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China Meets Global De-Industrialization:

Industrial Structural Transformation of China[1]

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[Abstract]

This paper examines China's industrial structural transformation over the past several decades, comparing it with Japan, Korea and the US. Using expanded sets of international comparable databases, we decompose aggregate productivity growth into sectoral productivity growth and inter-sector resource reallocation.

Our findings reveal notable trend changes in labor shares across sectors with significant time differences, earlier de-industrialization in the US and latest industrialization in China. Notably, in the US, manufacturing has lagged behind trade, finance and business services in labor share, and ICT in productivity for years. In contrast, in China, while these service sectors remain minimal in labor share, their relative productivities surpass those of manufacturing. Despite her remarkable productivity growth, significant gaps persist in all sectoral productivity levels between China and the others. We explore how fast these gaps could be narrowed by current sectoral productivity growth trends.

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INTRODUCTION

Modern economic growth (Kuznets, 1966) in the 19th century was achieved through industrialization via exports or *export industrialization*. In contrast, industrialization aimed only at the domestic market is called as *import substitution* for domestic production. Most prewar (WWI) industrializers such as Germany and the US also adopted this import substitution strategy during the 19th century. They imposed high tariffs on competitive imported products and maintained high exchange rates to lower the prices of imported intermediate and capital goods for domestic production. Nevertheless, these protectionist strategies were relatively short-lived, so that the manufacturing sector equipped with competitiveness turned to foreign markets, graduating import substitution for export industrialization. Japan followed a similar path toward the end of World War I.

After World War II, most developing economies began pursuing economic growth through import substitution. Only a few emerging market economies in East Asia, such as Korea and Taiwan, started export industrialization with labor intensive manufacturing products in the 1960s. The increasing share of these emerging market economies in world manufacturing exports threatened the manufacturing sectors in advanced economies[2]. Nevertheless, for the majority of developing economies, the shift from import substitution to export industrialization strategies was not an easy policy decision.

This is why some southeast Asian economies following Korea and Taiwan were spotlighted in World Bank (1993)'s *East Asian Miracle*, which stressed their exceptional cooperative market-government relationships among developing economies. In fact, most maintained high (effective) tariff rates and exchange rates, while their heavily protected manufacturing sectors largely failed to enhance their international competitiveness until the 1990s. These manufacturing sectors often became vested interests, incentivised to continue seeking protection. One of the reasons why the Miracle economies could avoid this trap may come at least partly from the political context, where authoritarian regimes in East Asia must resort to economic policy changes to establish their political legitimacy.

Thus, East Asia achieved exceptional success in export industrialization among developing economies. Industrialization itself, however, was an economic development strategy commonly shared among post WWII developing economies, including those in South Asia, Latin America, Sub-Sahara Africa, Middle East and socialist countries. Almost all of them failed to industrialize, though, mainly because they stuck to import substitution in capital-intensive heavy and chemical industries, neglecting export industrialization in unskilled labor-intensive light manufacturing industries, which better

[2] It was reflected in the OECD report in 1977, titled, The Challenges of Newly Industrializing Countries.

suited their factor endowments.

Since the Industrial Revolution (IR), economic development has been driven by manufacturing. Industrialization jointly enhanced productivity and generated unskilled labor jobs. The success of labor intensive manufacturing comes from its tradability in the world market and its higher income elasticity of demand. Agriculture also exports its products, but its income elasticity of demand is lower and agricultural productivity growth tends to rely on labor saving technological innovation. In contrast, services' tradability as well as their job creation was limited as compared to manufacturing sector until recently.

Entering the 21st century, however, we observe that technological innovation and economic globalization seem to threaten the once effective development strategy of export industrialization. On one hand, the *digital revolution* undermines comparative advantages of a rich pool of unskilled labor, while on the other, global value chains are clustering in a few economies rather than dispersing across many. This raises concerns that export industrialization may not able to jointly realize productivity growth and job creation any more.

Kohsaka (2023) re-examined the process of industrial structural transformation and productivity growth across economies under these changing global economic environments. Using the disseminating database developed by the Groningen Growth and Development Centre (GGDC), he provided some new insights on cross-economy labor share changes and sectoral productivity growth in 42 advanced and developing economies during the period of 1947-2013, particularly focusing on their dispersions and concentrations, and considering their implications for the future of de-industrialization and development strategies.

Building on this previous work, this chapter focuses on China's industrial structural transformation and productivity growth in international comparison. Particularly, we select a few successful industrializers/de-industrializers and meticulously examine their sectoral productivity growth and inter-sector resource reallocation over the decades, using expanded sets of international comparable databases, i.e. Groningen Growth and Development Centre 10 sector database (GGDC 10SD), GGDC Economic Transformation Database (GGDC ETD), World Input-Output Database, Socio-Economic Accounts (WIOD SEA) and Penn World Table (PWT) 10.01[3].

It is well known that advanced economies graduated from industrialization by the 1970s

[3] The more recent the data, the more disaggregated aspects we can scrutinize. In this chapter, we reach as many as 56 sectors and as long as the year of 2018, but not uniformly across sector, country and period, but only on a selected basis.

and are in the process of de-industrialization and *servicification*. Furthermore, developing economies also seem to have started de-industrialization since the 1990s, which raises worries about its possibly negative impact on their economic development (e.g. Rodrik, 2016 and IMF, 2018).

Emphasizing that there is no such a thing as a "mean or typical" developing economy in terms of economic development, this chapter examines income convergence processes of selected economies including China. Focusing China and the other potential fore-runners to China, we decompose their aggregate productivity growth into both sectoral productivity growth and inter-sector resource reallocation, examine their structural transformation patterns as part of the income convergence process, and clarify their implications for China's past and future convergence.

Our findings can be summarized as follows: We note that there is no universal pattern of industrial structural transformation across income levels and/or over time, such as the conventional inverted U-shaped rise and fall of manufacturing's share in employment and output. However, advanced economies and a few developing economies who have succeeded income convergence (*income convergers* hereafter) appear to share some common patterns.

Among these *income convergers*, we select four (de-)industrializing economies (the US, Japan, Korea and China) and decompose their productivity growth into sectoral productivity growth and inter-sectoral reallocation of resources individually. The US is the earliest (de-) industrializer, Japan the first late comer, Korea next to Japan and China one of the latest industrializers in East Asia.

Using GGDC 10SD, we find: the US had already shifted from an industrial society to a financial society in the post-WWII period, where financial service became the leading contributor to aggregate productivity growth through both sectoral productivity growth and inter-sector reallocation. Japan's postwar rapid growth period of 1953-1970 represented classical industrialization from a low-income agricultural society. Japan remained on its plateau of industrialization until its de-industrialization and secular growth slowdown known as *Japanization*, which began in the 1990s. Korea's industrialization during 1970-1990 was also classical, but it started to de-industrialize immediately at its peak around 1990, in contrast to Japan. China started its industrialization in the 1990s with the lowest labor productivity among the three industrializers in East Asia. High sectoral productivity growth remains across the board, not only in manufacturing, and there is no symptom of de-industrialization even after the Global Financial Crisis (GFC), whereas its decline in agricultural labor share has been fairly modest compared to those of Japan and Korea.

Using ETD for the period of 1990-2018, we find distinct contributions across financial intermediation, real estate and business service within (broad) financial service as: In Japan, business service replaced manufacturing as the leading contributor to aggregate productivity growth during de-industrialization, mainly through reallocation rather than sectoral productivity growth. In Korea, manufacturing held the leading contributor to aggregate productivity growth despite de-industrialization. In China, we find little qualitative changes in sectoral contributions, while observing significantly larger growth contributions of financial intermediation and business service in the post-GFC period.

Using WIOD SEA for the period of 2000-2014, we find distinct contributions across ICT, financial intermediation, real estate, business service excluding ICT as: The US witnessed altercating leading growth-contributors among ICT, financial intermediation, real estate and business service. Japan witnessed that government service, business service and real estate contributed dominantly in an alternating way mainly through reallocation, while de-industrializing Korea witnessed limited growth contribution from ICT, finance, real estate and business service. China witnessed ever-dominant manufacturing's growth contribution, but little changes in growth contributions of those frontier sectors as business service and ICT.

Finally, with significant gaps in both aggregate and sectoral productivity levels among economies, we noted very weak convergence in agriculture compared to manufacturing and services in East Asia. Experimentally calculating the years needed to converge to a target productivity level based on the present sectoral productivity growths, we find that China, for example, needs more than a century for agriculture's convergence, while 32 years for manufacture's.

The first section below summarizes how industrial structural transformation has been discussed in the literature, and observes, based on GGDC 10 sector database, that there is no universal pattern across economies. However, the alternating rise and fall of manufacturing's labor share, i.e. industrialization and de-industrialization, can be traced only among *income convergers* including advanced and developing economies such as those in East Asia.

The second section, after introducing the decomposition of aggregate productivity growth, overviews sectoral labor shares and productivities of selected (de-)industrializers, and shows how we can detect similarities and uniqueness among them. Then, the Section introduces each economies' decomposition results across decades one by one, and points out the findings on individual components' roles. Particularly, we will show which sector, out of agriculture, mining, manufacturing and seven services sectors, contributes to aggregate productivity growth to what extent and through which channel. This section will clarify the relative positions of these industrializers.

The third section extends the second by using additional datasets, i.e. GGDC ETD for 12 sectors, 1990-2018 without US data on the one hand, and WIOD SEA for 56 sectors, 2000-2014 with US data on the other hand. First, on GGDC ETD, we distinguish between business service, finance and insurance, and real estate from one broad finance sector and identify their individual contributions to aggregate productivity growth. Next, on WIOD SEA with US data, we go into furthermore disaggregated sectors such as ICT sector as well as manufacturing's 19 subsectors across the full lineup of economies.

The fourth section turns to the issue of sectoral productivity convergence among economies. Just like income convergence among advanced economies, their aggregate as well as sectoral productivities may or may not converge, while significant gaps in productivity levels persist between advanced and developing economies including East Asia. This section examines what we observe about productivity convergence when including emerging market economies like China and presents simple projection exercises on how fast aggregate and sectoral productivities catch up to those of US for expositional purposes. The fifth section summarizes our findings and discusses them in the broader context of structural transformation under productivity growth. The last section concludes the chapter.

