Heterogeneous Paths of Structural Transformation [†]

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Abstract

This paper investigates driving forces and aggregate implications of cross-country heterogeneous patterns in structural transformation and the "premature deindustrialization" phenomenon in Rodrik (2016). There are four major findings in my analysis. First, different from what the term "premature deindustrialization" suggests, low-manufacturing-peak economies do not observe significant decline in manufacturing as seen in the deindustrialization process in the US. These economies follow a different pattern of structural transformation characterized with flat evolution of manufacturing share instead of the conventional steep hump shapes documented in developed economies. Second, flat manufacturing economies tend to allocate substantially more labor into low-skilled services compared to steep manufacturing economies. Both steep and flat manufacturing patterns are prevalent not just among earlier (post-1950s) developers but also among recent (post-1990s) developers. Third, variation in initial relative productivity levels between manufacturing and low-skilled services quantitatively accounts for the observed heterogeneity in structural change patterns. Cross-country differences in initial relative productivity levels reflect persistent gaps in relative sectoral productivity as a result of country-specific static factors such as distortions, institutions. Fourth, steep manufacturing economies experience substantial catch-up in aggregate productivity relative to the US, whereas flat manufacturing economies observe stagnation and slowdown. Productivity gains in manufacturing explain a majority of the catch-up experiences while lack of growth in low-skilled services accounts largely for the slowdown experiences.

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 economic sectors - is a prominent feature of economic development. One common pattern of structural transformation is the hump-shaped evolution of manufacturing[1] sector - rise at early stages of development (i.e., industrialization), reach a peak and then decline at later stages (i.e., deindustrialization). Rodrik (2016) observes that many recent developers experience a substantially lower value of the peak and attain the peak at lower level of development compared to earlier developers. He considers this phenomenon as puzzling and problematic for development process in low-income countries. A recent paper by Huneeus and Rogerson (2020) also reports a large degree of heterogeneity in the peaks of manufacturing evolution across countries and refers to this phenomenon as heterogeneous paths of industrialization.

In this paper, I further investigate different important aspects of heterogeneous patterns in structural change process across countries. From the GDDC 10-Sector Database and the Penn World Table (PWT) 10.0, I construct panel dataset which consists of 22 countries experiencing hump-shaped manufacturing patterns in the sample and spans the period from 1950 to 2010 for most countries. I document these following stylized facts. First, economies with low manufacturing peak do not exhibit significant decline in the size of manufacturing sector as the term "premature deindustrialization" suggests. Instead, those low-manufacturing-peak economies experience a flat profile of manufacturing share with little changes over the course of development. This pattern of flat manufacturing profiles is different from the standard pattern of steep evolution with significant rise followed by sharp fall in manufacturing share documented in the US and many other advanced economies. Second, there also exists much heterogeneity in the types of services expanded between advanced economies and flat manufacturing ones. While advanced economies tend to develop high-skilled services,

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

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

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

In the benchmark model, sectoral productivities are the major driving forces of structural transformation patterns. Sectoral productivity profiles are driven by sectoral productivity growth rates (dynamic factors) and initial sectoral productivity levels (static factors). Using the calibrated model to the US economy, I perform counterfactuals assuming sectoral productivity growth rates of the US but changing initial relative productivity levels. By lowering initial relative productivity level of low-skilled services relative to manufacturing,

the counterfactuals generate structural change patterns very close to the patterns in most of the flat manufacturing economies. The counterfactual result suggests that variation in initial relative productivity levels quantitatively generates cross-country differences in structural change paths. Initial sectoral productivity levels reflect country-specific components that are persistent over the course of development.

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

The paper eventually employs the model to study aggregate implications of heterogeneous paths of structural transformation. During the period from 1965 to 2010, most steep manufacturing economies experience substantial catch-up episodes in aggregate labor productivity relative to the US, whereas flat manufacturing economies experience stagnation and slowdown. To study the aggregate implications of sectoral productivity, I perform four sets of counterfactual exercises by setting productivity growth rate to the US rate for each sector among agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactual exercises report that productivity growth in agriculture and high-skilled services sectors has little impact on aggregate productivity. The catch-up experiences in steep manufacturing economies are mostly associated with the catch-up in manufacturing productivity. On the other hand, stagnation experiences in flat manufacturing are mainly attributed

to the low productivity growth and dominant size of low-skilled services sector.

This paper is related to literature studying structural transformation.[2] In particular, the paper is directly linked to the recent literature studying heterogeneous patterns in industrialization experience. Rodrik (2016) attributes the premature deindustrialization to the rise of globalization. Sposi et al. (2020) emphasize the role of open economy factors and find that variation in trade costs can largely account for cross-country deindustrialization patterns. In a closed economy context, Huneeus and Rogerson (2020) provide a finding that variation in sectoral productivity growth, particularly in agriculture, can quantitatively explain the observed variation in the peak of manufacturing hump-shape patterns across countries. This paper is different from Rodrik (2016) and Huneeus and Rogerson (2020) in three major aspects. First, this paper shows that the manufacturing peak and the timing of the peak do not fully characterize heterogeneity in structural change patterns. Two other important features of heterogeneity are the steepness of the manufacturing hump-shaped patterns and the allocation of labor into low-skilled services. Second, the analysis shows that variation in initial relative sectoral productivity levels accounts for majority of variation in observed structural change patterns. Beyond the formal analysis, evidence on informality suggests that differences in cross-country sectoral productivity levels could potentially result from country-specific institutions and distortions. Third, different from previous papers, this paper takes a further step in investigating aggregate implications of the phenomenon and finds that heterogeneity in structural change patterns is critical to understand variation in cross-country aggregate outcomes.

My work is also related to literature studying skill-biased structural change. Recent papers by Buera et al. (2021) and Ngai and Sevinc (2020) document skill-biased structural transformation patterns as the reallocation process from low skill intensive sectors to high

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

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

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

The paper is organized as follows. Section 2 describes the data and the data sources. In the section 3, I document a set of stylized facts on heterogeneous patterns in structural transformation across economies. Section 4 sets up a four-sector model of structural transformation and calibrates to the US 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 patterns. In section 6, I document patterns in aggregate productivity growth and use the model to investigate the implications of sectoral productivity across economies. Section 7 provides suggestive evidence and discussion on potential sources of explanations. Section 8 concludes

the paper.

2 Data Description

The main set of countries and periods in this analysis is from GGDC 10-Sector Database (Timmer et al., 2015). Among the 41 countries in the sample, this paper focuses on the group of 22 countries that exhibit hump-shaped patterns in manufacturing employment share. I exclude 8 countries that only experience rise in manufacturing throughout the sample periods (industrialization) and 5 other countries that mostly experience decline in manufacturing throughout the sample periods (deindustrialization). The remaining 6 economies are excluded due to data issues.

I aggregate the ten sectors into four using the following method. Agriculture is kept the same. 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. Detailed descriptions of the disaggregation will be presented in section 3. For each economy, I compute the employment shares for the four sectors and denote as L_a, L_m, L_{ls}, L_{hs} for agriculture, manufacturing, low-skilled services and high-skilled services respectively. To analyze the trend of the series, I smooth sectoral employment shares by standard practice using HP filter with $\lambda = 6.25$. The data are merged with data from Penn World Table (PWT) 10.0 (Feenstra et al., 2015) to study aggregate implications of structural change patterns in section 6. PPP-adjusted measure of real aggregate output and employment data are used to calculate real aggregate labor productivity.

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

Analysis (BEA) data for 1929-1950 period and 10-sector Database for 1950-2010 period.

Other than GGDC 10-Sector Database and Penn World Table 10.0, I also employ three other datasets to document stylized facts in section 3 and to provide suggestive evidence and discussion in section 7. I use labor hours and compensation by sectors and skills data from KLEMS Database 2007 (Timmer et al., 2007) for the classification of services sectors into high-skilled and low-skilled services. The dataset consists of 26 European economies together with the US and Japan during the period 1970-2004. To document structural transformation patterns across recent (post-1990s) emerging economies, I employ the GDDC/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 the similar manner. In section 7, I use employment by status in employment and economic activity data 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 (as a proxy for informality) by economic sector, country and year.

3 Heterogeneous Paths of Structural Transformation

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

aggregate growth.

Figure 1: Heterogeneous Patterns of Structural Transformation

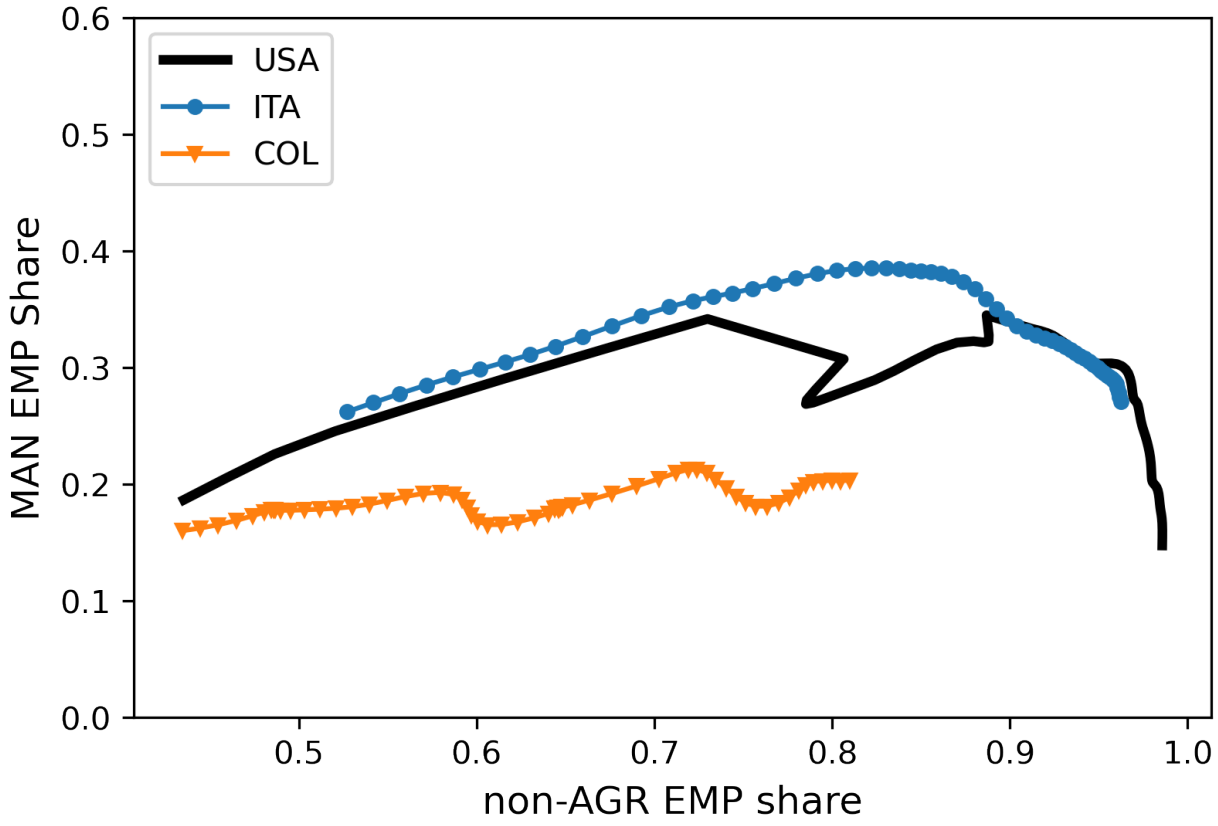


Figure 1 plots manufacturing employment share against nonagricultural employment share[3] of three economies: the US, Italy and Colombia. The US and Italy are examples for high manufacturing peak (more than 35%) with steep rise and decline in manufacturing. In contrast, Colombia illustrates the pattern of low-peak (around 20%) and flat hump-shaped profile in manufacturing labor share. Next subsections will present further cross-country evidence on this heterogeneity. To highlight the difference in the patterns of manufacturing evolution, I will classify countries into two groups of patterns: steep manufacturing group characterized with high peak and steep profile of manufacturing (similar to the US and Italy) and flat manufacturing group characterized with low peak and flat profile of manufacturing

[3]Following Huneeus and Rogerson (2020), this representation of data is very similar to the standard representation of sectoral employment share over GDP per capita while having an advantage of visualizing the labor reallocation process from agriculture towards manufacturing and services.

(similar to Colombia).

