closer to the data with a steeper rise in low-skilled services and a flatter hump shape of manufacturing. The counterfactual shows that differences in structural transformation patterns between Colombia and the United States largely remain after shutting down all the differences in sectoral productivity growth rates between the two countries. This result suggests that the initial relative productivity levels are quantitatively important to account for the observed heterogeneous structural transformation patterns between Colombia and the United States. The remaining gaps in the structural transformation patterns between this counterfactual and the data are attributed to the dynamic factors (the sectoral productivity growth rates).

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 the 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 sectoral employment shares in the counterfactual using the initial sectoral productivity levels and the sectoral productivity growth rates in Colombia.

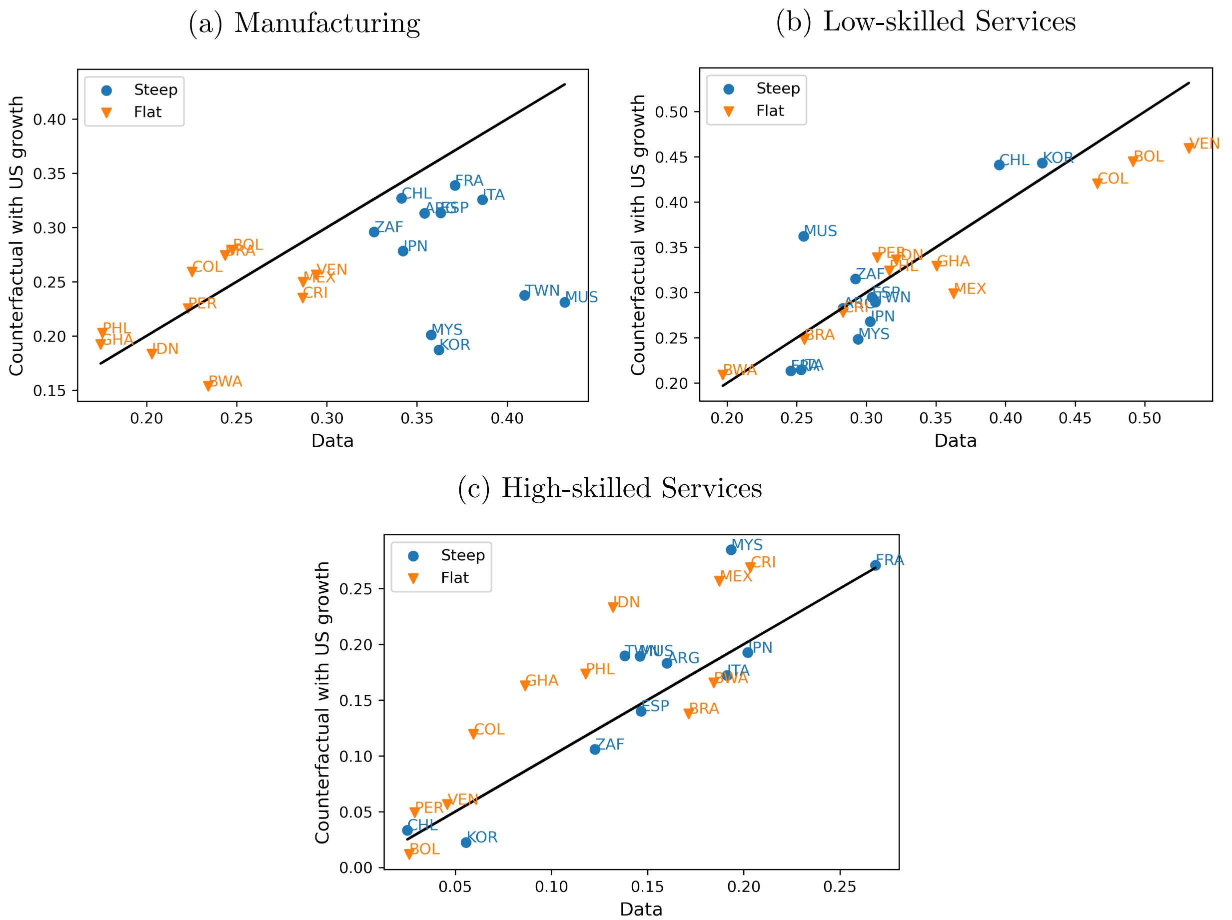
Figure 16d shows that incorporating both the sectoral initial productivity levels and the sectoral productivity growth rates of Colombia generate the structural transformation patterns very close to the data. Figure 16c shows the sectoral employment shares by the counterfactual using Colombia's initial 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 generated by this counterfactual are also close to the data, suggesting a limited explanatory power of productivity growth in agriculture.

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

Cross-country Counterfactual Results

The counterfactual exercise is conducted for the other countries in the sample. For each country, the counterfactual sectoral productivity and employment profiles are generated assuming the country's initial conditions and the United States sectoral productivity growth rates. Figure 17 plots the sectoral employment shares in the peak year of the manufacturing employment share in this counterfactual against the data. The counterfactual generates structural transformation patterns very close to the data, suggesting that the differences in the initial relative productivity levels are quantitatively sufficient in driving the observed heterogeneous patterns between the steep- and the flat-manufacturing countries.