1. INDUSTRIALIZATION, STRUCTURAL TRANSFORMATION AND ECONOMIC GROWTH

From the outset, *modern economic growth* (Kuznets, 1966) was a process of industrialization, which accompanies a transformation in industrial structure from an agricultural society. A national industrial structure has been conventionally decomposed into three broad sectors, i.e. agriculture, manufacturing and services. In the early 19th century, the United States was an agricultural society where agriculture occupied more than 80 % of its total employment, while manufacturing and services did less than 10 % each. Since then, the agriculture's labor share trend-declined to below 50 % around the Civil War era in the 1860s, and further to below 10% by the 1970s. By contrast, the shares of both manufacturing and services rose parallelly to 30% until the early 20th century. Then, the former slowed down its growth, almost peaked out at before 40% and started to decline in the beginning of the 1950s, while the latter started to rise at higher speed[4].

Similar trends are observed commonly in advanced economies. As one popular example, Herrendorf et al. (2013, Figure 2) show scatter maps of a combination of sectoral employment and value added shares with respect to per capita income levels (constant international dollars in 1990) across a panel of 10 advanced economies over the years of 1800-2000. It showed: the higher the income level, the lower the employment share of agriculture to less than 10% and the higher that of services to more than 70%. Whereas, as to manufacturing, the higher the income level, the higher its labor share up to 30-50% but the lower its share from there to around 20%, being called as hump-shaped[5]. Comin et al (2021) tried to recover the hump-shaped pattern by presuming some nonhomethetic preferences, and Sposi et al. (2021) did so by also presuming nonhomothetic preferences, differential sectoral productivity growth and trade integration, both theoretically and empirically.

However, this hump-shaped or inverted U-shaped pattern of changes in employment share of manufacturing is not necessarily shared in common, neither across economies nor across income levels (Kohsaka 2023). In fact, Figure 1 shows a scatter plot across an extended panel of 42 advanced and developing economies over the period of 1947-2013 based on GGDC 10 sector database. Apparently, we cannot clearly detect one single hump for manufacturing with respect to income levels, anymore.

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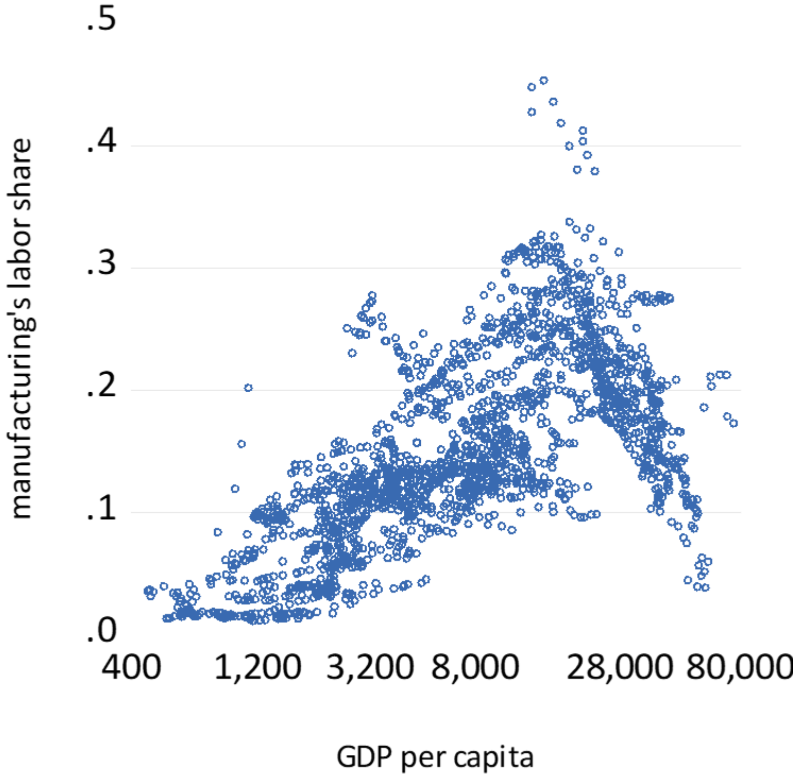
4 Acemoglu (2009), Figure 20.1.

5 Also its original figure showed that, while these patterns of industrial transformation across sectors are similar between shares in employment and value added, the employment share in agriculture is higher than its value added share at the same income level and the other way around in manufacturing, which suggests that the labor productivity (= value added/ employment) is generally lower in agriculture than in manufacturing.

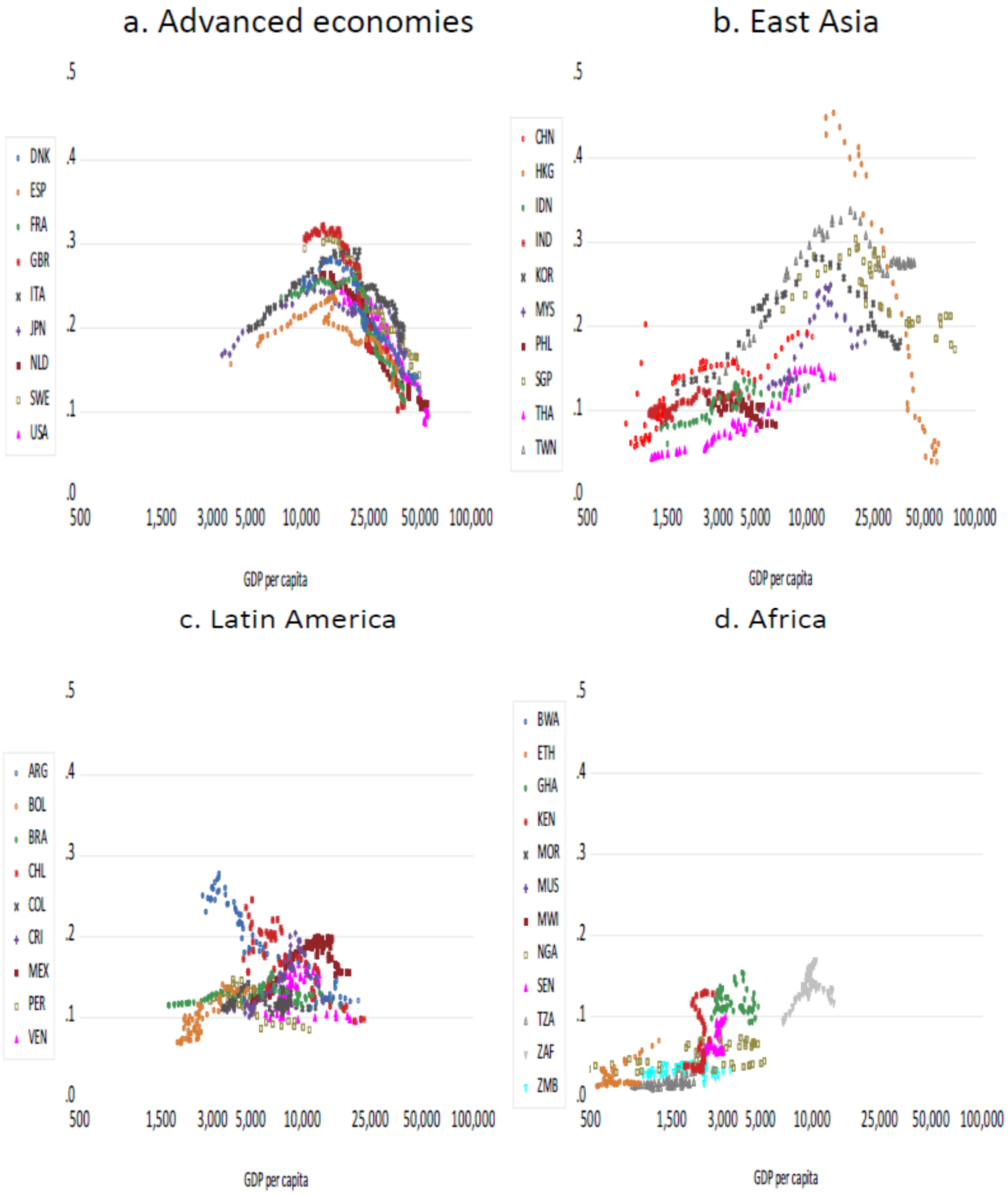
Figure 1: Manufacturing's labor shares and income levels, 42 economies, 1950-2011



Note: GDP per capita: real GDP per capita (2005 constant price at 2005 market exchange rate). Data: Groningen Growth and Development Centre (GGDC), 10 sector database (10SD).

Rather, if we look at Figure 2, we can detect a hump-shaped pattern of manufacturing labor share only in advanced as well as in few developing economies in East Asia (Panel b), but not anymore in other economies as in Latin America and Africa (Panel c and d). In other words, the hump-shaped pattern can be found not universally across economies, but only in some set of economies.