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

To disaggregate services sector, I employ the standard method of classification of services into high-skilled and low-skilled services. Following the method 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[4] is lower than the median of the broad services sector. From data on labor hours by skills, I compute hour share of high-skilled labor for each economic sector across 28 countries over 34 years included in KLEMS Database. Economic sectors in 10-sector Database and KLEMS 2007 are defined based on the International Standard Industrial Classification, Revision 3.1 (ISIC Rev.3.1). The disaggregation results are impressively consistent across economies and over time (see Figure A.1). Classification using labor compensation by skills instead of hours also yields similar results (see Figure A.2). The final classification is determined based on the majority of countries in the sample:

- Low-skilled services: Trade Services (Wholesale and Retail Trade (G), Hotels and Restaurants (H)), Transport Services (Transport, Storage and Communications (I)), Personal Services (Other Community, Social and Personal Service Activities, Activities of Private Households (O,P))

- High-skilled services: Business Services (Financial Intermediation, Renting and Busi-

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

ness Activities (excluding owner occupied rents) (J,K)), Government Services (Public Administration and Defense, Education, Health and Social work (L,M,N))

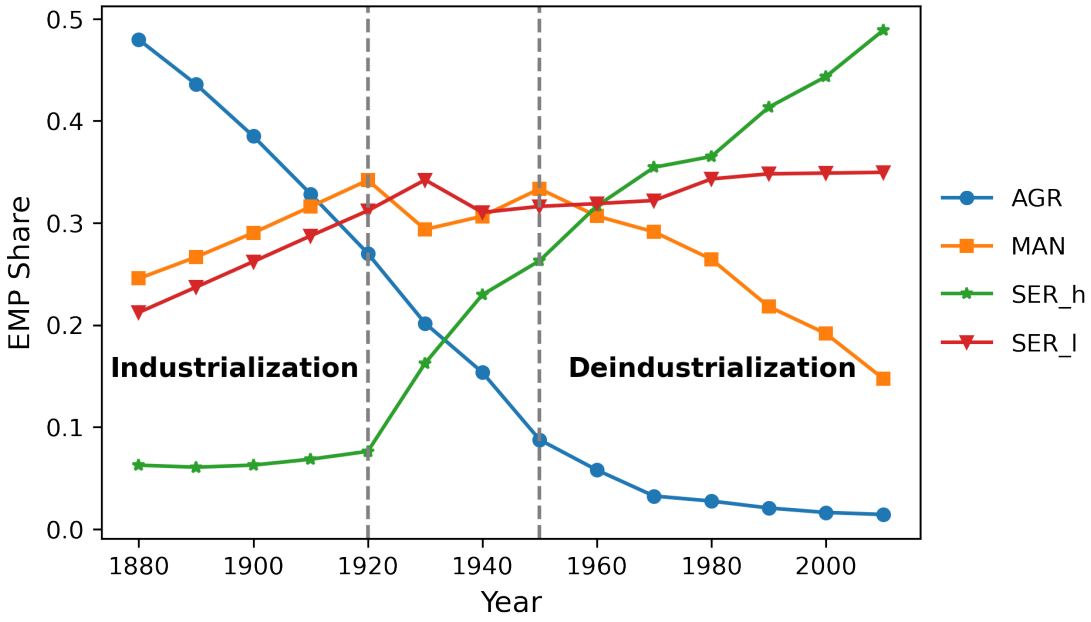
This classification is similar to Fang and Herrendorf (2021)'s classification reported for China. Based on this four-sector classification, I will present the structural transformation patterns across countries. Subsection 3.1 first exhibits the patterns in the US as a benchmark and other economies in steep manufacturing group. Subsection 3.2 documents the patterns in flat manufacturing economies. Subsection 3.3 provides further evidence on the heterogeneity in the structural change patterns across recent (post-1990s) emerging economies.

3.1 Patterns in Steep Manufacturing Economies

Patterns in the US

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

Figure 2: US Sectoral Employment Shares 1880-2010



- Industrialization Phase (1880-1920): Labor out of agriculture is mostly reallocated towards manufacturing and low-skilled services. High-skilled services sector accounts for a minor share.

- Great Depression and World War II period (1920-1950): Manufacturing starts reaching the peak and high-skilled services employment share starts rising.

- Deindustrialization Phase (1950-2010): Agricultural employment share becomes very small. Labor out of manufacturing is mostly reallocated towards high-skilled services. Employment share in low-skilled services does not vary significantly. High-skilled services sector eventually takes over the economy.

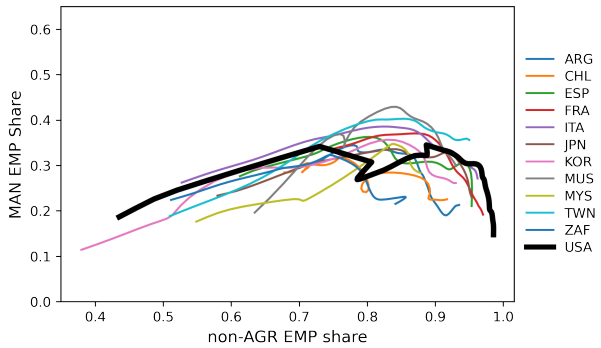
Common Patterns across Steep Manufacturing Economies

The structural change patterns are quite similar in other developed economies such as United Kingdom, Canada, Italy and Japan (see Figure B.1). These developed economies

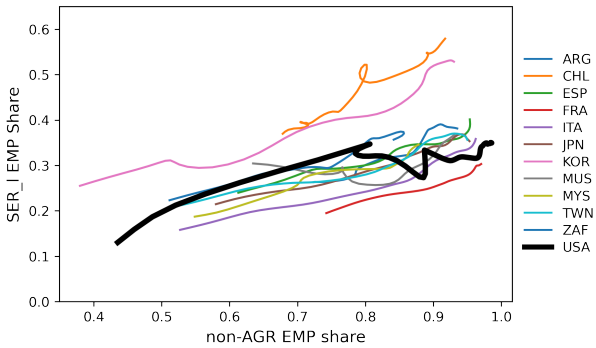
experience qualitatively similar patterns to the US in industrialization and deindustrialization phases. Figure 3 documents the structural change patterns in steep manufacturing economies. The patterns are characterized with steep rise and fall in evolution of manufacturing employment share over the course of development. Low-skilled services rise along with manufacturing at earlier stage when high-skilled services mostly develop and dominate the economy at later stage. The structural change patterns differ significantly before and after the peak of manufacturing.

Figure 3: Steep Manufacturing Economies

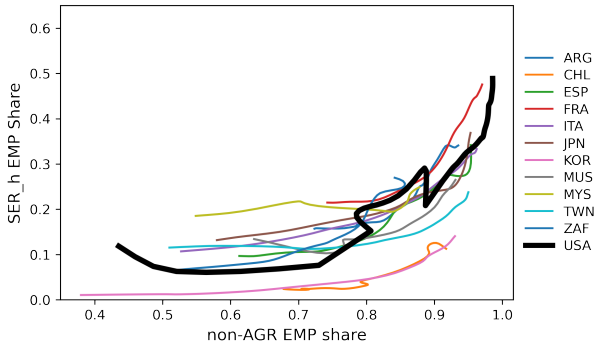
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



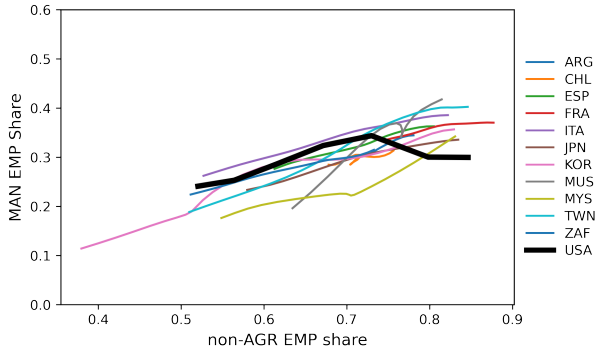
To better visualize the structural change patterns, I separate the sample period of all steep manufacturing economies into two phases: industrialization (before the manufacturing peak) and deindustrialization (after the manufacturing peak). Manufacturing, low-skilled services and high-skilled services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

skilled services during industrialization and deindustrialization phases respectively. These figures exhibit stark differences in the patterns of structural change between industrialization and deindustrialization phases.

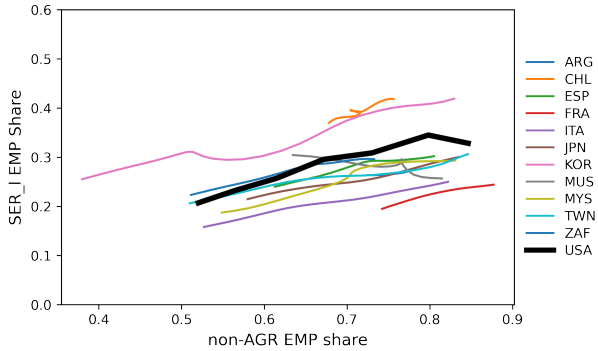
The industrialization phase is characterized with the reallocation of labor out of agriculture to manufacturing and low-skilled services. The sizes of manufacturing and low-skilled services sectors are comparable on average in this phase. High-skilled services sector, on the other hand, is smaller on average and exhibits larger variation across economies.

Figure 4: Industrialization Phase - Steep Manufacturing Economies

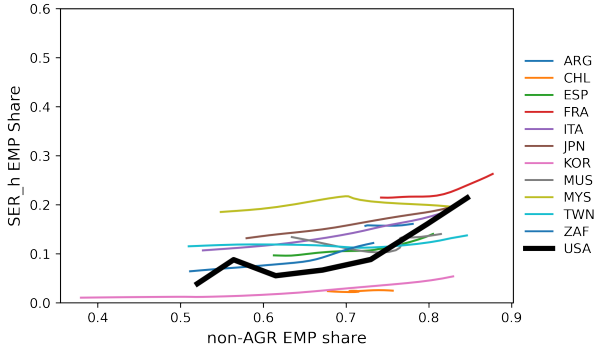
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

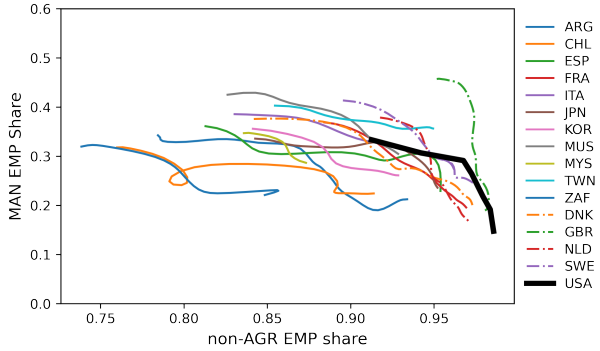


During deindustrialization phase, labor share in agriculture becomes minor. As discussed above, significantly different from industrialization phase, the deindustrialization phase is marked with sharp decline in manufacturing sector. Labor is reallocated towards high-skilled services, making this sector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

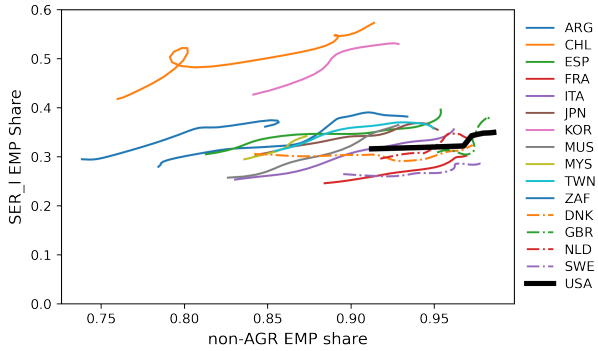
Low-skilled services employment share experiences less changes during this phase.

Figure 5: Deindustrialization Phase - Steep Manufacturing Economies

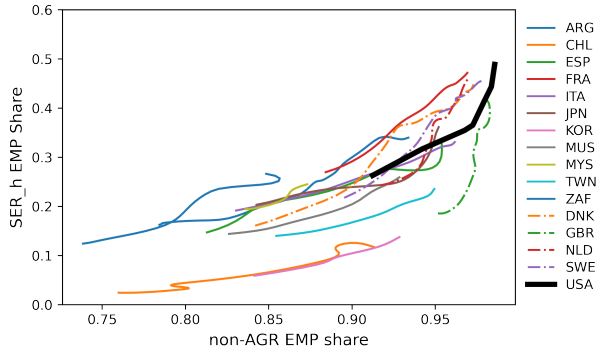
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



3.2 Patterns in Flat Manufacturing Economies

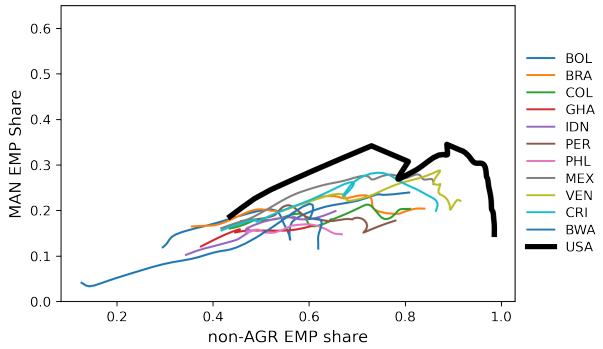
Flat manufacturing economies, on the other hand, do not observe significant deviation in structural change patterns before and after the peak of manufacturing. I find that the evolution in the shares of low-skilled and high-skilled services exhibits similar trends before and after the peak of manufacturing.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

little and low-skilled services sector substantially expands.