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



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. The solid black line represents the 45-degree line on which the counterfactual perfectly fits the data. The counterfactual generates the sectoral employment shares close to the data, suggesting that variation in the initial sectoral productivity levels can account for the observed heterogeneity in structural transformation.

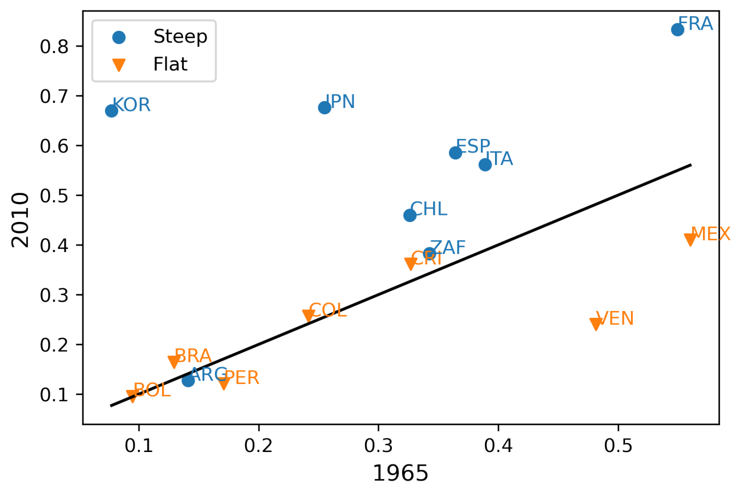
6 Aggregate Implications

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 the 22 countries are included in the analysis.

6.1 Aggregate and Sectoral Productivity Patterns

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

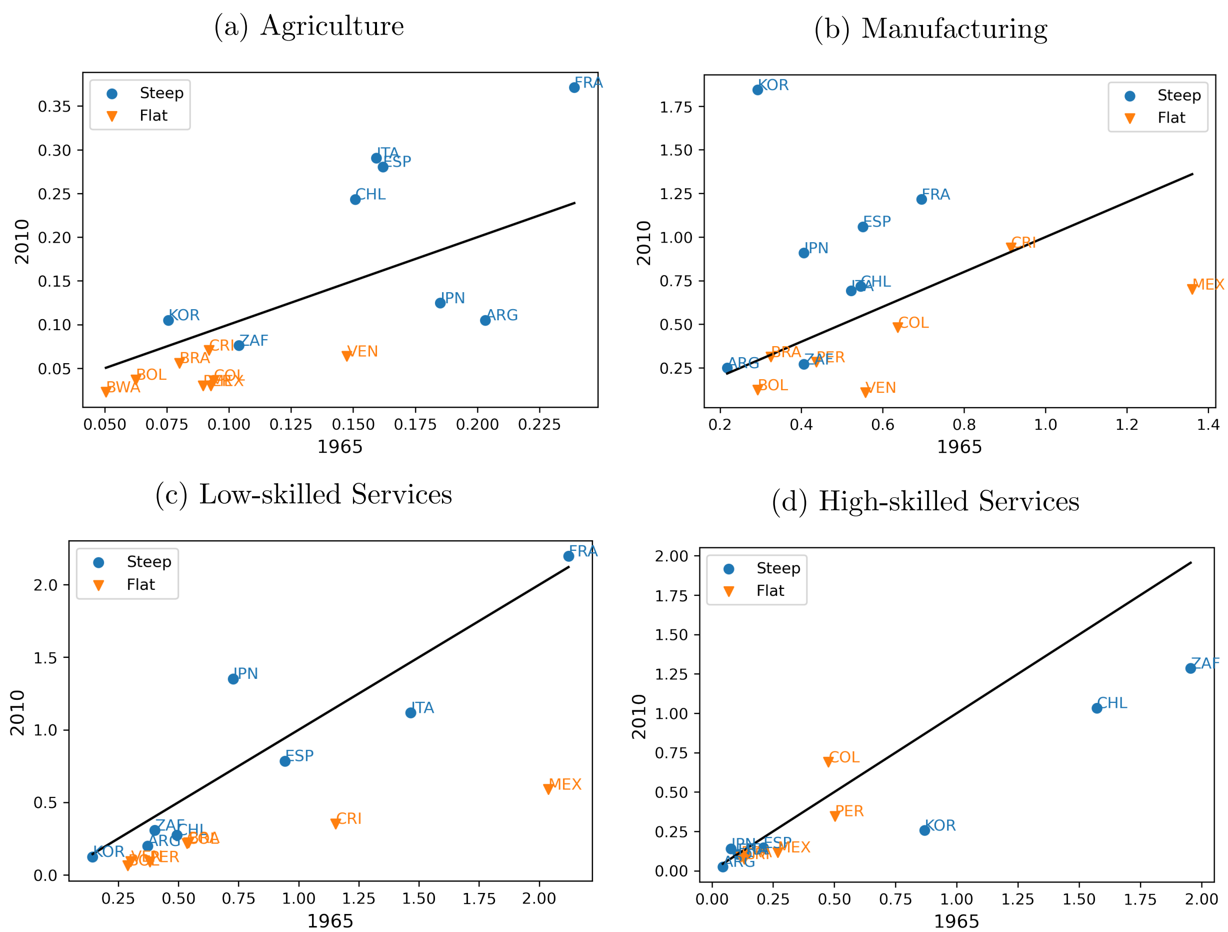
Figure 18: Aggregate Labor Productivity Relative to the United States: 1965-2010