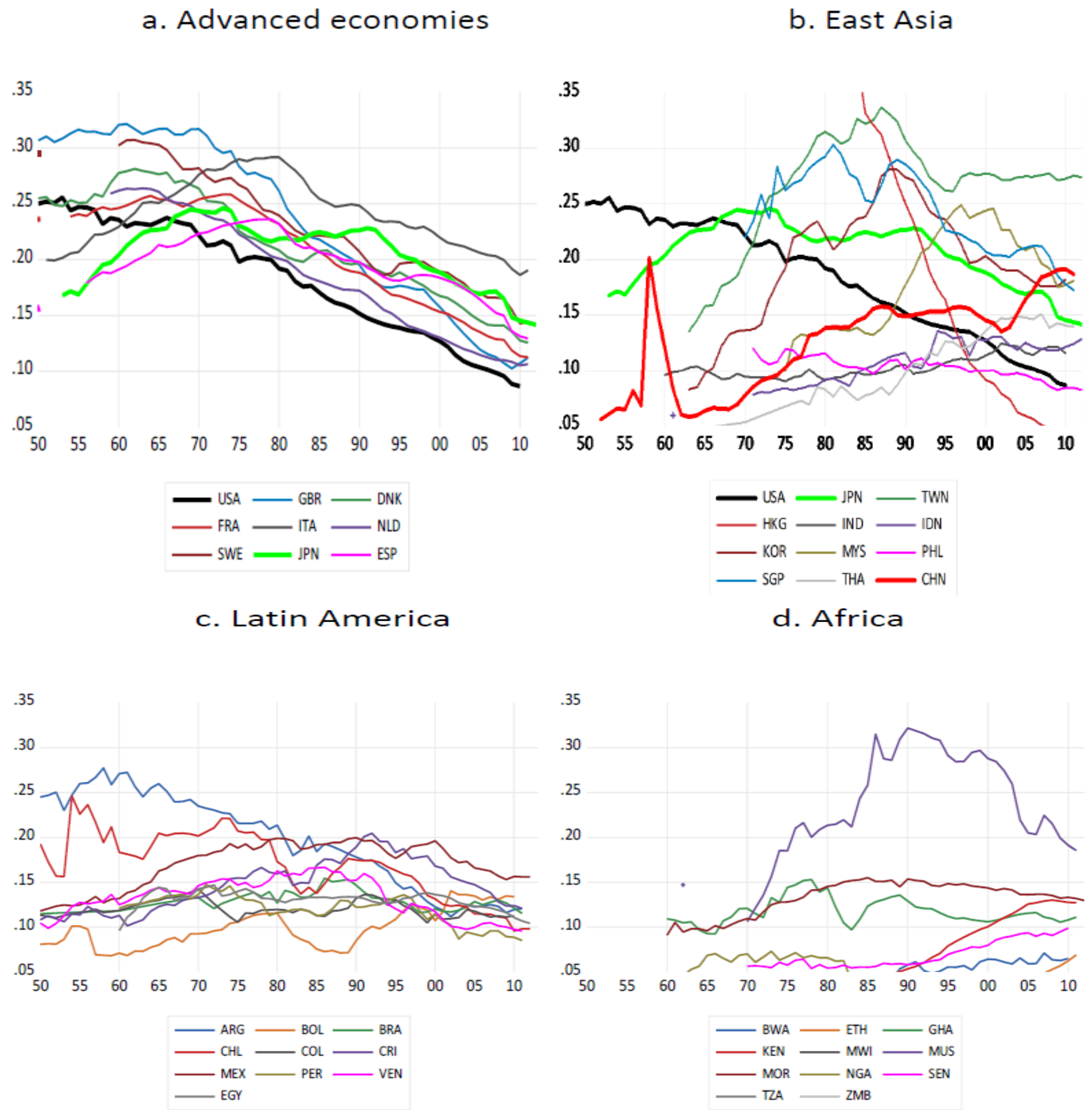
Figure 2: Manufacturing's labor shares and income levels, by region, 1947-2013



Note: same as in Figure 1.

Alternatively, if we turn to look at time-series patterns of manufacturing' labor shares across economies by region in Figure 3, we can again detect a hump-shaped pattern of manufacturing's labor shares in advanced and some developing economies in East Asia with some time lags one another, but not in other regions. Manufacturing's labor shares peaked out between 1960 and 1980 in advanced economies except for the US, while they did so mostly by around 1990 in East Asia except for China[6].

Figure 3: Manufacturing's labor share, by region, 1950-2011



Note: same as in Figure 1.

Parallel to structural transformation, if we look at their income growth performances by GDP per capita (2005 constant price and market exchange rate) in logarithm (Figure

6 In fact, meticulous observers may detect non-single humps across economies over time, partly due to business cycles as in China in the late 1990s and the late 2000s, and Singapore in the late 1970s and the late 1980s, while they may detect not so conspicuous humps even in Figure 4b.

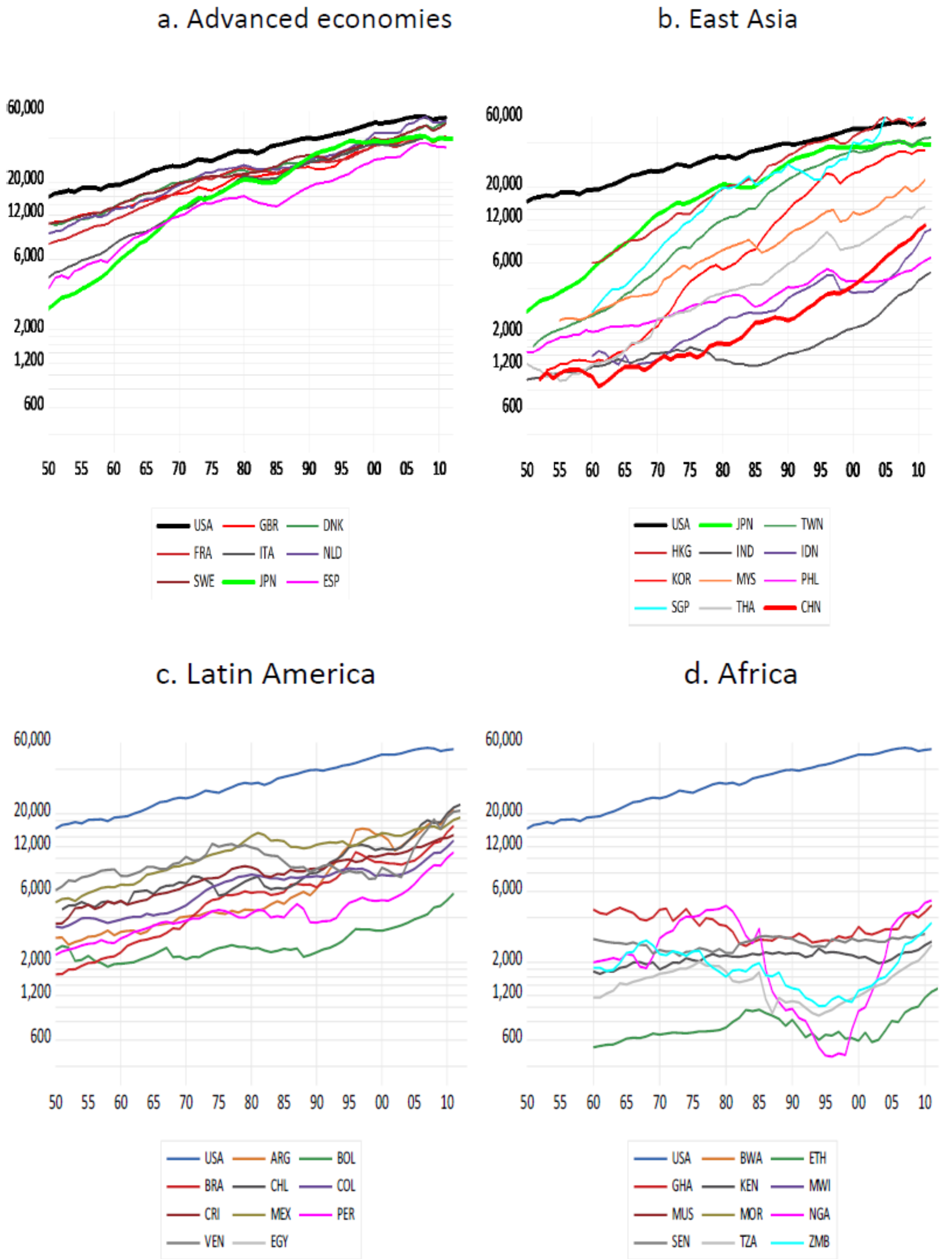
4), we can detect more or less income convergence in the former groups (Panels a and b), but stagnation or divergence in the latter (Panels c and d). More precisely, first, we can observe a strong income convergence among advanced economies and, second, we can also detect some income convergence (represented by steeper slopes of income lines) among a few developing economies in East Asia, particularly in Hong Kong, Korea, Singapore and Taiwan, then followed by Malaysia, Thailand and then China, with more or less significant time lags, catching up with advanced economies. In contrast, in Latin America we hardly find income convergence throughout the period and in Africa, we generally observe income divergence instead. This is consistent with the historical fact that industrial structural transformation goes together with modern economic growth

When the productivity level of manufacturing is higher than that of agriculture as in advanced economies in 1800-2000, resource reallocation from agriculture to manufacturing or structural transformation under industrialization would, other things being equal, enhance an aggregate productivity level even without any sectoral productivity growth (reallocation effect on aggregate productivity growth). In addition, when the productivity growth of manufacturing is higher than that of agriculture, the same re-allocation would further enhance the national productivity growth (sectoral growth effect on aggregate growth). In fact, both of these seem to have really happened in modern economic growth. In this sense, industrialization has been the engine of sustained productivity growth or modern economic growth in advanced as well as some other economies.

In advanced economies, however, the manufacturing labor share has kept declining recently, i.e. *de-industrialization* has prevailed since around the 1970s (Figure 4). If the share of manufacturing with higher productivity level and growth be replaced by that of services with lower productivity level and growth, it would lead to lower aggregate productivity level and growth.

In developing economies, because their agriculture shares remain large, the resource shift by industrialization has been expected to enhance their aggregate productivity level and growth, as experienced by advanced economies. In fact, however, the resource shift from agriculture to manufacturing was limited and/or skipped, and that from agriculture to services turned out to be conspicuous particularly in recent years.

Figure 4: GDP per capita, by region, 1950-2011



Note: GDP per capita (2005 constant price, market exchange rate). Data: Penn World Table 10.01.

In other words, in most developing economies, their relatively small manufacturing shares started to decline at lower income levels as compared to advanced economies or earlier industrializers. This fact is labeled as *pre-mature de-industrialization* by Rodrik (2016). IMF (2018, page 6) also states: "many of the developing economies with declining manufacturing shares never experienced strong expansion of the shares to begin with, unlike most of the economies that developed earlier. As a result, compared with those of earlier developers, the manufacturing employment shares of many developing economies have typically peaked at lower shares and income levels."