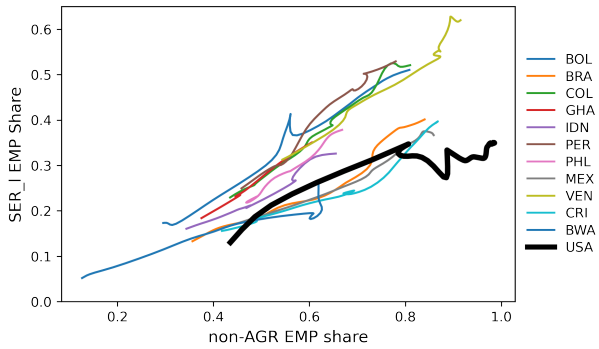
Figure 6 presents structural change patterns across flat manufacturing economies. Manufacturing, low-skilled services and high-skilled services employment shares are plotted against non-agricultural employment share. We can observe that the paths of manufacturing share are relatively flat and lower in flat manufacturing economies compared to the US. The low-skilled services sector is considerably larger and expands at steeper rate compared to the US. High-skilled services sector remains insignificant throughout the sample period for most economies in the group.

Figure 6: Structural Transformation Patterns - Flat Manufacturing Economies

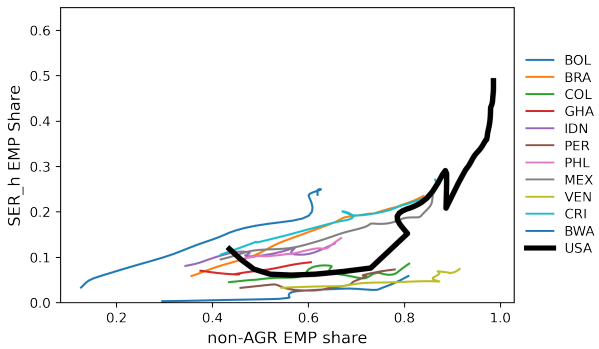
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



3.3 Heterogeneous Patterns Across Recent Developing Economies

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

This paper overcomes these two limitations with the use of data from a broad set of recent emerging economies and focusing on the evolution of labor allocation into manufacturing and services. Using data from GDDC/UNU-WIDER Economic Transformation Database (ETD) (de Vries et al., 2021), I document industrialization patterns across recent developing economies. The database covers broader sets of recent developing economies during the period 1990-2018. Among 51 countries in the sample, there are 29 countries that have observed significant industrialization (at least 10 years) during the sample period. Even though the industry classification of ETD is based on ISIC Rev.4 Code, twelve economic sectors are aggregated into agriculture, manufacturing, low-skilled services and high-skilled services using a similar method.[5] 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).

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

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

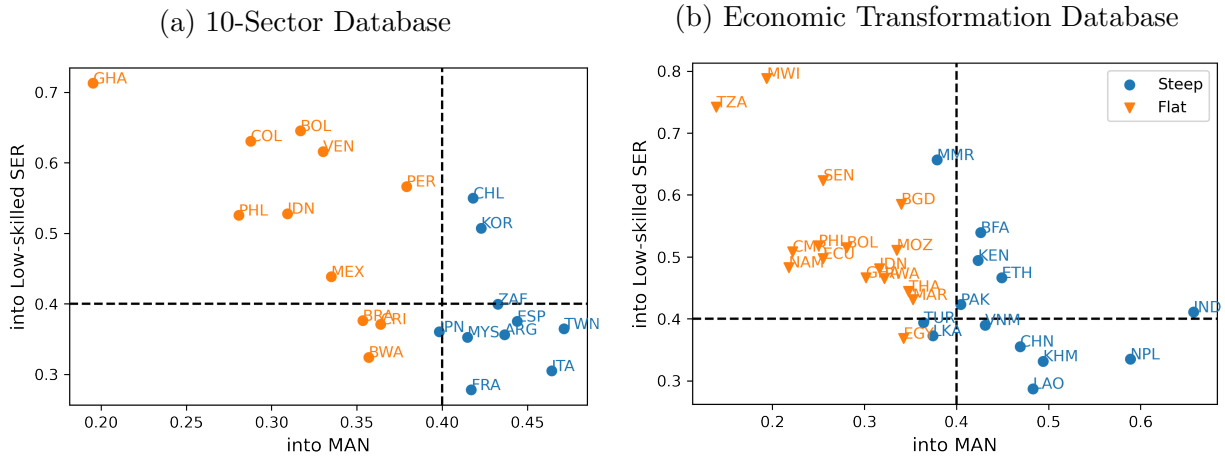


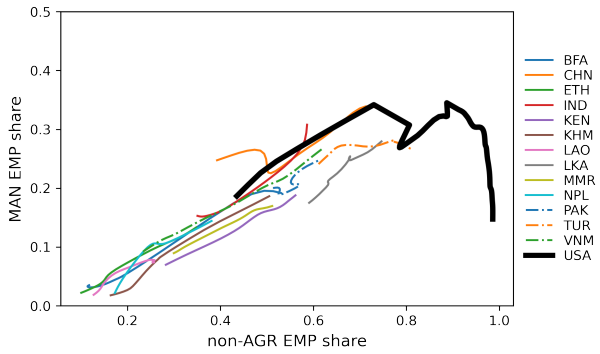
Figure 7 shows cross-country pattern of labor reallocation out of agriculture into manufacturing and low-skilled services. The black dash line presents the labor allocation into manufacturing and low-skilled services in the US during industrialization: Out of 10% labor share leaving agriculture, around 4% labor share is reallocated towards manufacturing and low-skilled services. Figure 7a and 7b plot the labor reallocation into manufacturing and low-skilled services of economies in 10-Sector Database (earlier developers during 1950-2010) and Economic Transformation Database (later developers during 1990-2018) respectively. There are two major similar structural transformation patterns between the two samples. First, similar to the stylized facts documented for economies in 10-Sector Database, industrialization experience in recent emerging economies after 1990 in ETD is also characterized with reallocation of labor mostly towards manufacturing and low-skilled services. Economies that allocate less labor into manufacturing (flat manufacturing) tend to allocate more labor into low-skilled services and vice versa. Second, different from Rodrik (2016)'s finding that post-1990 economies tend to attain lower manufacturing peak or follow flat manufacturing pattern, figure 7b shows that 13 recent developers out of 29 allocate similar or even more labor into manufacturing compared to the US during industrialization phase. Moreover, both steep and flat manufacturing patterns occur in all of the three regions: Africa, Asia

and Latin America. This evidence suggests that heterogeneous structural transformation patterns of steep and flat manufacturing are prevalent across economies and not subject to a specific time period or a geographical region.

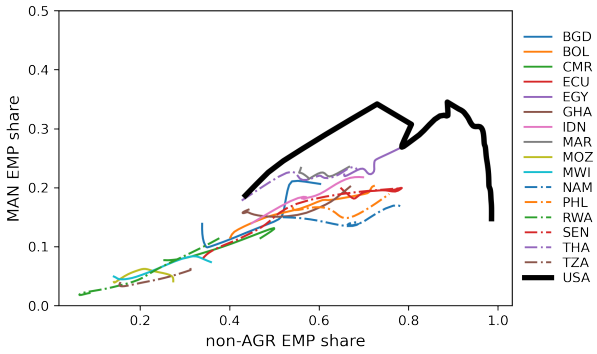
Figure 8 further illustrates the structural transformation patterns of recent steep manufacturing economies along with the ones that exhibit flat manufacturing pattern. In figure 8a and 8b, while many recent emerging economies follow similar patterns to the US with steep evolution of manufacturing, many others follow flat manufacturing patterns with less labor reallocation towards manufacturing. Figure 8c and 8d show that compared to the US and other recent steep manufacturing economies, recent flat manufacturing economies also tend to allocate substantially more labor towards low-skilled services.

Figure 8: Structural Transformation Patterns in Recent Developing Economies

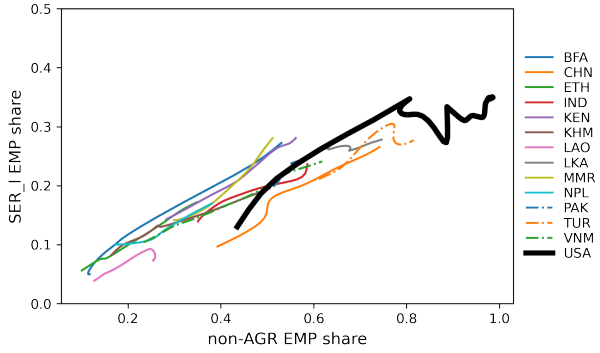
(a) Steep Manufacturing - Manufacturing



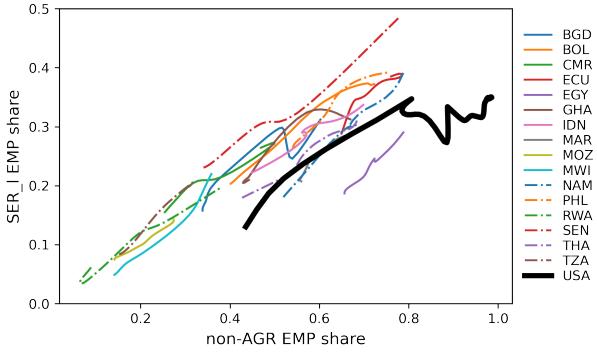
(b) Flat Manufacturing - Manufacturing



(c) Steep Manufacturing - Low-skilled Services



(d) Flat Manufacturing - Low-skilled Services



4 Model

4.1 Model Description

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

Production. Technology

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

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

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

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

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

The literature emphasizes on two forces behind structural change between manufacturing and services: income effect and substitution effect. However, similar to Huneeus and Rogerson (2020), I also find limited role of income effect in allocating labor between manu-

facturing and services sectors during early to middle stage of development across economies. The assumption of homothetic CES preference across manufacturing and services serves to generate tractability and transparency.

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

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

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

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

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

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

3. Goods markets clear

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

4. Labor market clears

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

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

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

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

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

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

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

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

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

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

Substituting conditions (7) and (8) yields

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

4.2 Productivity Dynamics

To maximize transparency, I focus on the case assuming constant technological progress in each of the four sectors

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

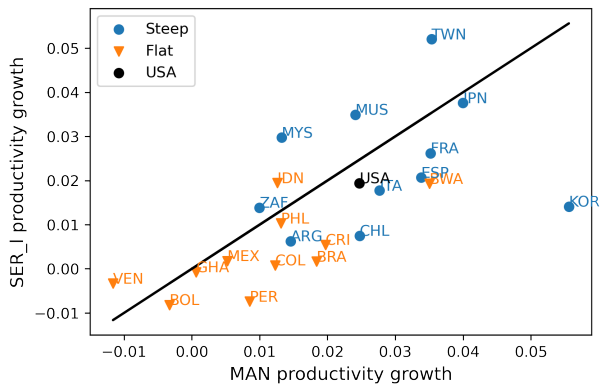
The structural transformation patterns are driven by relative sectoral productivity growth

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

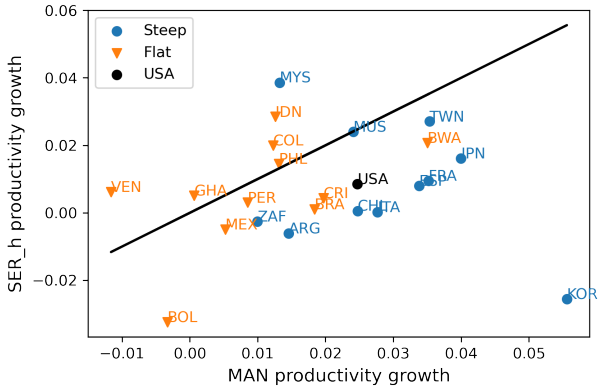
Figure 9 reports the annualized growth rates of labor productivity in low-skilled services and high-skilled services against manufacturing sectors along with a 45-degree black line. Empirical evidence generally indicates that manufacturing has higher productivity growth than both high- and low-skilled services in most of the sample countries. Compared to high-skilled services, productivity growth rates in both manufacturing and low-skilled services are subject to larger variation across countries. Steep manufacturing economies tend to observe higher productivity growth rates in both manufacturing and low-skilled services than flat manufacturing economies. High-skilled services productivity growth rates, on the other hand, are quite similar across economies.

Figure 9: Sectoral Labor Productivity Growth Rates

(a) Manufacturing vs. Low-skilled Services



(b) Manufacturing vs. High-skilled Services



4.3 Benchmark Calibration to the US

In this section, I present calibration strategy to capture evolution of sectoral employment shares in the US during industrialization phase 1880-1950. Due to the lack of data on US

sectoral productivity for the period 1880-1950, I follow Huneeus and Rogerson (2020) to assume agricultural productivity growth (g_a) to be 2.39% to match the observed trend in agricultural employment share. Other sectoral growth rates (g_m, g_{ls}, g_{hs}) during 1880-1950 are assumed to be the growth rates between 1950 and 1970.