Notes: Data on the aggregate labor productivity levels are from the Penn World Table 10.0. The plot reports the aggregate labor productivity level relative to the United States in 1965 and 2010. The solid black 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 the real aggregate labor productivity relative to the United States in 2010 against the values in 1965 as well as the 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 countries in the 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: Sectoral Productivity Relative to the United States: 1965-2010



Notes: Data on the sectoral labor productivity levels are inferred by the model. Each plot reports the labor productivity level relative to the United States for each sector in 1965 and 2010. The solid black 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.

Figure 19 next reports the 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 the 45-degree line. There has been considerable variation in the labor productivity growth experiences across sectors and countries. In Figure 19a, while only four countries 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 the steep-manufacturing group, most flat-manufacturing countries experience a decline in the manufacturing productivity relative to the United States. Figure

19c presents a pattern of little catch-up or decline in low-skilled services productivity compared to the United States for most countries. While most steep-manufacturing countries experience little change in the low-skilled services productivity relative to the United States, the flat-manufacturing countries have substantial fall in the low-skilled services productivity compared to the United States. In Figure 19d, there has been little change in the high-skilled services productivity relative to the United States for most countries in the sample.

6.2 Role of Sectoral Productivity in Aggregate Productivity

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

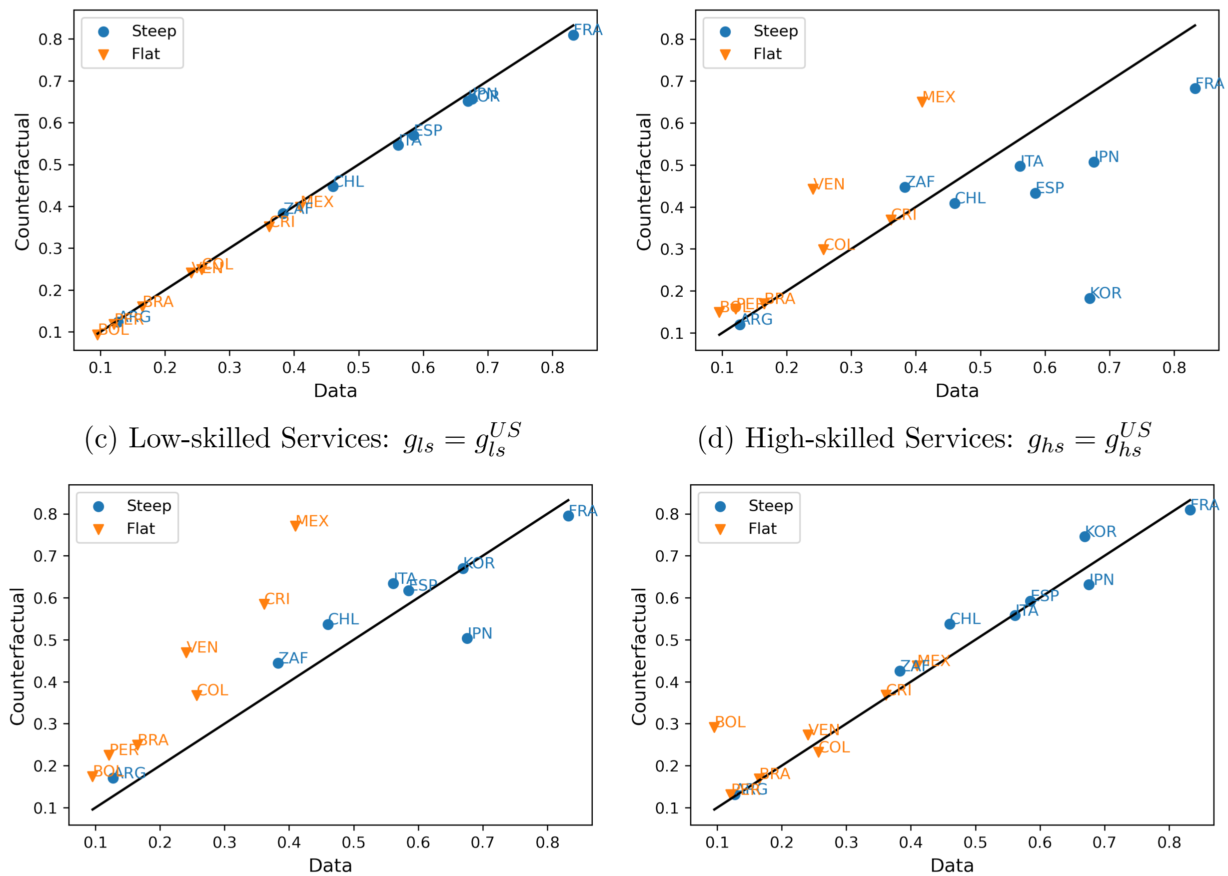
For most countries, setting sectoral productivity growth rates in agriculture and high-skilled services to the United States growth rates generates very small impacts on relative aggregate productivity. These two counterfactual results, reported in Figure 20a and 20d, indicate a small role of agriculture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