Once, in advanced economies, it was worried that the reallocation of resources from manufacturing to services may slow down aggregate productivity growth (Baumol, 1976), because manufacturing, being technologically advanced sectors as compared to services, was regarded as a higher productivity growth sector. Among developing economies, it was only those in East Asia since the 1960s, who realized income convergence with advanced economies along with increasing employment and export shares of manufacturing. Particularly, Rodrik (2013) and McMillan and Rodrik (2011) argue that, because unconditional productivity convergence can be found not in aggregate economy but in manufacturing, the structural transformation of developing economies during 1990-2005, being without an increase in manufacturing employment, may not be able to lead to income convergence.

Casual observations thus far suggest that there is no universal pattern of structural transformation across income levels or over time, but that advanced economies and a few developing economies appear to share some similar patterns of structural transformation, i.e. a rise and a fall of manufacturing's labor share across income levels and over time. Those industrializing economies also show more or less income convergence, catching up with the frontier income level among advanced economies.

Noting that China is one of these few, exceptional developing economies, or possibly one of the last group of them, we focus on China's industrial structural transformation in international comparison in this chapter. Specifically, in the following sections, we select four successful industrializers/de-industrializers, i.e. the US, Japan, Korea and China, and analyze their transformations along with their aggregate productivity growth by looking into their sectoral productivity growth and inter-sector resource reallocation across decades.

Advanced economies such as the US started de-industrialization by the 1970s, while developing economies have also started de-industrialization since the 1990s too, rarely succeeding in industrialization or catching up with advanced economies in income. Therefore, we decompose the aggregate productivity growth of these selected successful industrializers into sectoral components, identify which sector contribute to what extent and through which channel, and compare the results to obtain what we can learn from their similarities and dissimilarities for the past and future of industrial structural transformation and productivity growth of China.

2. LONG-RUN TRENDS OF STRUCTURAL TRANSFORMATION BASED ON GGDC 10 SECTOR DATABASE, 1950-2010

Decomposing aggregate productivity growth

We recall that aggregate productivity growth is simply a weighted average of sectoral productivity growth, which significantly differs across sectors and over time along with their changing weights. Which sector contributes most to aggregate productivity growth, and when? How are resources reallocated among sectors under structural transformation? These whole pictures end up with aggregate productivity growth after all.

Thus, in the wake of previous works such as Diao et al. (2017) and Kohsaka and Shinkai (2015), we decompose labor productivity growth into sectoral labor productivity growth and reallocation of labor between sectors, where an increase (decrease) in labor share in higher (lower) productivity sectors is expected to increase (decrease) the aggregate labor productivity of the economy as a whole.

Sector i's labor productivity in period t, $y_{i,t}$, is defined as $y_{it} = Y_{i,t}/L_{i,t}$ where Y and L are value added and employment of the sector, respectively. Sector i's labor share at t, $\theta_{i,t}$, is defined as $\theta_{i,t} = L_{i,t}/L_t$. Then, the aggregate labor productivity in period t, y_t, is expressed as a total sum of sectoral productivity multiplied by labor shares, i.e. $y_t = \Sigma_i \theta_{i,t} y_{i,t}$. Now, we can decompose the aggregate labor productivity change into a sectoral productivity growth and a reallocation of labor as:

$$\Delta y_t = y_t - y_0 = \Sigma_i\theta_{i,t}y_{i,t} - \Sigma_i\theta_{i,0}y_{i,0} = \Sigma_i\theta_{i,0}\Delta y_{i,t} + \Sigma_i[(y_{i,0} + \Delta y_{i,t})\Delta\theta_{i,t}]$$

By dividing both sides by the initial labor productivity, we obtain the following in growth terms:

$$\Delta y_t/y_0 = \Sigma_i\theta_{i,0}\,(y_{i,0}/y_0)\,(\Delta y_{i,t}/y_{i,0}) + \Sigma_i\,(y_{i,0}/y_0)\,(1 + \Delta y_{i,t}/y_{i,0})\,\Delta\theta_{i,t} \quad (1)$$

The first term of the right hand side of Equation (1) implies that, the larger the initial sectoral labor share ($\theta_{i,0}$) and the higher the initial sectoral relative productivity level ($y_{i,0}/y_0$), the larger the contribution of its sectoral productivity growth to the aggregate productivity growth, which we call the *sectoral productivity growth effect* on aggregate labor productivity growth. The second term implies that, the larger the initial sectoral relative productivity level ($y_{i,0}/y_0$) and the higher the sectoral productivity growth ($\Delta y_{i,t}/y_{i,0}$), the larger the contribution of its increase in sectoral labor share to the aggregate labor productivity growth, which we call the (*inter-sector labor) reallocation effect* on aggregate labor productivity growth[7].

Overview of sectoral labor shares and productivities for decomposition

Our first and main data set consists of sectoral real value added in local currencies (2005 constant prices) and employment (persons employed) in 42 advanced and developing economies for the period of 1947-2011, obtained from Groningen Growth and Development Centre 10-Sector Database (GGDC 10SD, hereafter).

In order to focus on China in international perspective, we refer to four economies, namely, China, Japan, Korea and US. The previous Figure 3 demonstrates that US is not only one of the earliest industrializers, but also the earliest de-industrializer, who started de-industrialization as early as in the early 1950s. Japan is one of the typical late industrializers in the late 19th century, recovered from the WWII disaster and its industrialization peaked out in the 1970s. Korea started industrialization around 1970, de-industrializing from the 1990s. Finally, China appeared to be the last industrializer or at least one of the last industrializers, who might start de-industrializing in the 2010s as we will observe later.

Figure 5, Panel a shows sectoral labor shares of the four economies in the period of 1950-2011. We picked up six major sectors, i.e. agriculture, manufacturing, construction, trade (wholesale, retail, hotels and restaurants), finance (including insurance, real estate and business services), and government service (not available for Korea). Other 4 sectors, i.e. mining, utilities (electricity, gas, water supply and sewage), transportation and private service are not shown because of their smaller sizes and influences on aggregate productivity growth.

We note here that finance and then government service are newly emerging sectors in the de-industrializing economies (US, Japan, and probably Korea), but no visible emerging sign in China. In fact, manufacturing's labor share became smaller than those of government service, trade and finance in US by 1990 and Japan by 2010, and smaller than that of trade and almost caught up by that of finance in Korea by 2010. This is the reality of de-industrialization. China's agriculture's labor share was beyond 40% until recently, therefore barely seen in the upper right-hand corner in Figure 6, while construction's rather unique to each economy. Conspicuous is a very small labor share of finance sector in China all through the periods.

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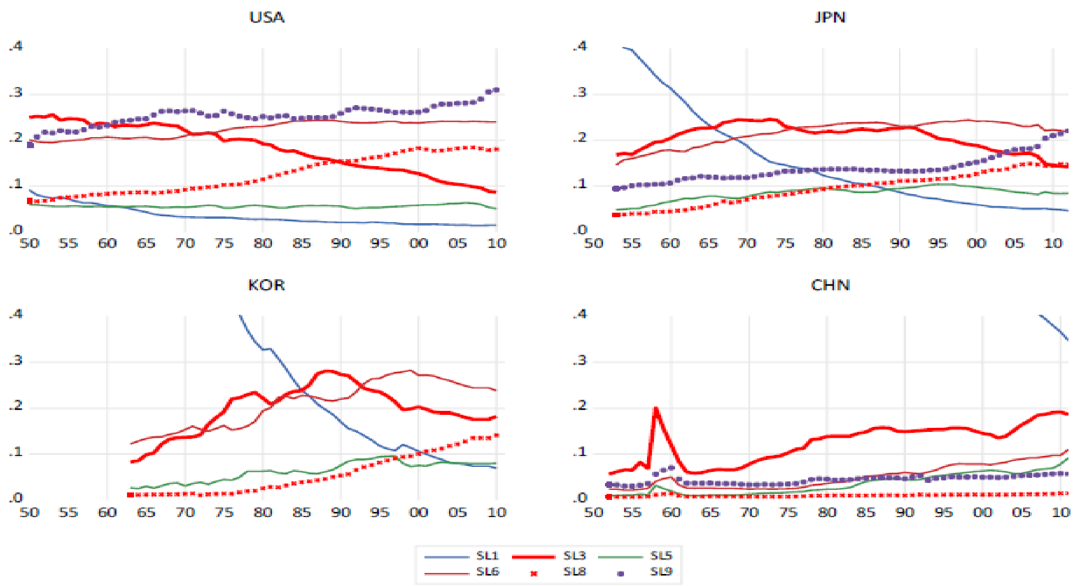
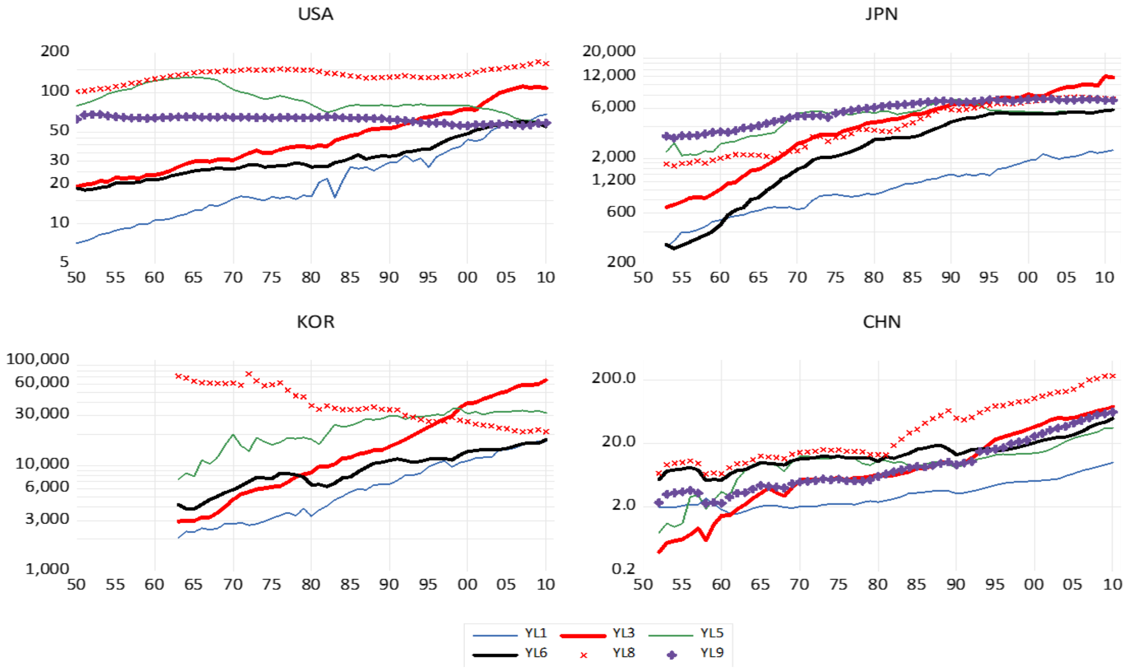
[7] Note that the reallocation effect consists of static (dependent only on initial labor share) and dynamic (dependent on both initial labor share and sectoral productivity growth) components.