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

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

Table 1: Benchmark Calibration

Figure 10: USA Sectoral Employment Shares: Model vs. Data

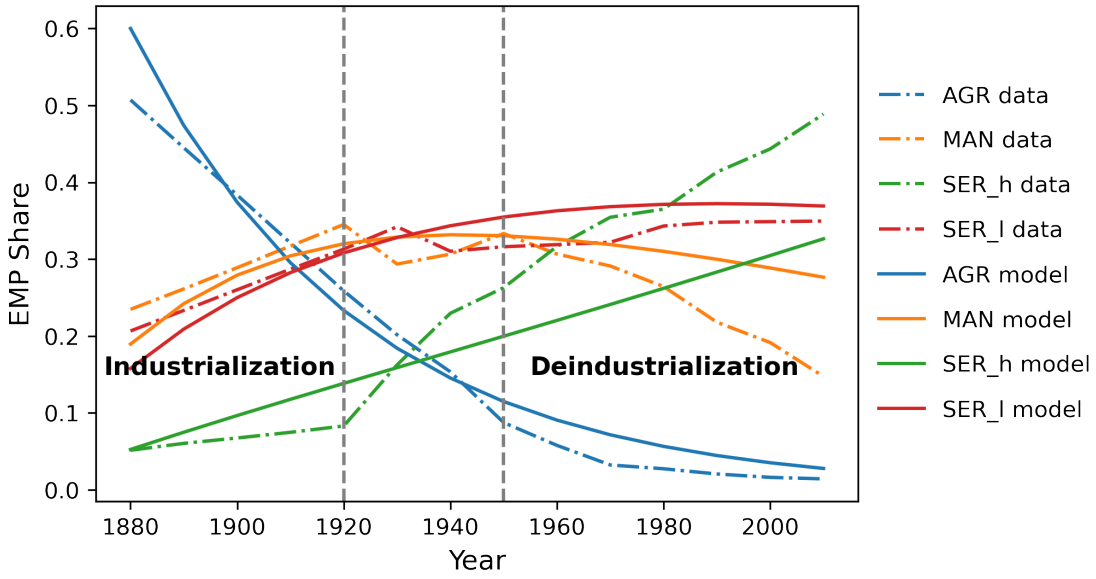


Figure 10 shows the fit of the calibrated model to the US data. The model can generate the hump shape of manufacturing with the peak close to observed data. The model generates employment shares very close to data during industrialization phase. However, the model doesn't generate very close fit to the employment shares for manufacturing and high-skilled services during deindustrialization phase. The reasons are potentially the simplification assumptions of constant sectoral labor productivity growth and no income effect for labor allocations between manufacturing and services sectors in the model. During late stage of development, sectoral productivity growth rates could greatly differ from previous stages and income effect becomes more important in leading to the decline of manufacturing and the expansion of high-skilled services. As this paper focuses more on early and middle stages of development across economies, abstraction from changes in growth and income effect does not significantly affect the results presented in the next sections while having an advantage of yielding better transparency to the analysis.

4.4 Explanatory Factors for Structural Change Patterns

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

This paper introduces and investigates initial sectoral productivity levels as another channel in shaping the observed patterns in section 3. The model suggests that two economies with similar sectoral productivity growth rates can still experience different relative productivity profiles if the initial relative productivity levels in nonagricultural sectors are different.

Consider a simple illustration of the US as a benchmark economy and an economy c. Assume both countries have same productivity growth rates in all sectors $g_i^c = g_i^{US} = g_i \quad \forall i \in \{a, m, ls, hs\}$ and initial agricultural productivity level $A_{a0}^c = A_{a0}^{US}$. The only difference between the two economies is in initial relative sectoral productivity levels among nonagricultural sectors $\frac{A_{i0}^c}{A_{m0}^c} \neq \frac{A_{i0}^{US}}{A_{m0}^{US}} \quad \forall i \in \{ls, hs\}$. As sectoral productivity grows at the same rate in both countries, relative productivity levels among nonagricultural sectors are different between country c and the US at any period t $\frac{A_{it}^c}{A_{mt}^c} \neq \frac{A_{it}^{US}}{A_{mt}^{US}} \quad \forall i \in \{ls, hs\}$ and the differences remain the same as the initial differences

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

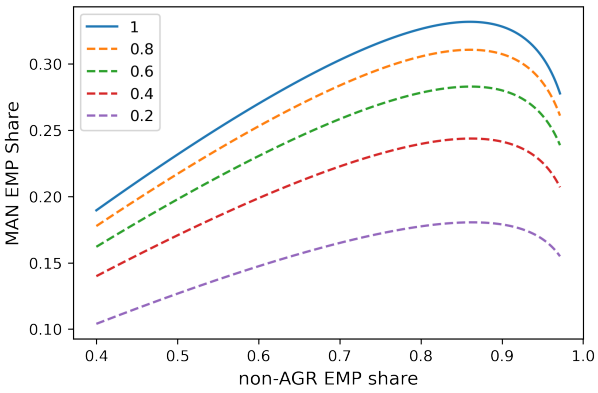
The difference in initial relative productivity levels represents a persistent gap in relative sectoral productivity levels between the two economies over the course of development. This gap can be resulted from country-specific static factors such as past growth rates, institutions, distortions, human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

To illustrate quantitative impact of initial relative productivity channel, I consider four economies similar to the US in sectoral labor productivity growth but with lower values of initial relative labor productivity of low-skilled services to manufacturing. Figure 11 presents the evolution of sectoral employment shares in these four counterfactual economies where initial relative labor productivity levels of low-skilled services to manufacturing are set to be $0.8, 0.6, 0.4$ and 0.2 of the benchmark economy (the US). Blue connected lines present the structural transformation pattern of the US, whereas the dashed lines exhibit the patterns in

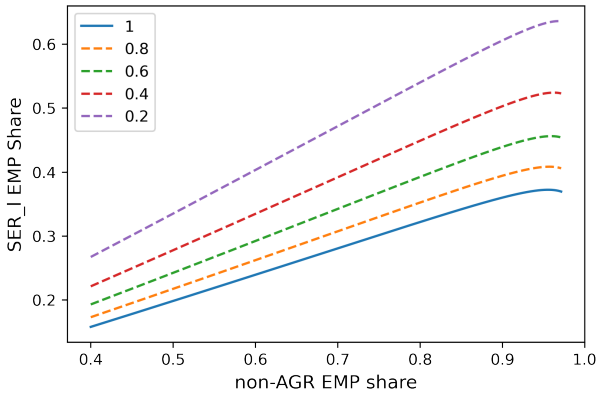
the four counterfactual economies. This departure where initial relative productivity levels are the only source of variation generates similar patterns to flat manufacturing economies: lower manufacturing peaks and flatter manufacturing hump shapes. Low-skilled services employment share also rises at steeper rate. The counterfactuals suggest that static factors leading to lower initial productivity of low-skilled services relative to manufacturing can qualitatively characterize the deviations in structural change patterns of flat manufacturing from the US.

Figure 11: Static Factors and Structural Change Patterns

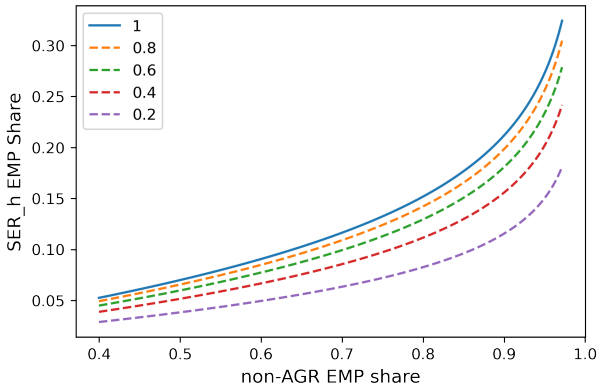
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



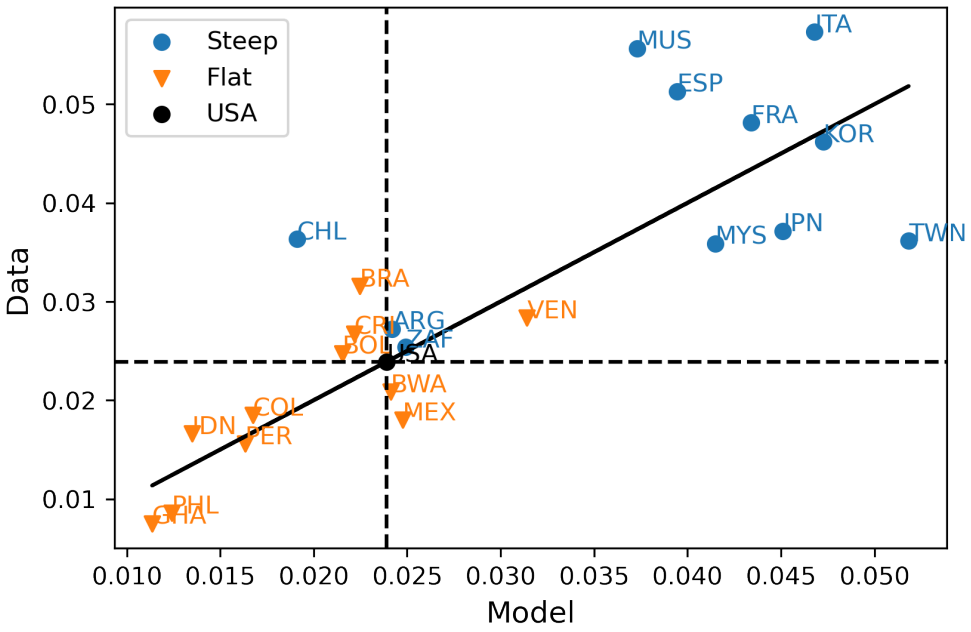
5 Cross-country Analysis

5.1 Cross-country Calibration

5.1.1 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 12 plots the agricultural labor productivity growth rates from the data and those inferred from the model. The growth rates inferred by the model track the data quite well for most of economies. The result suggests a good fit of model for explaining the evolution of labor share in agricultural sector.

Figure 12: Agricultural Productivity Growth: Model vs. Data



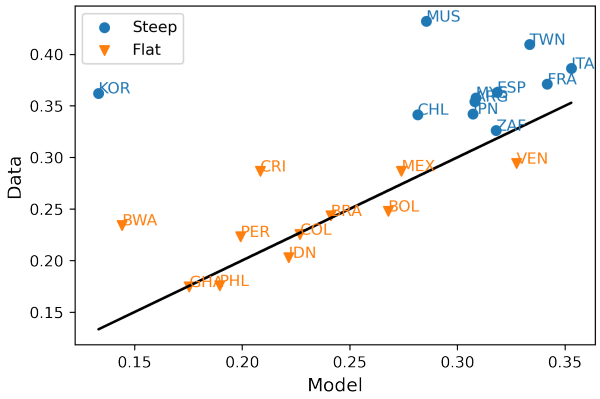
5.1.2 Manufacturing and Services Sectors Calibration

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

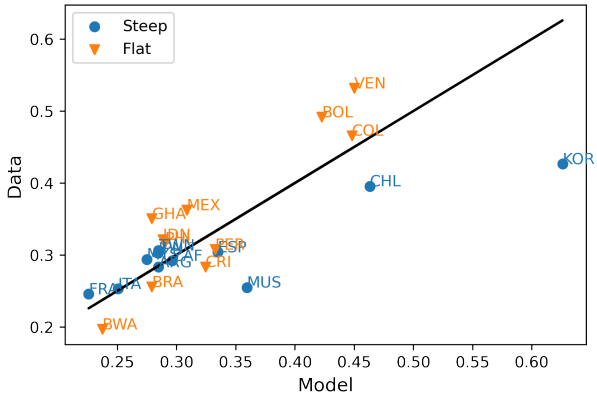
Figure 13 reports the shares of employment for each sector in the peak year of manufacturing labor share in the model and in the data. Figure 14 plots the shares of employment in each sector in the last sample period in the model and in the data. The model can generate quite good fit in sectoral employment shares in the peak year as well as in the last year. The overall fit of the structural change paths is quite impressive for a simple model.