Figure 20b presents the results of the counterfactual using the manufacturing productivity growth rate in the United States. The counterfactual generates much lower aggregate labor productivity levels for most of the steep-manufacturing countries. For the 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 countries. The low-skilled services productivity growth contributes little to the catch-up experiences in most steep-manufacturing countries (except Japan).

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 the aggregate labor productivity levels relative to the United States in 2010 in the data and in each of the counterfactual. The solid black 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.

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 countries. In flat-manufacturing countries, 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 the 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 countries with flat-manufacturing patterns and that human capital is weakly correlated with the structural transformation.

7.1 Informal Economy

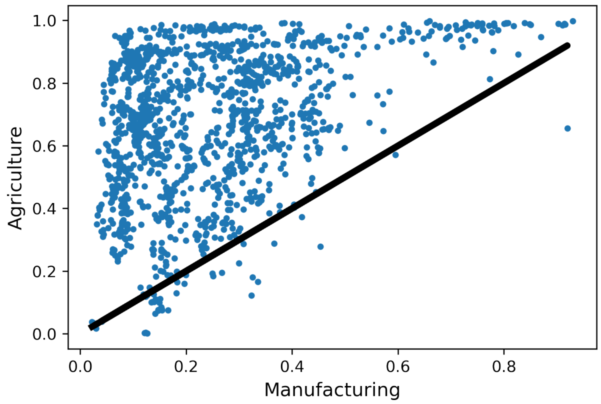
Informal economy has been considered an important aspect of developing countries. Informal sector is associated with small-scaled production, lack of physical and human capital and low productivity. Main driving sources of informality include weak institutions regarding tax, social security, bureaucracy, 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 the degree of informality (Elgin et al., 2021). The data are from the International Labour Organization (ILO) Database covering employment by economic sector and employment status. 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.

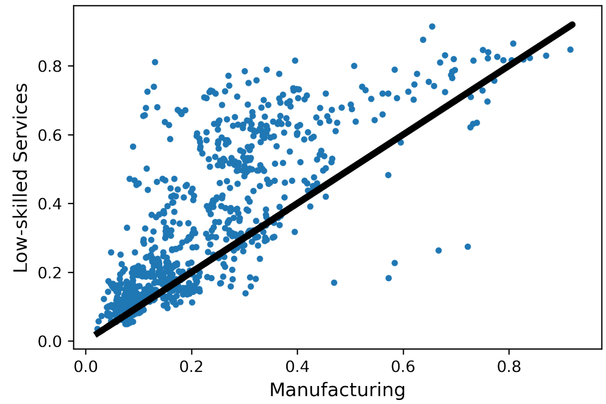
Figure 21 plots the self-employment share in agriculture, low-skilled services and high-skilled services against manufacturing respectively. The solid black line in the figures represents the 45-degree line. Figure 21a and 21b show that self-employment share in agriculture and low-skilled services is 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 the self-employment share as a proxy for the degree of informality differs significantly across sectors. While agriculture and low-skilled services tend to be more informal, manufacturing and high-skilled services are generally more formal.

Figure 21: Self-Employment Share by Sector

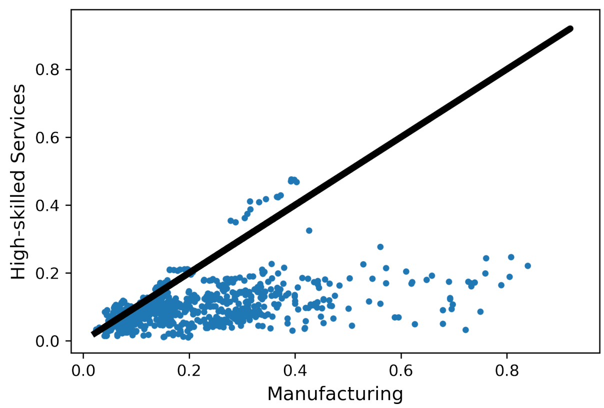
(a) Agriculture vs. Manufacturing



(b) Low-skilled Services vs. Manufacturing



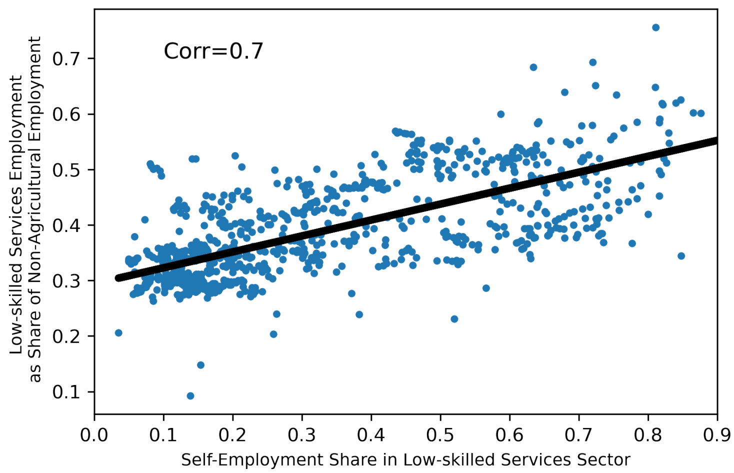
(c) High-skilled services vs. Manufacturing