Figure 5: Sectoral labor share and labor productivity, 1950-2011

a. Sectoral labor share



b. Sectoral labor productivity



Note: Labor shares are: sl1: agriculture, sl3: manufacturing, sl5: construction, sl6: trade, sl8: finance, sl9: government service. Labor productivities are; yl1: agriculture, yl3: manufacturing, yl5: construction, yl6: trade, yl8: finance, yl9: government service. Data: GGDC 10SD.

In de-industrializing US, *reallocation* or a shift in labor share[8] is from manufacturing to mainly finance in the 1980s and 1990s, then to trade in the 1970s and 1980s and to government service in the 1950s, 1960s and 2000s. Reallocation is from agriculture to manufacturing and all services until the 1970s in industrializing Japan and until the 1990s in industrializing Korea, and then from agriculture and manufacturing to services, particularly finance and government service, since the 1990s in both de-industrializing Japan and Korea. In China, the last industrializer among the four, reallocation is from agriculture to all the others since the 1970s.

Very roughly speaking, with respect to a pattern of industrial structural transformation, Japan looks like US with 50 years' lag, Korea like Japan with 20 years' lag but compressed, and China like Korea with 10 years' lag, whose transformation appears prolonged instead of compressed. A decline in agriculture's labor shares showed distinct difference in timing and pace across the economies. All sectoral labor shares changed generally smoothly, which suits our long-run (low frequency) productivity growth decomposition well.

Similarly, Figure 5, Panel b shows sectoral labor productivity levels of the same sectors of the four economies in the same period, at constant 2005 national prices in logarithm. Sectoral labor productivities show positive growth except for construction in US and finance in Korea. Manufacturing's labor productivity growths are generally higher than the other sectors across the economies, while there seem to be some convergence in labor productivity across some sectors across economies, except for finance and manufacturing in US, agriculture in Japan, manufacturing and construction in Korea and agriculture and finance in China. Most of sectoral labor productivity levels show fairly monotonous increases.

The decomposition results of long-run productivity growth, 1950-2010

Now we are ready to go into the result of productivity growth decomposition of the four economies one by one, first US, the earliest de-industrializer, second, Japan, a typical de-industrializing industrializer, third, Korea, a typical late de-industrializing, late industrializer, and last, China, a typical last industrializer.

Since we are concerned with long-run productivity growth and structural transformation, we need to be careful in choosing observation periods. In order for the decomposition to be useful, we would like to focus on trends as well as changes in trends in choosing both beginnings and ends of periods. As shown below, as far as the four industrializers are concerned, we find that 1970 and 1990 are fairly good period-markers, being commonly applicable to all. We decompose aggregate productivity growths for the

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[8] Throughout this chapter, we refer to a shift in labor share across sectors as (inter-sector) reallocation of resources (labor), which may or may not need an inter-sector labor movement.

periods of 1950-1970, 1970-90, and 1990-2010, as possible as their availability allows.

United States

Table 1 shows the result of growth decomposition of the US for the period of 1950-1970, 1970-1990 and 1990-2010. We recall that, the larger the initial relative productivity and the initial labor share, the larger the contribution of the sectoral productivity growth to the aggregate productivity growth on the one hand, and that, the larger the initial relative productivity and the sectoral productivity growth, the larger the contribution of the sectoral labor share change or reallocation to the aggregate productivity growth. The Table shows the metrics of these components in the first four rows and growth contributions in the latter three rows in the three periods, respectively, as will be repeated in the following Tables 2-11.

Table 1: Productivity growth decomposition, US, 1950-2010

usa											
1950-1970	agr	mining	manu	util	const	trade	transp	fin/b-serv	g-serv	p-serv	total
productivity growth	0.0396	0.0533	0.0237	0.0567	0.0145	0.0167	0.0289	0.0177	0.0017	0.0099	**0.0204**
initial relative productivity	0.1886	3.1367	0.5065	1.5152	2.1052	0.4959	0.5392	2.7135	1.6599	0.7965	
initial labor share	0.0912	0.0157	0.2501	0.0074	0.0588	0.2011	0.0783	**0.0678**	**0.1891**	0.0405	
labor share change	-0.0589	-0.0083	-0.0285	-0.0007	-0.0055	0.0086	-0.0183	**0.0242**	**0.0750**	0.0124	
contribution ratio:											
sectoral growth	0.0405	0.1799	**0.1514**	0.0453	0.0827	0.0786	0.0651	**0.1549**	**0.0213**	0.0140	0.8339
reallocation	-0.0484	-0.1474	**-0.0461**	-0.0067	-0.0311	0.0119	-0.0349	**0.1868**	**0.2580**	0.0242	0.1661
1970-1990	agr	mining	manu	util	const	trade	transp	fin/b-serv	g-serv	p-serv	total
productivity growth	0.0325	-0.0053	0.0287	0.0190	-0.0143	0.0113	0.0264	-0.0053	-0.0019	0.0168	0.0081
initial relative productivity	0.2737	5.9155	0.5395	3.0487	1.8729	0.4610	0.6364	2.5713	1.1448	0.6465	
initial labor share	0.0323	0.0074	0.2216	0.0067	0.0533	**0.2097**	0.0600	**0.0920**	0.2641	0.0530	
labor share change	-0.0120	-0.0015	**-0.0700**	-0.0008	0.0027	**0.0312**	-0.0124	**0.0626**	-0.0051	0.0054	
contribution ratio:											
sectoral growth	0.0450	-0.0250	**0.5168**	0.0530	-0.1422	**0.1392**	0.1484	**-0.1353**	-0.0645	0.0773	0.6127
reallocation	-0.0355	-0.0454	**-0.3781**	-0.0214	0.0218	**0.1025**	-0.0753	**0.8231**	-0.0322	0.0278	0.3873
1990-2010	agr	mining	manu	util	const	trade	transp	fin/b-serv	g-serv	p-serv	total
productivity growth	0.0432	0.0107	0.0357	0.0181	-0.0188	0.0263	0.0265	0.0120	-0.0030	-0.0008	0.0126
initial relative productivity	0.4411	4.5243	0.8074	3.7793	1.1938	0.4913	0.9108	1.9670	0.9372	0.7680	
initial labor share	0.0203	0.0059	0.1516	0.0058	0.0560	0.2409	0.0477	**0.1545**	**0.2590**	0.0584	
labor share change	-0.0056	-0.0009	**-0.0649**	-0.0020	-0.0055	-0.0008	-0.0033	**0.0259**	**0.0508**	0.0063	
contribution ratio:											
sectoral growth	0.0416	0.0221	0.4363	0.0333	-0.0742	**0.2822**	0.1048	**0.2878**	**-0.0496**	-0.0026	1.0818
reallocation	-0.0203	-0.0180	-0.3709	-0.0383	-0.0158	**-0.0023**	-0.0178	**0.2273**	**0.1575**	0.0168	-0.0818

Note: agr: agriculture, min: mining, manu: manufacturing, util: electricity, gas, water supply. const: construction, trade: trade & commerce, transp: transportation, fin/b-serv: finance, insurance, real estate & business service, g-serve: government service, p-serve: private service. Data: GGDC 10SD.

Starting from the GDP per capita of as high as US$15,911 (1950 at 2005 constant price), the aggregate labor productivity growths of the US were 2.04%, 0.81% and 1.26% for the periods of 1950-1970, 1970-1990 and 1990-2010, respectively. In other words, the US experienced a steady growth in 1950-1970, but some stagnation in 1970-1990, and then moderate recovery in 1990-2010.

Initially in 1950, sectoral labor shares were largest in manufacturing (25%), followed by trade (20%) and government service (19%), agriculture (less than 10%) and relatively small in mining and utilities (Table 1, third row), but the manufacturing share kept declining to less than 9% by 2010, while both trade and government service's shares slowly grew to 25% and 30%, respectively, and financial service's share rapidly grew from less than 7% and surpassed manufacturing's to 18% by 2010 (third row from the bottom). Apparently, the US economy continued to de-industrialize since the 1950s and resources shifted from manufacturing toward services, particularly financial service and government service to the present.

Throughout this de-industrialization, sectoral labor productivity growths were steadily high in agriculture (3.9, 3.2 and 4.3%), manufacturing (2.4,2.9, 3.6%), and transportation, while those in the other sectors were volatile and seemingly sensitive to changes in aggregate productivity growth. Consequently, relative sectoral labor productivity levels tend to converge each other, because they were relatively lower in agriculture, manufacturing, trade and transportation services and higher in mining, utilities, construction, financial and government services.

Our decomposition of aggregate productivity growth appears to show somewhat alternate contributing sectors to aggregate productivity growth across the three periods. In 1950-1970, mining, manufacturing and financial service were major contributors through sectoral productivity growth, followed by agriculture, utilities, construction, trade and transportation services, i.e. all sectors contributed there, explaining 83.4% of the aggregate productivity growth. While mining, agriculture, manufacturing, construction and transportation service shrank in labor share, financial and government services absorbed[9] labor and the total reallocation effect to the aggregate productivity growth turned out to be positive and non-negligible (16.6%). As a consequence, financial service turned out to be the dominant contributor to aggregate productivity growth through both sectoral productivity growth and reallocation (by 15+19=34% of the total), followed by government service (28%), the second, and then manufacturing (10%), the third.