Figure 13: EMP share at Peak MAN year: Model vs. Data

(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services

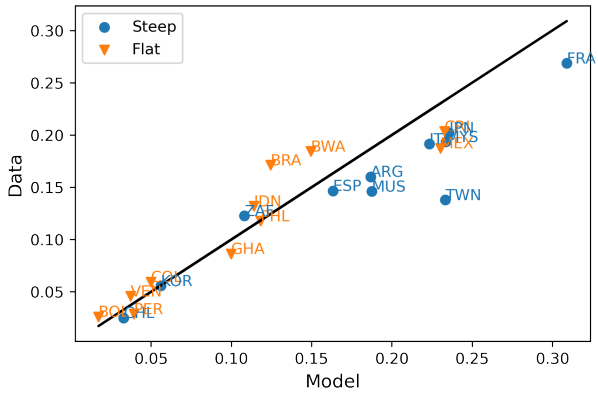
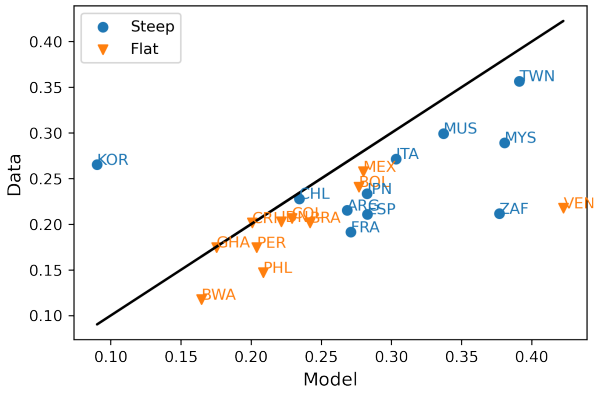
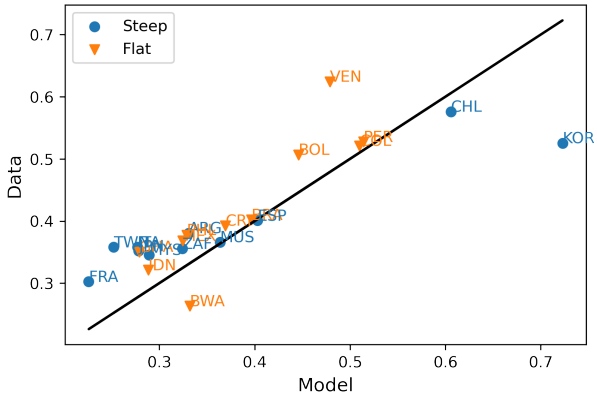


Figure 14: Last year EMP share: Model vs. Data

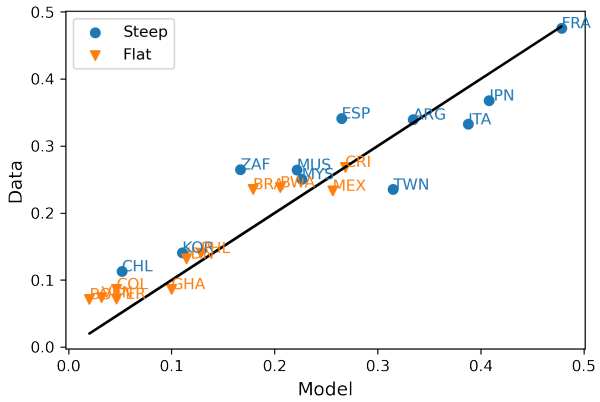
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



5.2 Counterfactual Analysis

This section will focus on counterfactual analysis to decompose the quantitative importance of initial sectoral productivity levels (static factors) and sectoral productivity growth rates (dynamic factors) in generating the heterogeneous patterns. As discussed in section 4, static and dynamic factors are the two forces driving heterogeneous sectoral productivity profiles across economies. The counterfactuals are conducted by setting the growth rates of labor productivity in all sectors to the rates of the US, leaving the initial sectoral productivity levels the same as calibrated values. These counterfactuals illustrate the importance of initial sectoral productivity levels for cross-country patterns in sectoral labor allocation.

The counterfactual results indicate that differences in initial sectoral productivity levels are found to be the main drivers of heterogeneity in structural change patterns between steep and flat manufacturing economies.

5.3 Illustrating Example of Colombia

This section presents the counterfactual exercise through an illustration of Colombia (COL). Figure 15 exhibits the evolution of manufacturing, low-skilled services and high-skilled services employment shares over non-agricultural employment share in the counterfactuals with Colombia data.

Figure 15a plots the US modeled sectoral employment shares (which is close to the shares in the US data presented earlier in Figure 10) and Colombia's shares in the data. Manufacturing employment share in the US experience a steep hump shape with significantly higher values than Colombia during industrialization phase. Low-skilled services employment share is substantially higher in Colombia compared to the US over the whole sample period. The economic structures between the US and Colombia are substantially different. At 80% non-agricultural employment share, while the US has approximately 32% labor share in manufacturing and 32% labor share in low-skilled services, Colombia economy comprises of approximately 20% labor share in manufacturing and 50% labor share in low-skilled services.

Figure 15b exhibits sectoral employment shares in Colombia data and the first counterfactual using Colombia's initial sectoral labor productivity and the US's productivity growth rates in agriculture, manufacturing, low-skilled services and high-skilled services. The counterfactual can generate structural change patterns closer to the data with a steeper rise in low-skilled services and a flatter hump shape of manufacturing. This result indicates that initial relative productivity levels have important implications for heterogeneous structural change patterns between Colombia and the US. The remaining gaps in structural change pat-

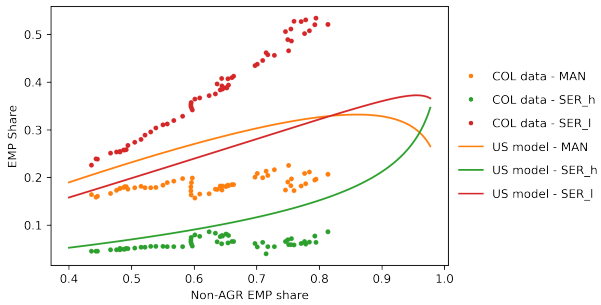
terns between this counterfactual and the data are attributed to dynamic factors (sectoral productivity growth rates).

Figure 15c shows that incorporating both sectoral initial productivity levels and sectoral productivity growth rates of Colombia generates structural change patterns very close to the data. Figure 15d shows sectoral employment shares by the counterfactual using Colombia's initial sectoral labor productivity with the US's agricultural productivity growth and Colombia's productivity growth rates in the other three sectors. The sectoral employment shares by this counterfactual are also close to the data, suggesting limited explanatory power of productivity growth in agriculture.

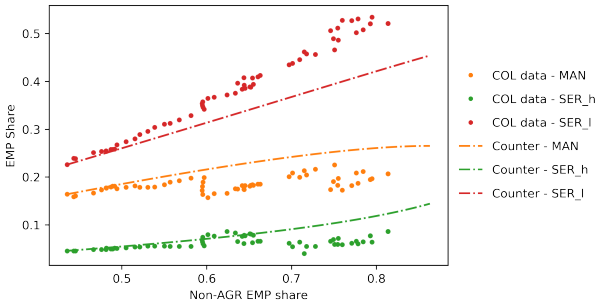
At 80% non-agricultural employment share, initial relative labor productivity contributes around 74% and 52% to the differences in manufacturing and low-skilled services labor shares between the US and Colombia. Sectoral productivity growth rates explain around 26% and 48% respectively to the observed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

Figure 15: Sectoral Employment Shares: Counterfactuals vs. Colombia data

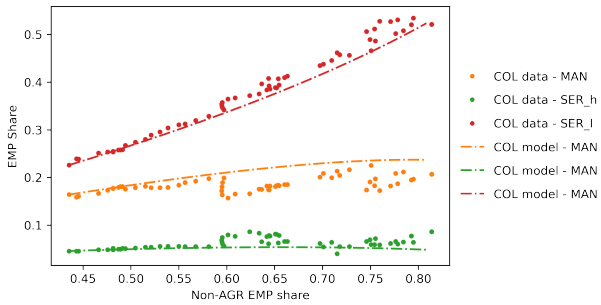
(a) $A_{i0} = A_{i0}^{US}$, $g_i = g_i^{US}$



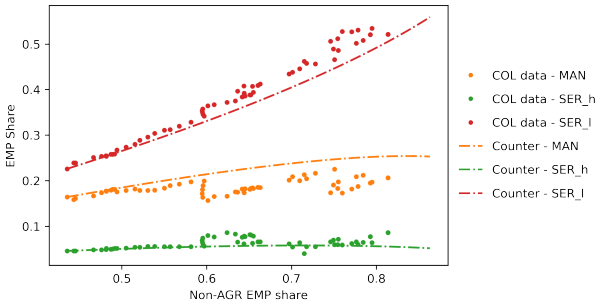
(b) $A_{i0} = A_{i0}^{COL}$, $g_i = g_i^{US}$



(c) $A_{i0} = A_{i0}^{COL}$, $g_i = g_i^{COL}$



(d) $A_{i0} = A_{i0}^{COL}$, $g_a = g_a^{US}$, $g_j = g_j^{COL}$

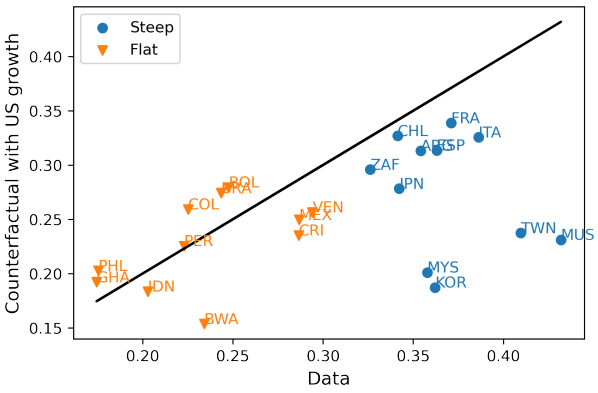


5.4 Role of Initial Relative Productivity Levels and Sectoral Productivity Growth Rates in Structural Change

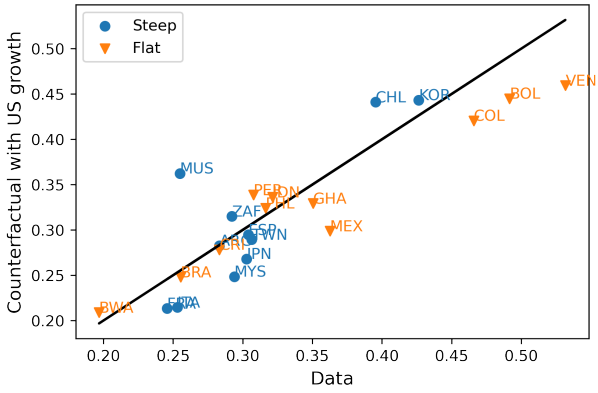
The counterfactual exercise is conducted for other economies in the sample. For each economy, the counterfactual sectoral productivity and employment profiles are generated assuming the economy's initial conditions and the US sectoral productivity growth rates. Figure 13 plots the sectoral employment shares in the peak year of manufacturing share in this counterfactual against the data. The counterfactual generates structural change patterns very close to the data, suggesting that the differences in initial relative productivity levels are quantitatively sufficient in driving observed heterogeneous patterns between steep and flat manufacturing economies.

Figure 16: EMP share at Peak MAN year: Counterfactual with the US growth vs. Data

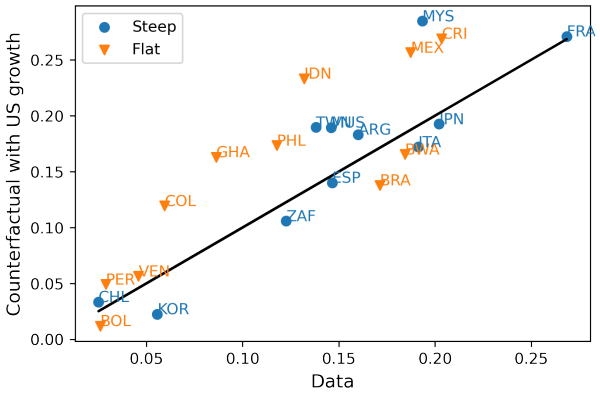
(a) Manufacturing



(b) Low-skilled Services



(c) High-skilled Services



6 Aggregate Implications

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

6.1 Aggregate and Sectoral Productivity Patterns

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

Figure 17 plots real aggregate labor productivity relative to the US in 2010 against values in 1965 as well as a 45-degree line to facilitate comparison. Majority of steep manufacturing countries lie very far above the 45-degree line, indicating episodes of substantial catch-up in aggregate productivity relative to the US. On the contrary, most economies in flat manufacturing group lie very close to or below 45-degree line, suggesting experiences of no catch-up or stagnation relative to the US.