Notes: Data on the self-employment share are from the International Labour Organization (ILO) Database. The solid black 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 the employment share of low-skilled services in non-agriculture and the self-employment share in low-skilled services across countries. The share of low-skilled services in non-agricultural sectors is computed by dividing the employment in low-skilled services by the non-agricultural employment. This measure serves as a proxy for the structural transformation pattern: A higher value indicates a higher share of labor leaving agriculture reallocating towards low-skilled services (closer to flat-manufacturing patterns). The reason for using the low-skilled services employment share instead of the manufacturing employment share is that the manufacturing employment share with respect to non-agriculture differs significantly in the industrialization and the deindustrialization due to the hump-shaped evolution. Instead, the employment share of low-skilled services rises over the course of development and exhibit a robust relationship respect to the non-agricultural employment share. Considering the sample consisting of 156 countries at various income levels, share of low-skilled services with respect to non-agriculture consequently better captures the heterogeneity in cross-country structural transformation 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 the degree of informality in low-skilled services sector and the employment share of low-skilled services. Countries with higher self-employment share (higher degree of informality) tend to allocate more labor towards low-skilled services. This evidence suggests that in countries with large informal sectors, low-skilled services sector is 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 the high degree of informality and the low productivity level in low-skilled services relative to manufacturing. In an economy with high fixed costs 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 the productivity level between manufacturing and low-skilled services in the flat-manufacturing countries.

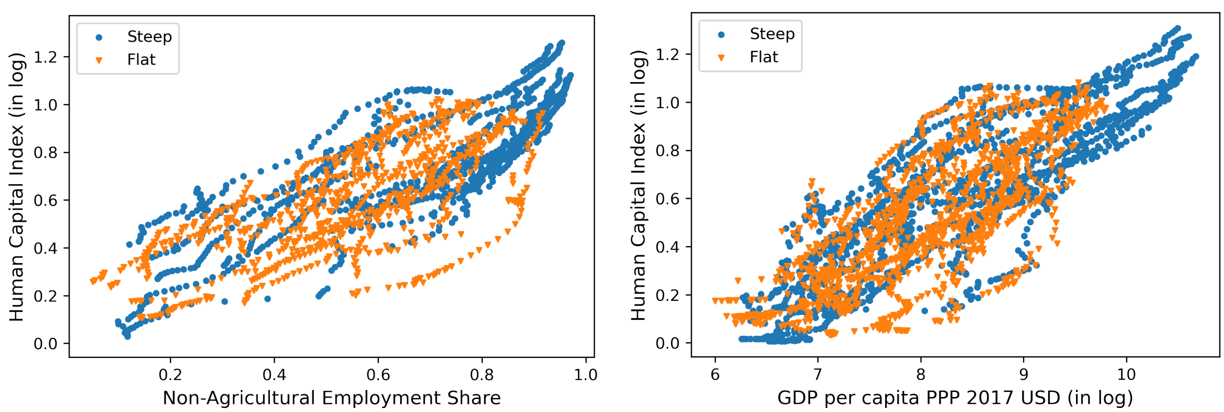
7.2 Human Capital

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 the flat-manufacturing countries with a substantially large low-skilled services sector subject to a low level of human capital or a lack of skilled labor? My finding, however, suggests that there is little correlation between human capital and heterogeneity in structural transformation 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 the 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 the non-agricultural employment share and the logarithm of GDP per capita (PPP 2017 USD) as two different measures of development level. Human capital tends to rise with development. There's no systematic difference in human capital index between the steep- and the flat-manufacturing countries: The flat-manufacturing countries do not exhibit a systematic pattern of lower human capital index. At different levels of development, there's little relationship between human capital index and the employment share of manufacturing. These results suggest no evidence for the role of human capital (measured by schooling) in explaining the substantial heterogeneity in structural transformation patterns across countries.

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 profiles with small changes in manufacturing employment share. The steep-manufacturing countries experience substantial labor reallocation of employment from agriculture to manufacturing during the industrialization phase and substantial reallocation from manufacturing to high-skilled services during the deindustrialization phase. The flat-manufacturing countries remains low level of the manufacturing employment share and exhibit unnoticeable distinction between the industrialization and the deindustrialization. The structural transformation pattern in the flat-manufacturing countries 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 the structural transformation process and the aggregate productivity. Among factors driving the sectoral labor productivity, the initial sectoral productivity levels can account for the majority of variation in structural transformation patterns. Country-specific institutions and distortions related to the degree of informality are potential sources explaining the lower productivity level and a larger size of low-skilled services relative to manufacturing in the flat-manufacturing countries.