Under the slower productivity growth during 1970-1990, only manufacturing, trade and

[9] As before (footnote 8), we refer to an increase in labor share as labor being absorbed, not necessarily labor movement involved.

transportation service were significant contributors through sectoral productivity growth, while construction, and financial and government services negatively contributed, explaining only 61.3% of aggregate productivity growth. Although manufacturing shrank in labor share, financial service and trade absorbed labor significantly, the total reallocation effect being as large as 38.7% of total aggregate productivity growth. As a consequence, financial service, again, dominantly contributed (by 68% of the total) to aggregate productivity growth, but only through reallocation in this period, because its productivity growth was slightly less than zero. By contrast, manufacturing contributed through sectoral productivity growth (52% of aggregate growth), but negatively contributed through reallocation (-38%) along with de-industrialization.

In the *Great Moderation* period of 1990-2010, manufacturing, and financial and trade services, followed by transportation service, were major contributors through sectoral productivity growth with construction being a negative contributor, explaining more than 100% of the aggregate productivity. In this period, the reallocation effect on aggregate productivity growth turned out to be negative, because declining manufacturing and other sectors' labor share could not be fully absorbed by growing government and financial services in this period. As a consequence, financial service remained dominant contributor (by 51% of the total), followed by trade (28%) and then government service (11%). Manufacturing's contribution through sectoral productivity growth (44%) was almost offset by its negative contribution through reallocation (-37%).

To sum up: In the postwar period of 1950-1970, our result revealed that the US' aggregate productivity growth (2.04%) was led primarily by financial service through both sectoral productivity growth and reallocation, while supported by shrinking manufacturing through sectoral productivity growth and by expanding government service through reallocation or labor absorption. Then, during the slower growth (0.8%) in 1970-1990, while shrinking manufacturing continued to contribute only through sectoral productivity growth, financial service contributed primarily, mostly through reallocation, supported by trade through both sectoral productivity growth and reallocation. In the Great Moderation period of 1990-2010, financial service remained leading in growth contribution through both sectoral productivity growth and reallocation supported by trade and government service, while manufacturing's growth contribution reduced to the third, following financial service, trade and government service.

Overall, while manufacturing remained a steady and important contributor to aggregate productivity growth through sectoral productivity growth, financial service remained the leading contributor through both sectoral productivity growth and reallocation, supported occasionally by government service and trade in the US' de-industrialization. In a word, our decomposition confirmed that the de-industrializing US had already shifted from an industrial to a financial state in the early postwar period.

Japan

Starting from the GDP per capita of as low as US$2,805 (1950 at 2005 constant price, market exchange rate), the aggregate labor productivity growths of Japan were 6.83%, 3.69% and 1.29% for the periods of 1953-1970, 1970-1990 and 1990-2010, respectively (Table 2). Initially in 1953, sectoral labor shares were largest in agriculture (42%), followed by manufacturing (17%) and trade service (15%), and relatively small in mining and utilities (more or less than 1%), but the manufacturing share increased to 26% in 1973, stay around there until the early1990s, and then started declining to less than 15%, while agriculture's share kept declining to 5% (2010), and trade, government and financial services' shares grew to 23%, 21% and 14%, respectively (Figure 5).

Table 2: Productivity growth decomposition, Japan, 1953-2010

jpn											
1953-1970	**agr**	**mining**	**manu**	**util**	**const**	**trade**	**transp**	**fin/b-serv**	**g-serv**	**p-serv**	**total**
productivity growth	0.0491	0.1356	0.0851	0.0996	0.0517	0.1022	0.0892	0.0169	0.0261	0.0241	**0.0683**
initial relative productivity	0.3224	0.6446	0.7673	2.5476	2.5688	0.3378	1.0485	1.9747	3.6318	3.8117	
initial labor share	0.4194	0.0163	0.1678	0.0049	**0.0480**	**0.1461**	0.0461	0.0371	0.0943	0.0201	
labor share change	**-0.2309**	-0.0113	**0.0758**	0.0000	**0.0290**	**0.0620**	0.0085	0.0334	0.0241	0.0094	
contribution ratio:											
sectoral growth	0.0819	0.0389	**0.1867**	0.0242	**0.0806**	**0.1005**	0.0763	0.0116	**0.0907**	0.0184	0.7098
reallocation	-0.0810	-0.0305	**0.1123**	0.0002	**0.0847**	**0.0528**	0.0183	0.0422	**0.0653**	0.0260	0.2902
1970-1990	**agr**	**mining**	**manu**	**util**	**const**	**trade**	**transp**	**fin/b-serv**	**g-serv**	**p-serv**	**total**
productivity growth	0.0394	0.0440	0.0436	0.0296	0.0146	0.0530	0.0252	0.0462	0.0162	0.0053	0.0369
initial relative productivity	0.2367	1.8200	1.0003	4.1589	1.9687	0.5740	1.4579	0.8533	1.8301	1.8563	
initial labor share	0.1884	0.0050	0.2436	0.0049	0.0770	0.2082	0.0546	0.0704	0.1183	0.0295	
labor share change	-0.1019	-0.0032	-0.0174	0.0012	0.0173	0.0222	0.0014	0.0406	0.0147	0.0251	
contribution ratio:											
sectoral growth	0.0488	0.0116	**0.3084**	0.0152	0.0477	**0.2029**	0.0482	**0.0828**	**0.0773**	0.0057	0.8486
reallocation	-0.0490	-0.0130	**-0.0384**	0.0086	0.0428	**0.0336**	0.0032	**0.0803**	**0.0347**	0.0486	0.1514
1990-2010	**agr**	**mining**	**manu**	**util**	**const**	**trade**	**transp**	**fin/b-serv**	**g-serv**	**p-serv**	**total**
productivity growth	0.0250	-0.0064	0.0318	0.0140	-0.0122	0.0124	0.0147	0.0123	0.0015	-0.0018	0.0129
initial relative productivity	0.2481	2.0860	1.1375	3.6093	1.2727	0.7807	1.1611	1.0191	1.2228	0.9990	
initial labor share	0.0865	0.0018	0.2262	0.0062	0.0944	0.2303	0.0560	**0.1111**	**0.1330**	0.0546	
labor share change	-0.0374	-0.0010	**-0.0807**	0.0014	-0.0102	-0.0073	0.0048	**0.0336**	**0.0770**	0.0196	
contribution ratio:											
sectoral growth	0.0469	-0.0015	**0.7662**	0.0243	-0.0890	**0.1725**	**0.0753**	**0.1067**	**0.0164**	-0.0067	1.1109
reallocation	-0.0519	-0.0062	**-0.5871**	0.0229	-0.0347	**-0.0249**	**0.0256**	**0.1494**	**0.3313**	0.0647	-0.1109

Note: same as in Table 1.

Apparently, Japan attained her postwar rapid growth through industrialization toward the 1970s and then plunged into de-industrialization in the 1990s. Accordingly, in contrast to the US, resources shifted from agriculture to manufacturing and services at first, then from agriculture to services, and then switched from agriculture and manufacturing toward services, particularly financial (and business) services and then government service (the latter being in response to population aging to the present). This is a process of typical industrialization and de-industrialization among late industrializers, indeed Japan started industrialization in the early 20th century.

Throughout this process of industrialization and then de-industrialization, sectoral labor productivity growths were steadily high in manufacturing (8.5, 4.2, 3.2%) and agriculture (4.9, 3.9, 2.5%). By contrast, while sectoral productivity growths were high in trade, transportation and financial services until the 1980s, they slowed down since the 1990s or during the *lost decades*. Relative sectoral productivity levels converged between lower manufacturing and trade service and higher construction and government and private services.

Our decomposition of aggregate productivity growth shows somewhat alternate contributing sectors to aggregate productivity growth across the three periods. During the postwar rapid growth (6.9%) period of 1953-1970, manufacturing was a leading contributor through both sectoral productivity growth and reallocation. Manufacturing contributed through sectoral productivity growth, followed by government service, trade, agriculture, and construction, explaining 71% of the aggregate productivity growth. While agriculture and mining shrank in labor share, manufacturing absorbed labor significantly, followed by construction, and government and trade services. As a consequence, the total reallocation effect amounted to 29% of aggregate productivity growth.

Under a moderate productivity growth (3.7%) during 1970-1990, manufacturing and trade service were, respectively, primary and secondary contributors through sectoral productivity growth, followed by financial and government services as well as by agriculture, transportation service and construction, explaining 84.9% of aggregate productivity growth. Although agriculture continued to and manufacturing began to shrink in labor share, financial and private services, construction and government and trade services absorbed labor significantly, the total reallocation effect being 15.1% of total aggregate productivity growth. As a consequence, manufacturing remained a leading contributor to aggregate productivity growth, but only through sectoral productivity growth, supported by trade and financial service.

Finally, in the lost decades of 1990-2010 with mere 1.3% aggregate productivity growth, only manufacturing barely supported aggregate productivity growth through sectoral productivity growth (3.2%), with construction being a negative contributor. In this period, the reallocation effect on aggregate productivity growth turned out to be negative, because significant declines in agriculture and manufacturing labor shares could not be absorbed by growing financial, government and private services. As a consequence, manufacturing ceased to be a leading contributor anymore, and financial and government services took leading contributors' positions mainly through reallocation, rather than sectoral productivity growth.

To sum up: Japan's postwar rapid growth period of 1953-1970 was characterized by classical industrialization with manufacturing expansion and agricultural shrinkage through both sectoral productivity growth and labor reallocation. Japan reached a plateau of industrialization around 1970 and remained there until it started de-industrialization in the 1990s. its de-industrialization, then, went along with a secular slowdown in productivity growth, termed *Japanization*. While manufacturing remained a steady and important contributor to aggregate productivity growth through sectoral productivity growth, financial and government services replaced manufacturing, becoming more significant contributors mainly through reallocation. Japan clearly follows the wake of the US as one of income convergers and de-industrializers, but only at a slower pace.