Figure 17: Aggregate Labor Productivity Relative to the US: 1965-2010

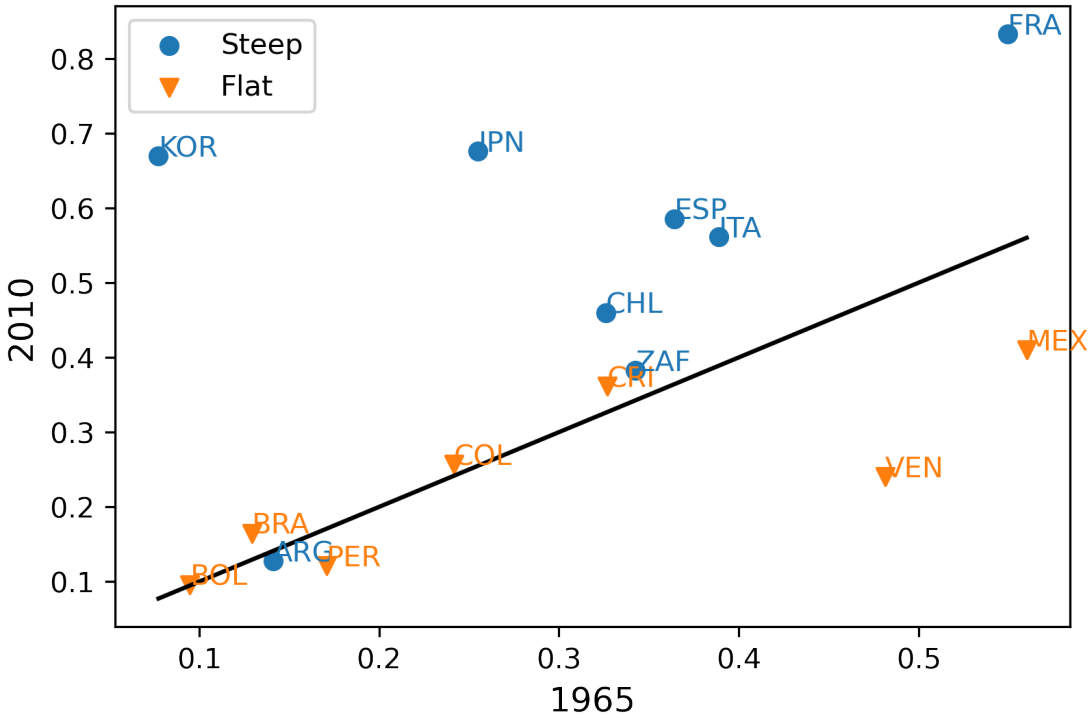
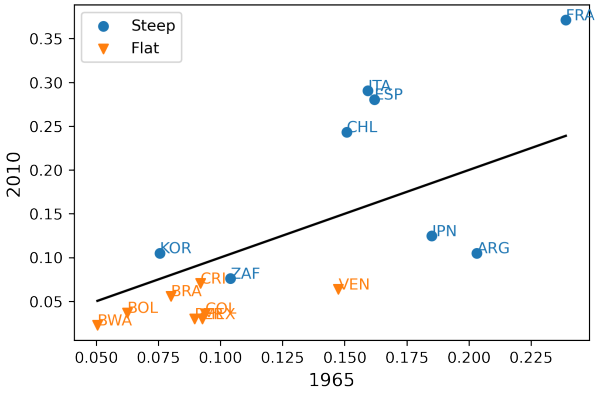


Figure 18 next reports productivity levels in agriculture, manufacturing, low-skilled services and high-skilled services relative to the US for each country in 2010 against 1965 along with a 45-degree line. There has been considerable variation in labor productivity growth experiences across sectors and economies. In Figure 18a, while only four economies experience significant catch-up in agricultural productivity to the US, the majority of countries in the sample have lower agricultural productivity growth relative to the US. Figure 18b shows that while there has been substantial manufacturing productivity catch-up in steep manufacturing group, most flat manufacturing economies experience a decline in manufacturing productivity relative to the US. Figure 18c presents patterns of little catch-up or decline in low-skilled services productivity compared to the US for most countries. While most steep manufacturing economies experience little change in low-skilled services productivity relative to the US, flat manufacturing countries have substantial fall in low-skilled services productivity compared to the US. In Figure 18d, there has been little change in high-skilled

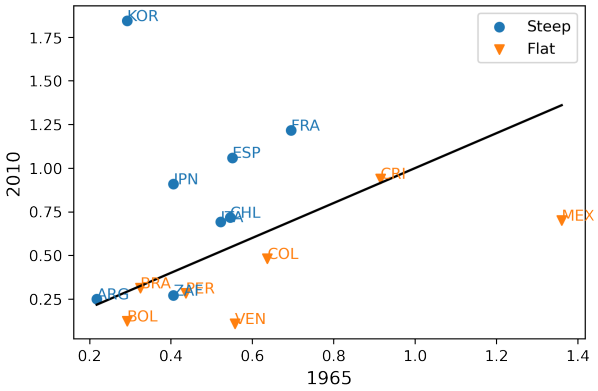
services productivity relative to the US for most economies in the sample.

Figure 18: Sectoral Productivity Relative to the US: 1965-2010

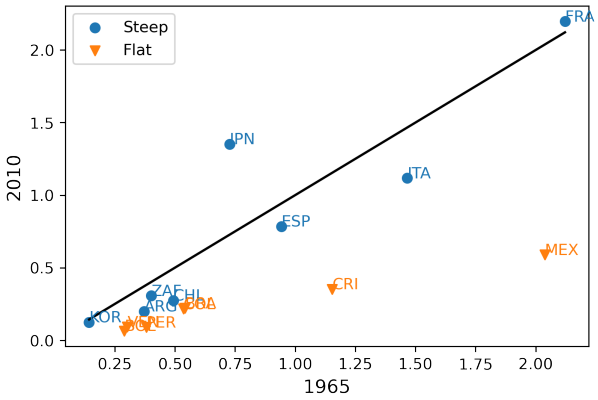
(a) Agriculture



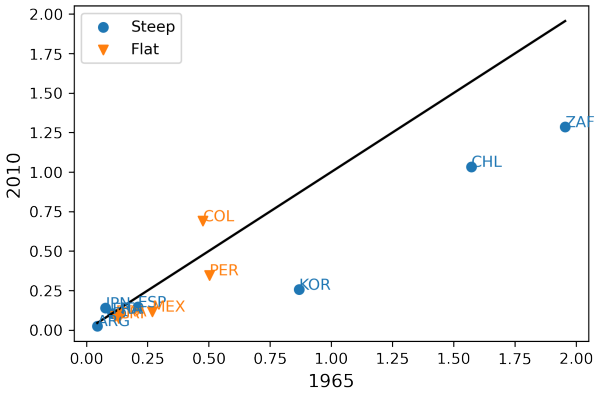
(b) Manufacturing



(c) Low-skilled Services



(d) High-skilled Services



6.2 Role of Sectoral Productivity in Aggregate Productivity

I will turn to the set of counterfactuals where productivity growth rate in one sector is set to the growth rate of the US. These counterfactuals illustrate the quantitative importance of sectoral productivity growth in explaining cross-country growth experiences. Figure 19 reports the counterfactual results for aggregate productivity relative to the US.

For most economies, setting sectoral productivity growth rates in agriculture and high-skilled services to the US growth rates generate very small impacts on relative aggregate

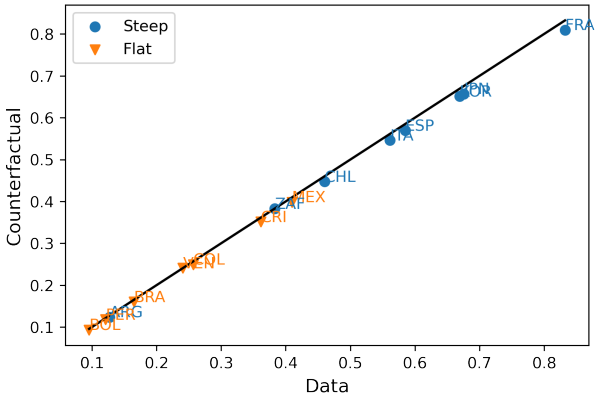
productivity. These two counterfactual results, reported in Figure 19a and 19d, indicate a small role of agriculture and high-skilled services sectors in explaining cross-country growth experiences.

Figure 19b presents results of the counterfactual using the US manufacturing productivity growth rate. The counterfactual generates much lower relative aggregate productivity for most of steep manufacturing economies. For flat manufacturing group, the counterfactual generates very small differences. In Figure 19c, the counterfactual for low-skilled services sector illustrates a significantly large aggregate impact for most flat manufacturing economies. Low-skilled services productivity growth contributes little to the catch-up experiences in most steep manufacturing economies (except Japan).

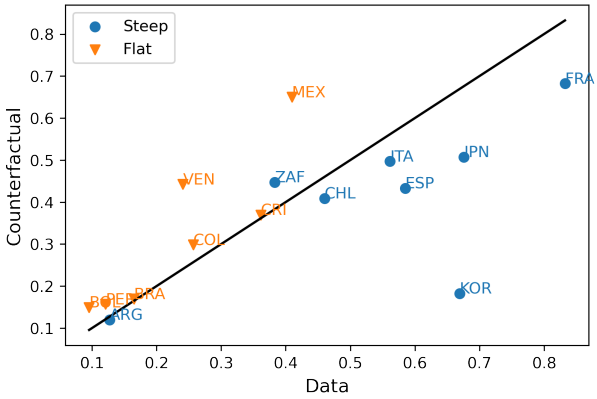
In summary, manufacturing and low-skilled services sectors are the two major sectors greatly contributing to the variation in cross-country growth experiences. Substantial catch-up in manufacturing productivity together with large manufacturing sector mostly accounts for aggregate catch-up experiences in steep manufacturing group of economies. On the other hand, for flat manufacturing, 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 US.

Figure 19: Aggregate Productivity Relative to the US: Counterfactual vs. Data

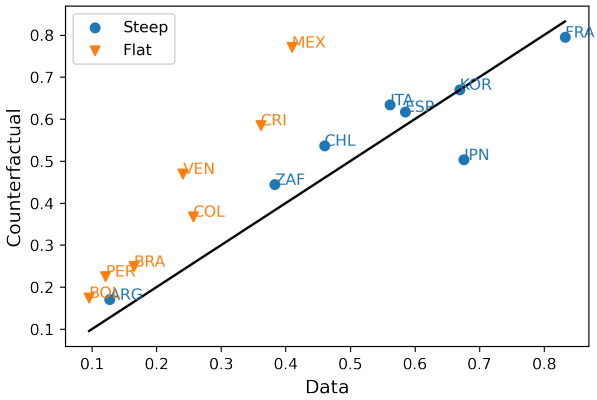
(a) Agriculture: $g_a = g_a^{US}$



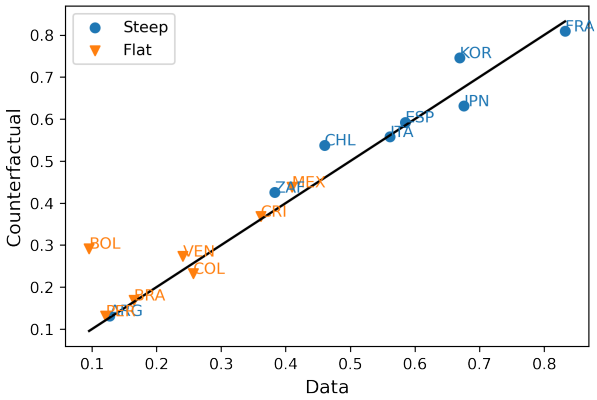
(b) Manufacturing: $g_m = g_m^{US}$



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



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



7 Discussion

This section takes a further step beyond this paper's formal analysis to discuss potential sources leading to cross-country variation in initial relative productivity levels (static factors) between manufacturing and low-skilled services. My findings suggest that informality has a dominant role in low-skilled services sector and especially in economies with flat manufacturing patterns. On the other hand, human capital does not seem to be a determining factor with low correlation with the structural change patterns.

7.1 Informal Economy

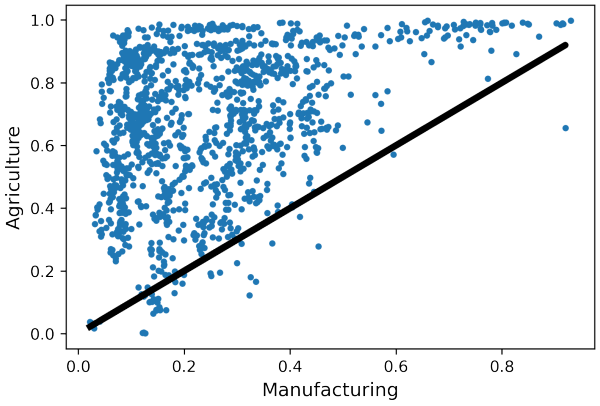
Informal economy has been considered an important aspect of developing economies. Informal sector is associated with small-scaled production, lack of physical and human capital and low productivity. Main driving sources of informality include weak institutions regarding tax, social security, bureaucracy,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

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

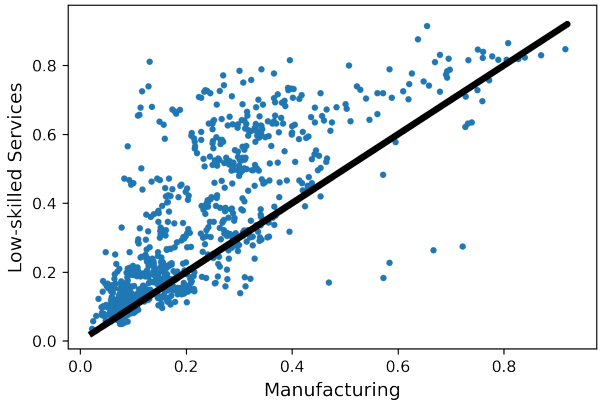
Figure 20 plots self-employment share in agriculture, low-skilled services and high-skilled services against manufacturing respectively. The black line in the figures represents 45-degree line. Figure 20a and 20b show that self-employment share in agriculture and low-skilled services is higher than in 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 20c. This evidence suggests that self-employment share or informality differs significantly across sectors. While agriculture and low-skilled services tend to have larger informal sector, manufacturing and high-skilled services are generally more formal.