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

These findings suggest that understanding country-specific sources of institutions and distortions driving sectoral productivity is crucial to understanding the heterogeneous paths of structural transformation and the consequences on aggregate growth across countries. An important question is why the flat-manufacturing countries have a 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 the flat-manufacturing countries. It will be also important to extend the analysis to open economy framework to understand how trade interacts with country-specific factors in driving the process of structural transformation and growth experiences.

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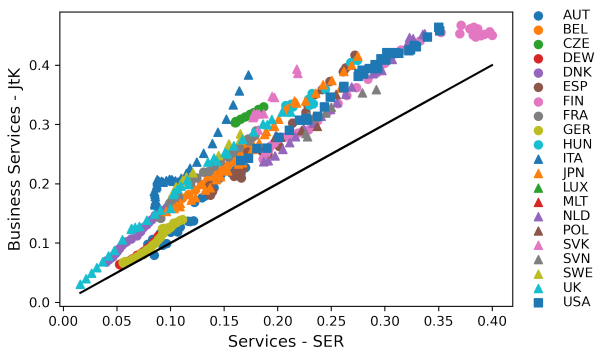
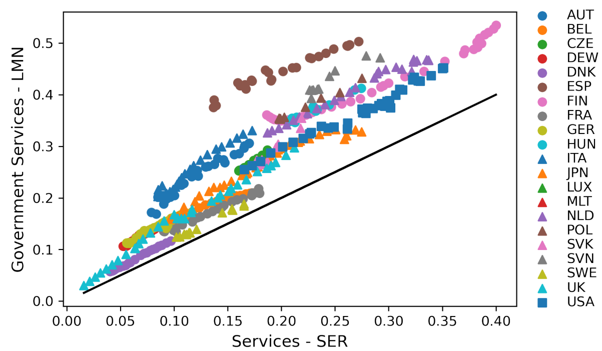
A Services Classifications - KLEMS