Korea

Starting from the GDP per capita of US$2,210 (1970, at 2005 constant price, market exchange rate), the aggregate labor productivity growths of Korea were 3.93% and 3.21% for the periods of 1970-1990 and 1990-2010, respectively (Table 3). Initially in 1970, sectoral labor shares were largest in agriculture (49%), followed by trade service (15%) and manufacturing (14%), and relatively small in mining and utilities (more or less than 1%), but the manufacturing share peaked out at 28% in 1988 and then declining quickly to 18% (2010), while agriculture's share kept declining to 7%, and trade, government/private and financial services' shares kept increasing to 24%, 22% and 14%, respectively.

Apparently, Korea started industrialization in the 1960s with doubling manufacturing labor share during 1970-1990 and then began to de-industrialize around 1990 (Figure 6). Resources shifted from agriculture to manufacturing and services at first and then immediately switched from agriculture and manufacturing toward services, in contrast to postwar Japan, particularly financial (and business) and government/private services. This appeared to be a more compressed process of industrialization and de-industrialization than that in postwar Japan.

Throughout this compressed process of industrialization and then de-industrialization, sectoral labor productivity growths were steadily high in manufacturing (6.0, 7.6%), agriculture (4.5, 4.8%) and transportation. But they were modest in construction, and negative in financial service, despite their relatively higher productivity levels, throughout the periods. Consequently, sectoral productivity levels appeared to converge among major sectors except for manufacturing (Figure 5).

Table 3: Productivity growth decomposition, Korea, 1970-2010

kor											
1970-1990	**agr**	**mining**	**manu**	**util**	**const**	**trade**	**transp**	**fin/b-serv**	**g-serv**	**p-serv**	**total**
productivity growth	0.0446	0.0460	0.0601	0.1047	0.0208	0.0328	0.0521	-0.0287	0.0000	0.0071	**0.0393**
initial relative productivity	0.3337	1.3076	0.5703	1.1963	2.3847	0.7090	0.7416	7.3415	0.0000	3.4355	
initial labor share	0.4905	0.0108	0.1364	0.0024	0.0301	0.1531	0.0359	0.0130	0.0000	0.1279	
labor share change	-0.3200	-0.0066	0.1376	0.0015	0.0450	0.0670	0.0156	0.0400	0.0000	0.0199	
contribution ratio:											
sectoral growth	0.1962	0.0177	**0.1483**	0.0158	**0.0314**	**0.0847**	0.0404	**-0.0363**	0.0000	**0.0572**	0.5556
reallocation	-0.2200	-0.0182	**0.2172**	0.0111	**0.1396**	**0.0780**	0.0276	**0.1414**	0.0000	**0.0678**	0.4444
1990-2010	**agr**	**mining**	**manu**	**util**	**const**	**trade**	**transp**	**fin/b-serv**	**g-serv**	**p-serv**	**total**
productivity growth	0.0483	0.0704	0.0756	0.0733	0.0031	0.0229	0.0431	-0.0237	0.0000	0.0010	0.0321
initial relative productivity	0.3693	1.4887	0.8481	4.0600	1.6648	0.6254	0.9483	1.8984	0.0000	1.8306	
initial labor share	0.1704	0.0042	0.2740	0.0039	0.0751	0.2201	0.0516	0.0530	0.0000	0.1478	
labor share change	-0.1014	-0.0035	-0.0920	-0.0008	0.0043	0.0180	0.0131	0.0876	0.0000	0.0746	
contribution ratio:											
sectoral growth	0.1120	0.0207	**0.8686**	0.0557	0.0090	**0.0892**	**0.0736**	**-0.0435**	0.0000	**0.0059**	1.1911
reallocation	-0.1091	-0.0232	**-0.3800**	-0.0150	0.0086	**0.0201**	**0.0328**	**0.1168**	0.0000	**0.1578**	-0.1911

Note: same as in Table 1.

Our decomposition of aggregate productivity growth shows somewhat alternate contributing sectors to aggregate productivity growth across the two periods. During the higher growth period of 1970-1990, agriculture (mainly due to its large initial labor share) and manufacturing were major contributors through sectoral productivity growth, followed by trade as well as government/private service and transportation, with financial service being a negative contributor, explaining 56% of the aggregate productivity growth. While agriculture rapidly shrank in labor share, growing manufacturing, financial service and construction absorbed labor. As a consequence, the total reallocation effect to the aggregate productivity growth amounted to 44% of aggregate productivity growth. As a consequence, manufacturing played as the dominant contributor to aggregate productivity growth through both sectoral productivity growth and reallocation (by 15+22=36% of the total), supported by construction (17%), trade (16%) and government/private services (13%). This was really the period of significant structural transformation under rapid industrialization, being comparable with the postwar Japan.

Under a bit moderate productivity growth during 1990-2010, suffering from the Asian Financial Crisis in 1997, manufacturing remained as the dominant contributor through sectoral productivity growth, complemented by trade and transportation, with financial service again being a negative contributor, explaining more than 100% of aggregate productivity growth. While agriculture and then manufacturing shrank in labor share, expanding government/private and financial services could not absorb labor enough, the total reallocation effect being negative. As a consequence, manufacturing remained dominant (by 87-38=49% of the total) in growth contribution, supported by government/private services (16%), trade (11%), transportation (10%) and financial service (8%).

To sum up: Korea's high growth period of 1970-1990 was also classical industrialization with manufacturing's expansion through both sectoral productivity growth and labor reallocation along with agriculture's sharp shrinkage in labor share. Once it reached a peak of industrialization toward the end of the 1980s, Korea immediately started de-industrialization, in contrast to Japan, who remained at her plateau for two decades, 1970-1990. While manufacturing started to shrink in labor share in the 1990s, it remained a dominant contributor to aggregate productivity growth through sectoral productivity growth, with government/private services and financial service supporting through reallocation by expanding labor absorption. Korea's industrialization in 1970-1990 and then de-industrialization in 1990-2010 appears as a compressed industrial structural transformation with productivity growth, compared to Japan.

China

Starting from the GDP per capita of as low as US$1,293 (1970, at 2005 constant price, market exchange rate), the aggregate labor productivity growth of China was 3.66% and 9.71% for the periods of 1970-1990 and 1990-2010, respectively (Table 4). Initially in 1970, sectoral labor shares were largest in agriculture (81%), followed by manufacturing (8%) and government service (3%), and relatively small in financial service and utilities (less than 1%). Undoubtedly, China was a totally agricultural society in 1970. Nevertheless, its pace of declining labor share in agriculture since then has been relatively modest, being still slightly less than by one half (from 81 to 37%) over the past 4 decades as compared to by one eighth (from 42 to 5%) over 6 decades in Japan and by one seventh (from 49 to 7%) over just 4 decades in Korea. Almost 10 years after the Reform and Opening-up policy advocated in 1979, its GDP per capita was US$2,427 (1990), being not much different from that of Korea (US$2,210) in 1970, around when Korea had already started rapid industrialization.

Table 4: Productivity growth decomposition, China, 1970-2010

chn											
1970-1990	agr	mining	manu	util	const	trade	transp	fin/b-serv	g-serv	p-serv	total
productivity growth	0.0242	0.0194	0.0257	0.0092	-0.0204	0.0077	0.0208	0.0645	0.0317	-0.0079	0.0366
initial relative productivity	0.6662	2.5661	1.7462	11.2670	4.1381	3.7321	2.9646	4.7231	1.6245	1.2597	
initial labor share	0.8077	0.0107	0.0778	0.0014	0.0122	0.0234	0.0154	0.0065	0.0329	0.0120	
labor share change	-0.2067	0.0069	0.0711	0.0018	0.0320	0.0365	0.0177	0.0031	0.0135	0.0241	
contribution ratio:											
sectoral growth	**0.3131**	0.0122	**0.0852**	0.0030	-0.0162	**0.0137**	0.0220	0.0720	0.0440	-0.0021	0.5470
reallocation	**-0.2108**	0.0248	**0.1957**	0.0226	0.0833	**0.1509**	0.0750	0.0483	0.0387	0.0246	0.4530
1990-2010	agr	mining	manu	util	const	trade	transp	fin/b-serv	g-serv	p-serv	total
productivity growth	0.0571	0.1376	0.1136	0.0938	0.0741	0.0679	0.0921	0.0790	0.1001	0.0409	**0.0971**
initial relative productivity	0.5233	1.8331	1.4120	6.5844	1.3346	2.1186	2.1769	8.0286	1.4771	0.5230	
initial labor share	0.6010	0.0177	0.1489	0.0032	0.0443	0.0599	0.0331	0.0095	0.0464	0.0361	
labor share change	-0.2340	-0.0049	0.0428	0.0018	0.0333	0.0369	0.0070	0.0047	0.0112	0.1012	
contribution ratio:											
sectoral growth	0.1191	0.0734	**0.2973**	0.0195	0.0349	**0.0642**	**0.0645**	**0.0509**	**0.0732**	0.0043	0.8014
reallocation	-0.0692	-0.0218	**0.0968**	0.0130	0.0345	**0.0540**	**0.0165**	**0.0321**	**0.0207**	0.0219	0.1986

Note: same as in Table 1.

In fact, China started industrialization since the 1980s, doubling manufacturing's labor share, with more than doubling those in construction, trade and private services in the period of 1970-1990. In the next two decades of 1990-2010, its export-oriented industrialization accelerated with aggregate productivity growth at almost 10% a year, just like post-war Japan, when resources shifted from agriculture to manufacturing and services, particularly to construction, trade and transportation services and government and private services (but not to financial service, all through the two periods).

As compared to the latter period, sectoral labor productivity growths in manufacturing (2.6%) as well as in agriculture (2.4%), and government service (3.2%) and transportation (2.1%) were modest in the first period of 1970-1990. In fact, although manufacturing was a leading contributor to aggregate productivity growth, it was not mainly through sectoral productivity growth (contribution of 8.5%), but mainly through (static) reallocation from agriculture (19.6%), followed by trade through reallocation there too (15.1%). Manufacturing could be said to be still in an infantry.