Figure 20: Share of Self-Employment by Sector

(a) Agriculture vs. Manufacturing



(b) Low-skilled Services vs. Manufacturing



(c) High-skilled services vs. Manufacturing

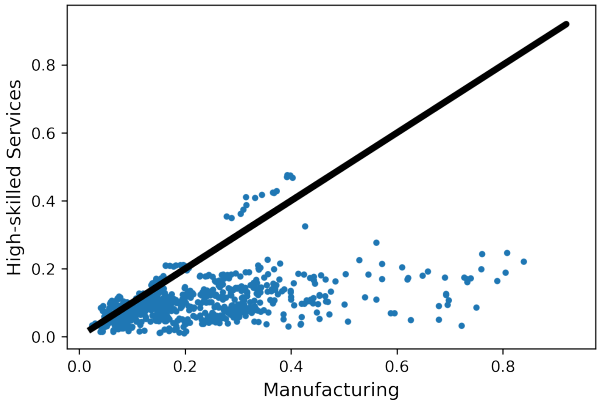


Figure 21 exhibits the relationship between employment share of low-skilled services in non-agriculture and self-employment share in low-skilled services across countries. Share of low-skilled services in non-agriculture is computed by dividing employment in low-skilled services by non-agricultural employment. This measure serves as a proxy for the structural transformation pattern: Higher value indicates higher share of labor leaving agriculture reallocating towards low-skilled services (closer to flat manufacturing patterns).[6]

[6]The reason for using low-skilled services share instead of manufacturing is that manufacturing share with respect to non-agriculture differs significantly in industrialization and deindustrialization due to the hump-shaped evolution. Instead, share of low-skilled services rises over the course of development and exhibit a robust relationship respect to non-agriculture. Considering the sample consisting of 156 economies at various income levels, share of low-skilled services with respect to non-agriculture consequently better captures heterogeneity in cross-country structural change patterns.

Figure 21: Low-skilled Services - Employment Share vs. Informality

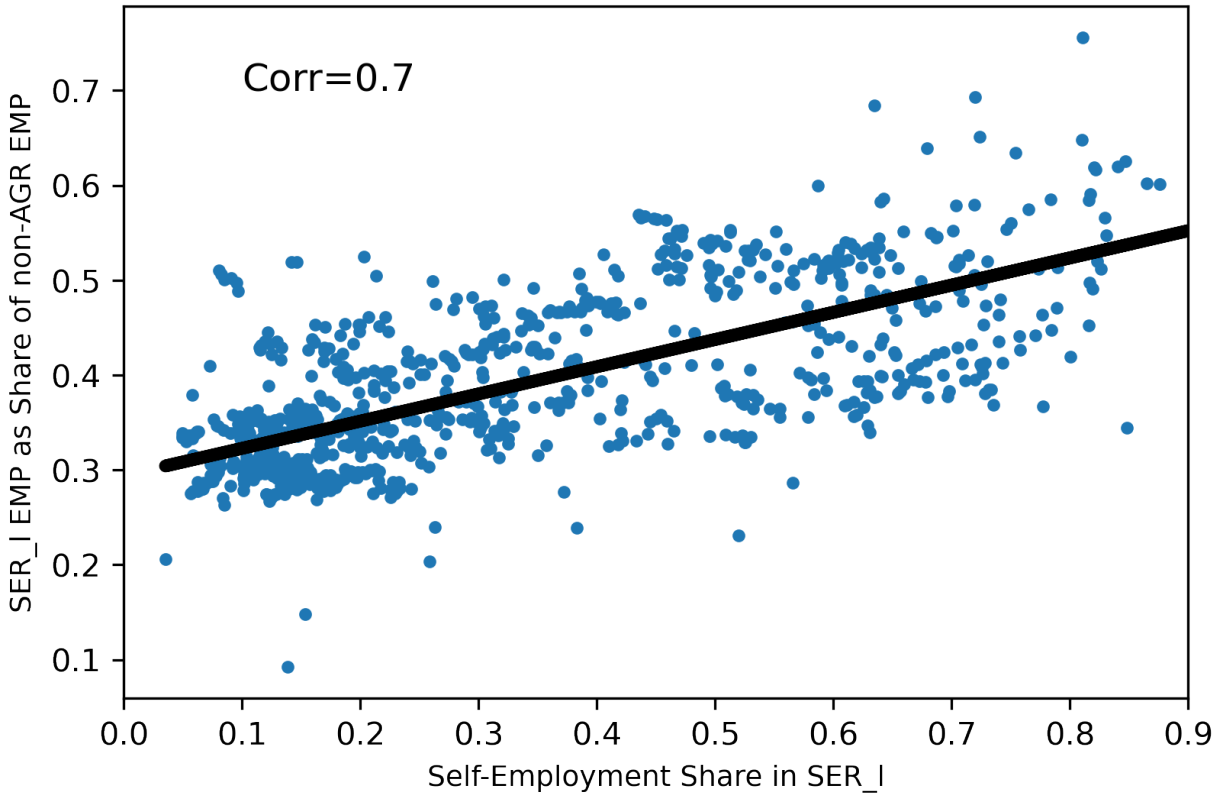


Figure 21 highlights a strong correlation (around 0.7) between informality of low-skilled services sector and employment share of low-skilled services. Countries with higher self-employment share (larger informal sector) tend to allocate more labor towards low-skilled services. This evidence suggests that in economies with large informal sectors due to weak institutions and high distortions, low-skilled services sector is more subject to absorb informal workers out of agriculture and consequently results in low productivity level due to dominance of small-scaled informal production.

High barrier to entry and/or high cost of business operation is an example of distortions that could contribute to high informality and low relative productivity in low-skilled services relative to manufacturing. In an economy with high fixed cost of starting and operating business, only a limited number of high-productivity firms can cover the fixed costs and

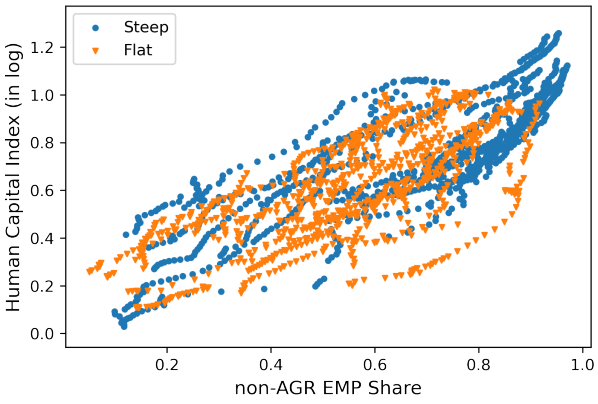
operate with profits. Among those existing firms, more firms will operate in manufacturing sector as manufacturing normally requires larger scale of operation compared to low-skilled services. On the other hand, most production units in low-skilled services will be informal small-scaled households with low productivity. This channel is an illustration of how distortions could contribute to a wide gap in productivity between manufacturing and low-skilled services in flat manufacturing economies.

7.2 Human Capital

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

Figure 22: Human Capital Index across Economies

(a) Non-AGR Employment Share



(b) Real GDP per capita PPP 2017 USD (in log)

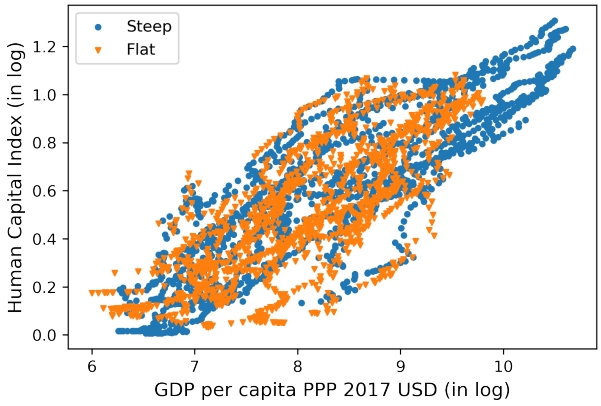


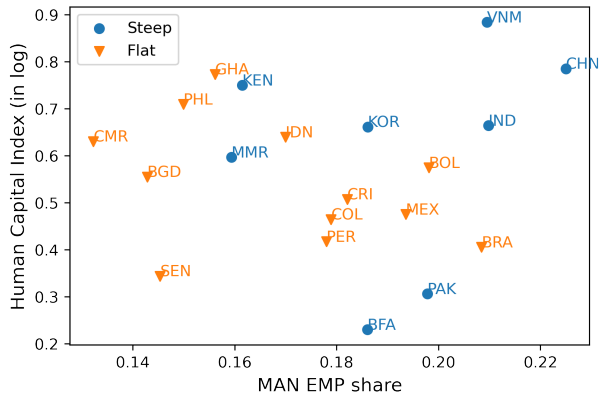
Figure 22 plots the logarithm of Human Capital Index (HCI)[7] against measures of development, non-agricultural employment share and logarithm of GDP per capita (PPP 2017

[7]provided by Penn World Table 10.0, based on years of schooling and returns to education

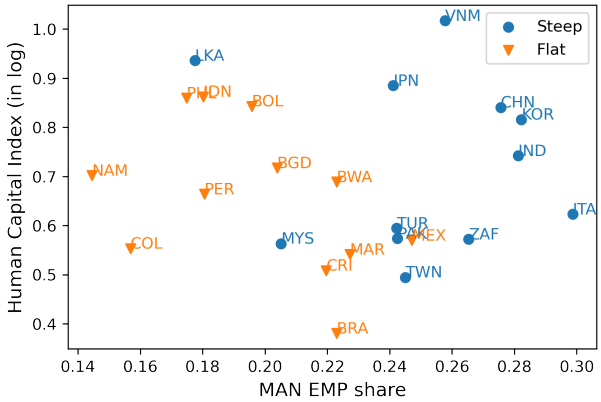
USD). Human capital tends to rise with development. There's no systematic difference in human capital index between steep manufacturing and flat manufacturing economies: Flat manufacturing economies do not exhibit systematic patterns of lower human capital. Figure 23 further presents HCI (in log) against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

Figure 23: Human Capital Index vs. MAN Employment Share

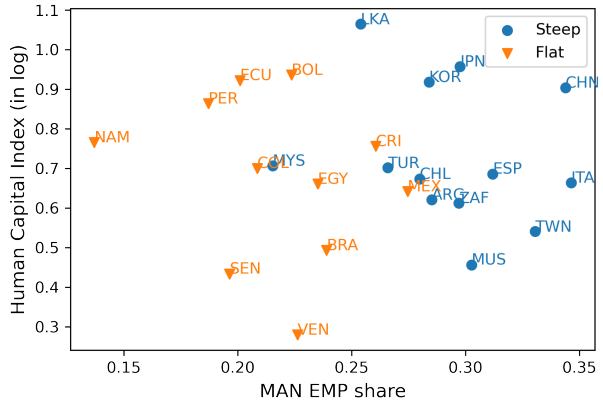
(a) At 50% Non-AGR Employment Share



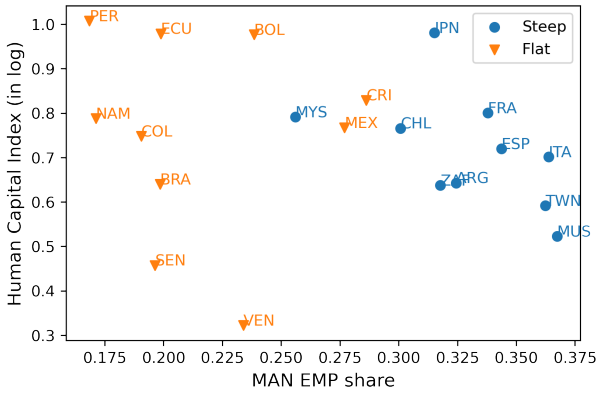
(b) At 60% Non-AGR Employment Share



(c) At 70% Non-AGR Employment Share



(d) At 75% Non-AGR Employment Share



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, many others experience flat hump shape with small changes in manufacturing labor share. Steep manufacturing economies experience substantial reallocation of labor from agriculture to manufacturing during industrialization phase and substantial reallocation from manufacturing to high-skilled services during deindustrialization phase. Flat manufacturing economies, on the other hand, attain lower peak of manufacturing shares and experience little distinction between industrialization and deindustrialization. Structural transformation patterns in flat manufacturing economies can be characterized by substantial reallocation of labor from agriculture to low-skilled services and little change in manufacturing sector.

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

The paper reports aggregate implications of structural transformation patterns. While steep manufacturing countries experience substantial aggregate productivity catch-up, flat manufacturing economies tend to experience no catch-up or decline in aggregate productivity relative to the US. The substantial catch-up episodes in steep manufacturing economies mainly result from catch-up in manufacturing productivity. Lack of aggregate growth in flat manufacturing instead can be explained largely by the low growth in low-skilled services

sector. Differences in agricultural and high-skilled services productivity growth contribute little to aggregate growth experiences across countries.