Figure A.1: High-skilled Labor Hour Share

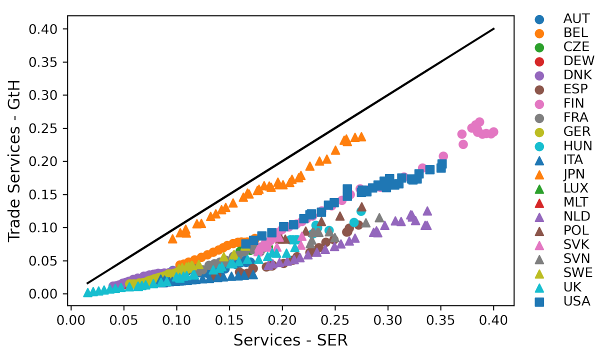
(a) Business Services - J+K



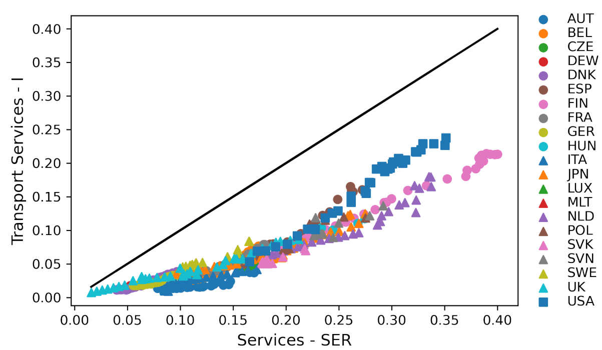
(b) Government Services - L,M,N



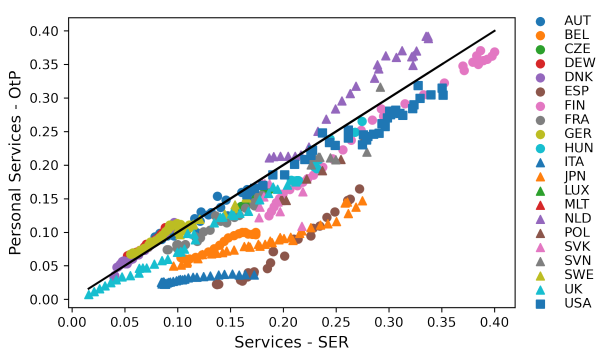
(c) Trade Services - G+H



(d) Transport Services - I



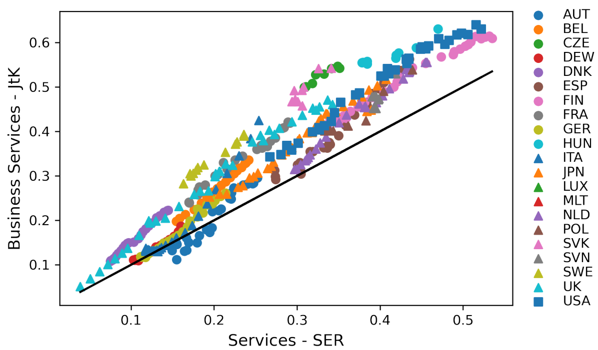
(e) Personal Services - O+P



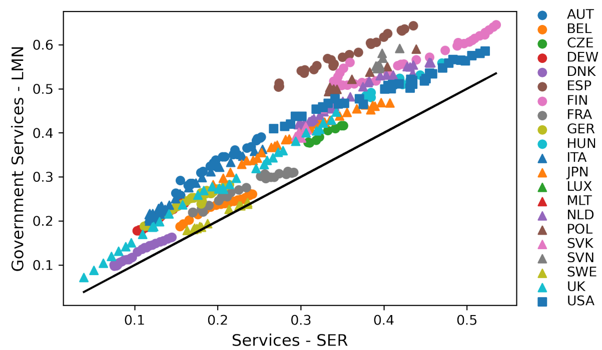
Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on share of hours worked by high-skilled workers for each sector are from KLEMS Database. The solid black line represents the 45-degree line on which the hour share of high-skilled labor in the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

Figure A.2: High-skilled Labor Compensation Share

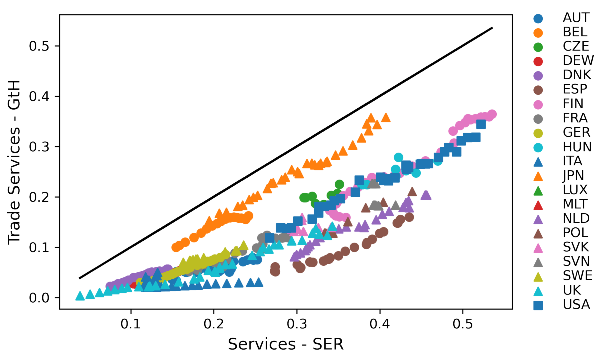
(a) Business Services - J+K



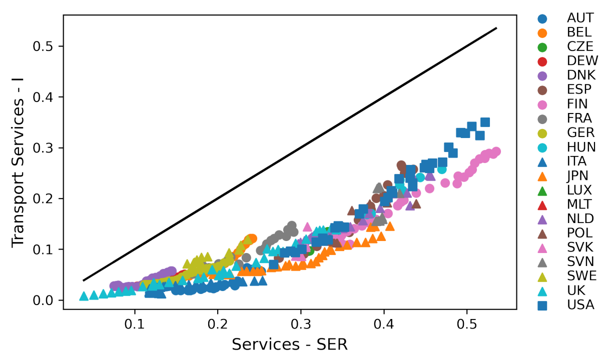
(b) Government Services - L,M,N



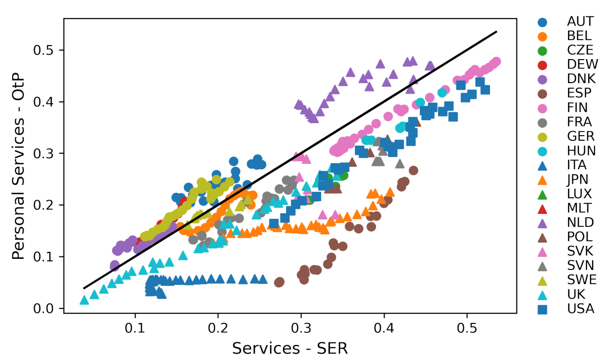
(c) Trade Services - G+H



(d) Transport Services - I



(e) Personal Services - O+P

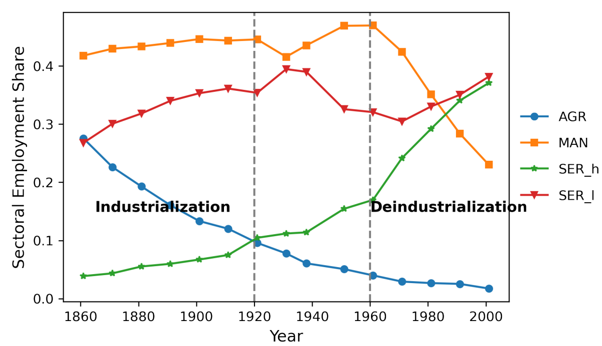


Notes: High-skilled worker is defined as worker with education with at least bachelor-equivalent degree. Data on the share of labor compensation by high-skilled workers for each sector are from the KLEMS 2007 Database. The solid black line represents the 45-degree line on which the labor compensation share of high-skilled labor in the sector is the same as the median of broad services sector.

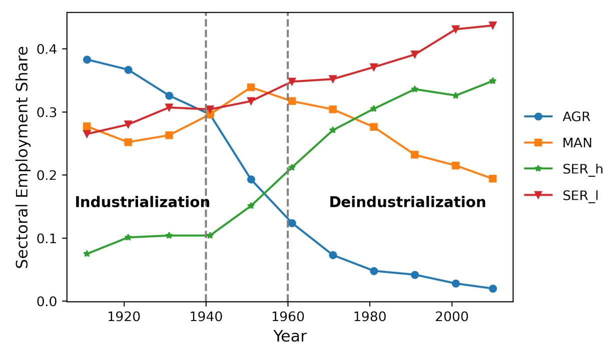
B Examples of Structural Transformation Patterns

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

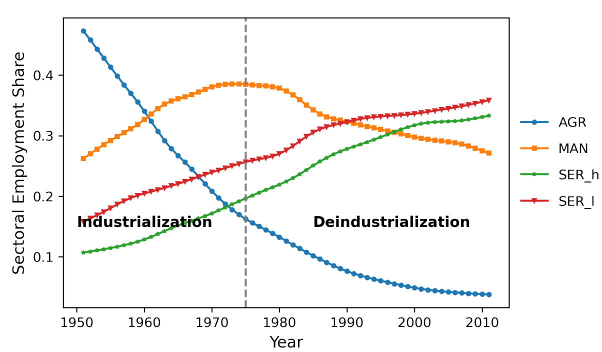
(a) United Kingdom



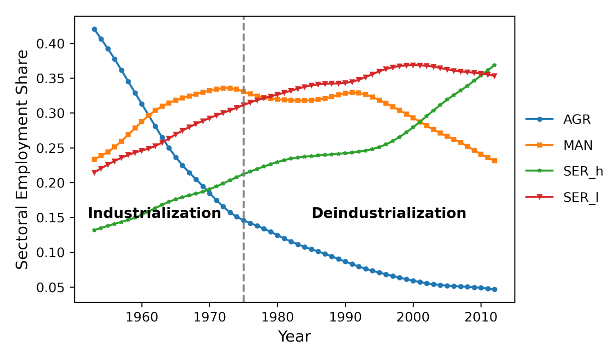
(b) Canada



(c) Italy

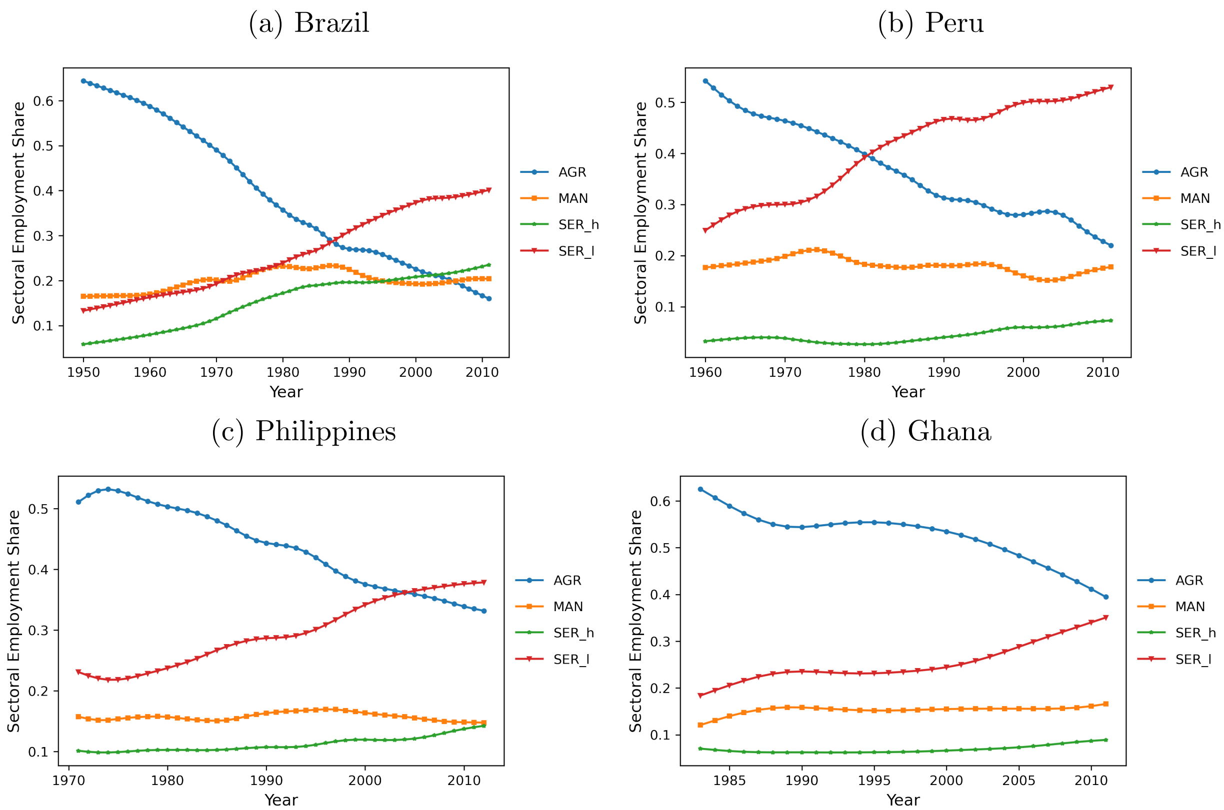


(d) Japan



Notes: Data 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



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