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

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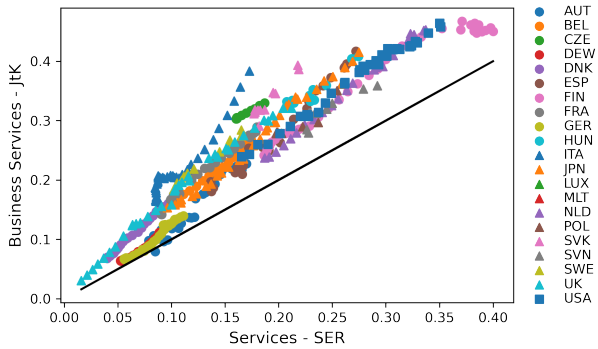
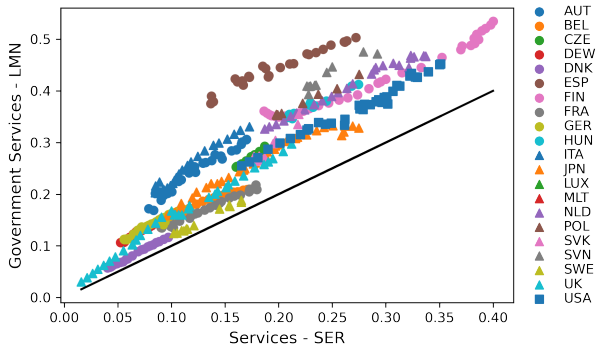
A Services Classifications - KLEMS

Figure A.1: High-skilled Labor Hour Share

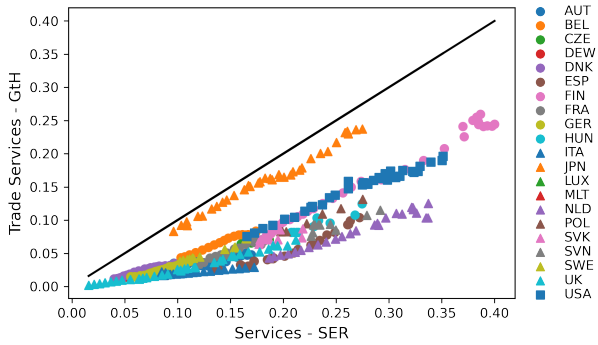
(a) Business Services - J+K



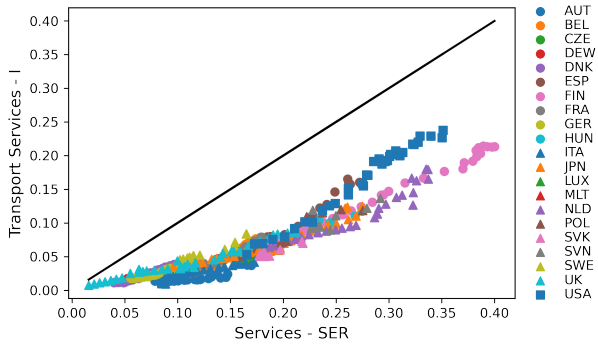
(b) Government Services - L,M,N



(c) Trade Services - G+H



(d) Transport Services - I



(e) Personal Services - O+P

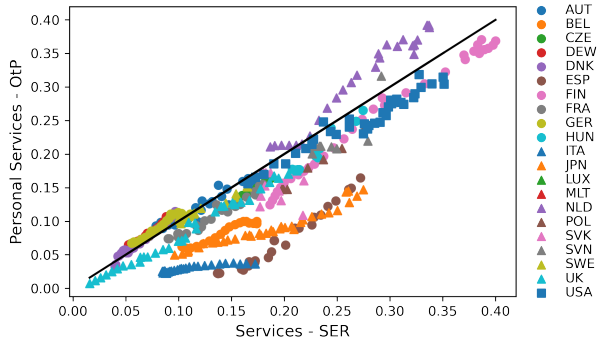
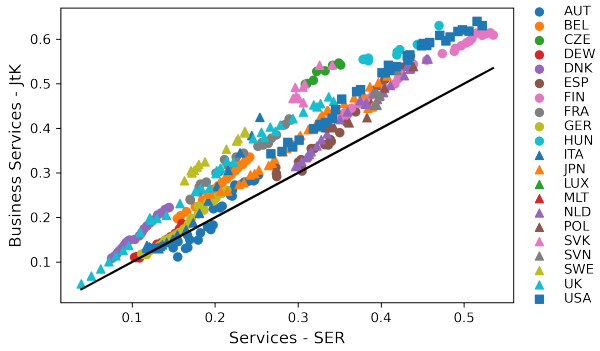
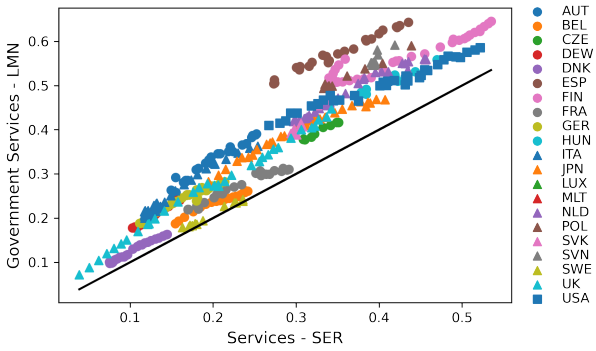


Figure A.2: High-skilled Labor Compensation Share

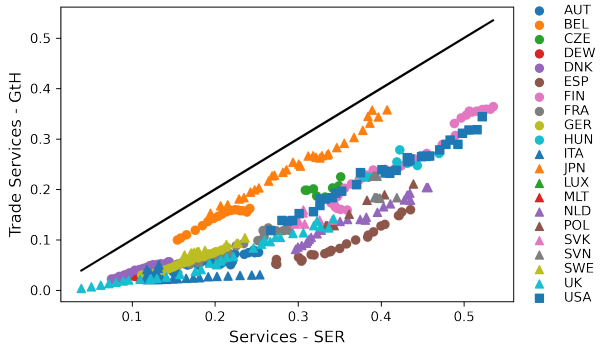
(a) Business Services - J+K



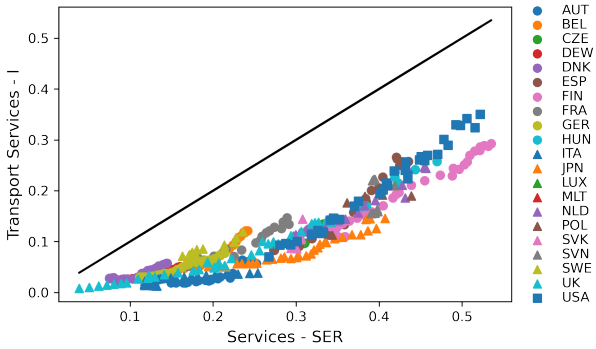
(b) Government Services - L,M,N



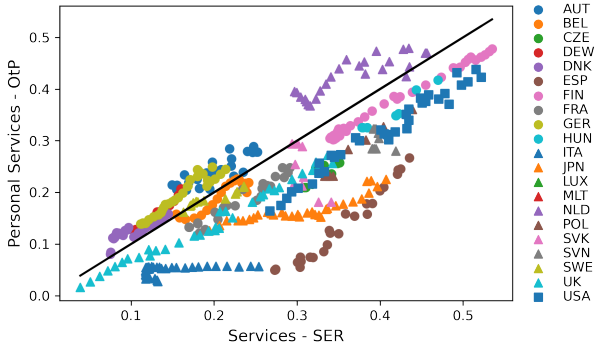
(c) Trade Services - G+H



(d) Transport Services - I



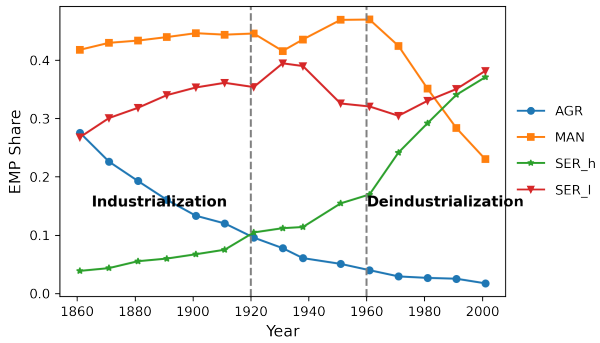
(e) Personal Services - O+P



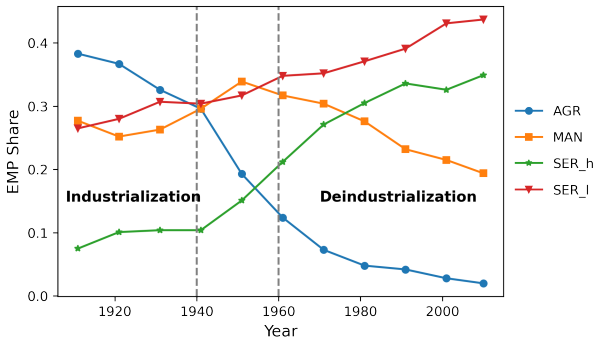
B Structural Transformation Patterns - Examples

Figure B.1: Structural Transformation Patterns - Developed Economies Examples

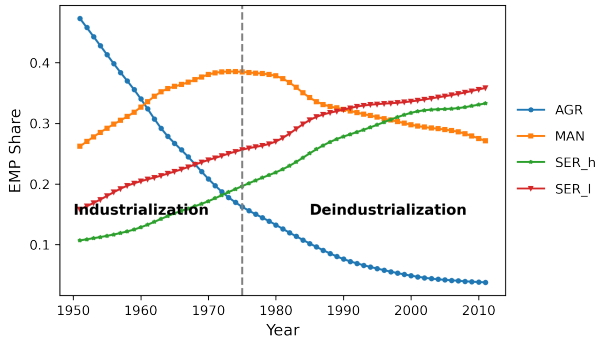
(a) United Kingdom



(b) Canada



(c) Italy



(d) Japan

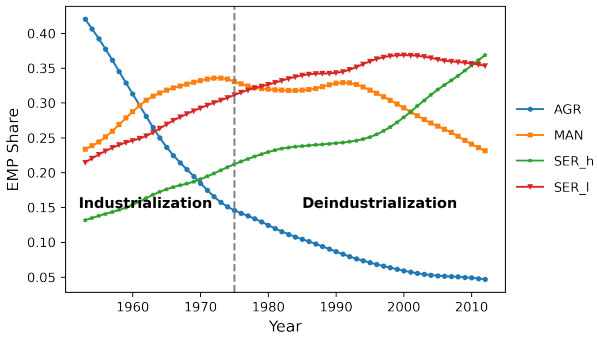
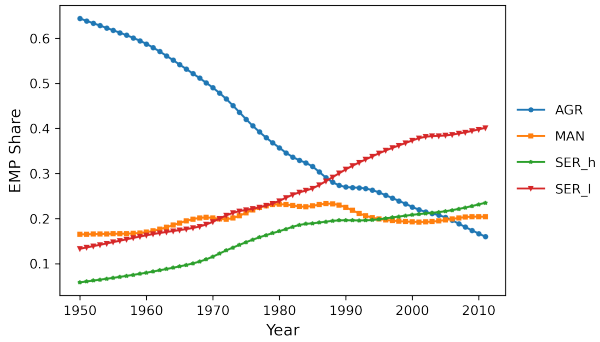
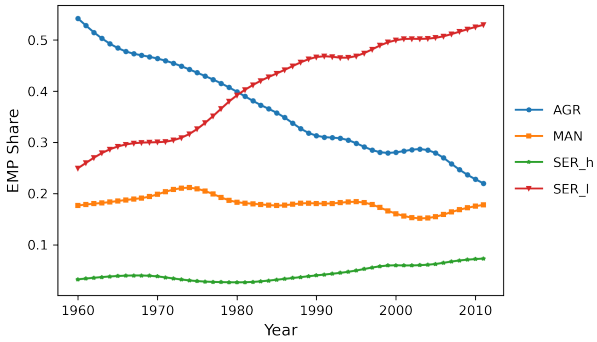


Figure B.2: Structural Transformation Patterns - Flat Manufacturing Examples

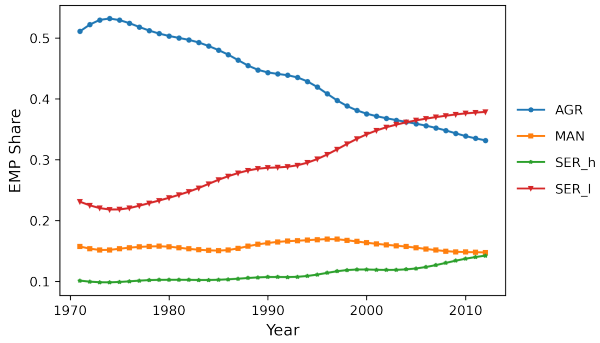
(a) Brazil



(b) Peru



(c) Philippines



(d) Ghana