Sectoral productivity growths almost exploded in the period of 1990-2010, the most in manufacturing (11.4%), closely followed by government (10%) and transportation services (9.2%), and then by mining, financial service, construction, trade service and then agriculture (5.7%). There appeared no symptom of convergence in relative sectoral productivity levels among sectors, though (Figure 5).

All in all, our decomposition of aggregate productivity growth shows alternate contributing sectors to aggregate productivity growth across the two periods. During the initial modest growth period of 1970-1990, agriculture was a major contributor (31.3%) through sectoral productivity growth, simply because of its largest labor share, followed by manufacturing (8.5%) and financial service, explaining 55% of the aggregate productivity growth. While agriculture steadily shrank in labor share, growing manufacturing and trade absorbed labor, supported by construction, transportation and financial service. As a consequence, the total reallocation effect to the aggregate productivity growth amounted to 45% of aggregate productivity growth. This period was the period of slow (compared to Japan and Korea), but significant structural transformation with relatively modest productivity growth, when manufacturing played a leading role by 9+20=29% of the total in growth contribution, supplemented by trade (16%) and agriculture (31-21=10%).

Under an explosive productivity growth during 1990-2010, manufacturing was the most dominant contributor (29.7%) to the aggregate productivity growth through sectoral productivity growth, followed by agriculture (11.9%), mining, and government, transportation, trade and financial services, explaining more than 80% of aggregate productivity growth. Against a relatively modest decline in agriculture's labor share, growing manufacturing, trade and other services absorbed labor more than enough. The total reallocation effect to the aggregate productivity growth was as large as 20% of aggregate productivity growth. As a consequence, manufacturing played the dominant contributor to aggregate productivity growth through both sectoral productivity growth and reallocation (by 30+10=40% of the total), followed by trade (11%), government service (9%) and financial service (8%). This period was really the period of continued structural transformation, this time, under rapid industrialization.

To sum up: China started substantial industrialization in the 1990s at the lowest initial labor productivity level among the three industrializers in East Asia in the post-WWII period. As a matter of fact, if we carefully look at her manufacturing's labor share since the 1970s, it once peaked out in the late 1980s, stayed on a plateau, then declined in the late 1990s (possibly due to Asian Financial Crisis in 1997-98) and resumed rising toward the end of 2000s (Figure 3, Figure 5).

In the meantime, however, we observe significantly higher productivity growths in most sectors other than agriculture since the 1990s onward (Figure 5), i.e. 11.4% in manufacturing particularly and 7-10% in services in the 1990s (Table 4). This is the reason why we find remarkable aggregate productivity growth of 9.7% for the period.

Apparently, relying on GGDC 10-sector database for the period of 1950-2011, *de-industrialization* is not yet a term in the Chinese dictionary, at least until the Global Financial Crisis in 2008.

Note here again that China was a totally agricultural society in 1970 and its agriculture's labor share was 60% in 1990. Nevertheless, its pace of declining labor share in agriculture since then has been relatively modest compared to those of Japan and Korea. In other words, sectors with higher productivity growth tend to have smaller labor shares in China, relative to prior industrializers in East Asia.

3. ADDITIONAL RESULTS ON RECENT DEVELOPMENTS FROM NEW DATABASES

3.1 Recent trends of structural transformation based on GGDC ETD, 1990-2018

In the GGDC 10 sector database so far, 'finance sector' includes finance, insurance, real estate and business service. GGDC released the Economic Transformation Database (ETD) in 2021, which also covers internationally comparable sectoral data on output and employment with more disaggregated 12 sectors, but only in 51 economies in Africa, Asia, and Latin America for the period of 1990 to 2018. Notably, this database re-organized a previous financial service sector into three sectors, i.e. finance (including insurance), real estate and business service[10]. Accordingly, we can identify individual contributions of these disaggregated, three new service sectors to aggregate productivity growth during the more recent decades in the ETD data. Note that business service includes information and communication (ICT)[11], professional, scientific and technical activities, and then administrative and support service activities, which are regarded as today's frontier innovative services. For a comparability with the previous long-term result above, we look at two periods between 1990-2010 and 2008-2018, the latter of which is to focus on the post-GFC influence. In fact, we witness visible slowdowns in aggregate productivity growths in each economy then.

As to the decomposition results, we refer to three economies, namely, China, Japan, and Korea, since US is not included in the ETD unfortunately. Just for comparison, we

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[10]**Business services**: Information and communication; Professional, scientific and technical activities; Administrative and support service activities, **Financial services**: Financial and insurance activities, **Real estate**: Real estate activities, **Government services**: Public administration and defense; compulsory social security; Education; Human health and social work activities, **Other services**: Arts, entertainment and recreation; Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; Activities of extraterritorial organizations and bodies.

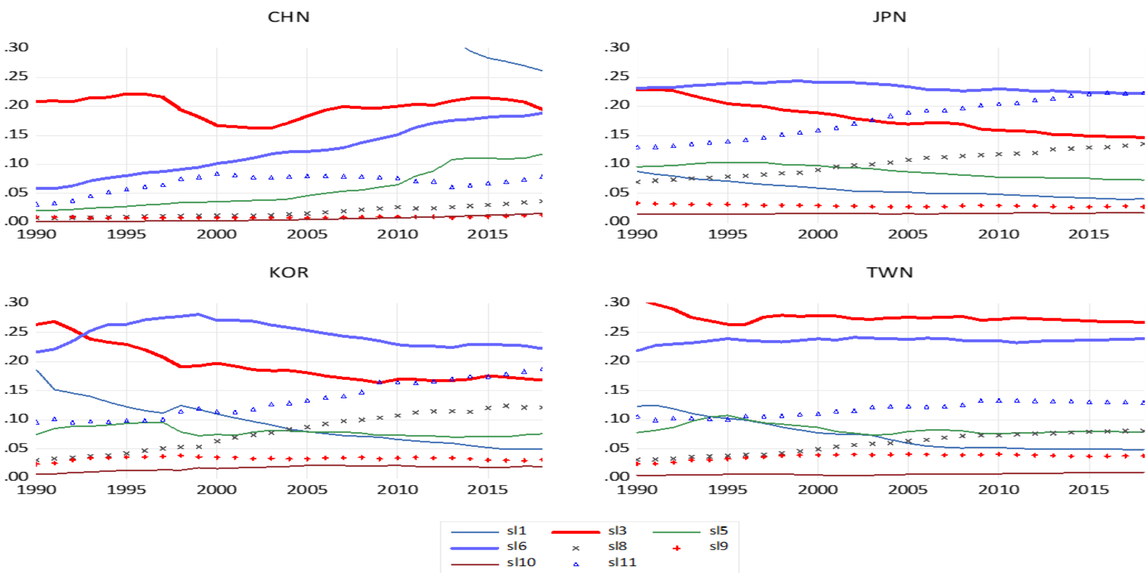
[11] Note that transportation in ETD is now excluding ICT.

add Taiwan in graphs only, which took similar growth path to Korea as a postwar industrializer, but slightly different from Korea in the past as well as to the present.

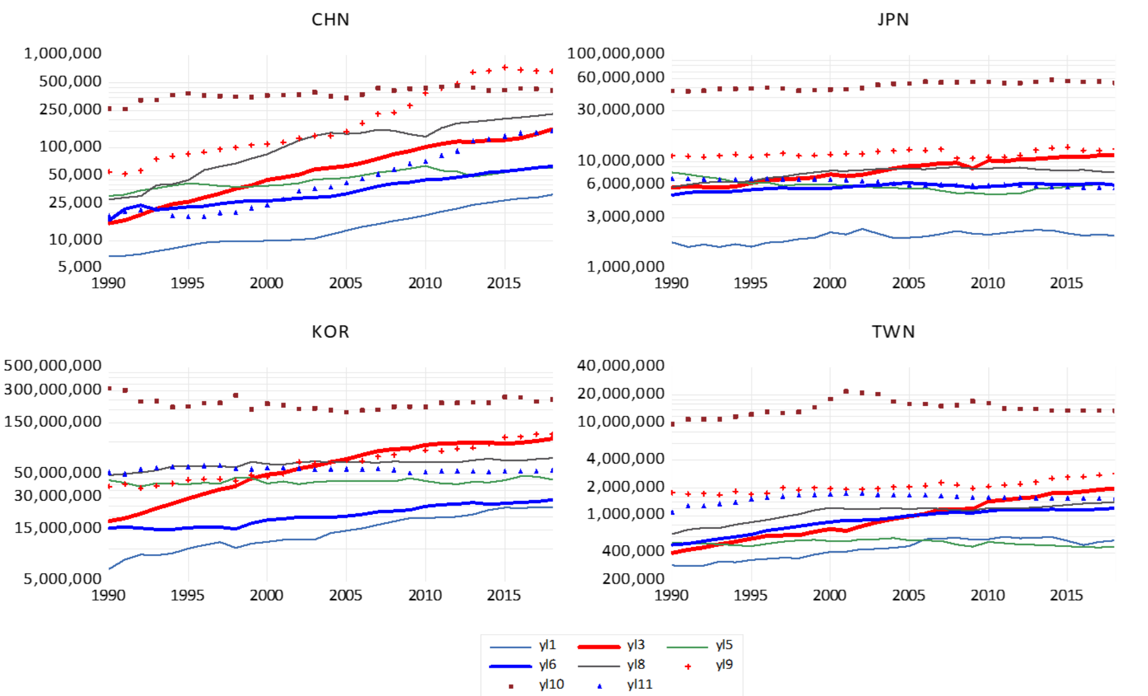
Figure 6, Panel a shows sectoral labor shares of the four economies, 1900-2018.

Figure 6: Sectoral labor share and productivity, 1990-2018

a. Sectoral labor share



b. Sectoral labor productivity



Note: Labor shares: sl1: agriculture, sl3: manufacturing, sl5: construction, sl6: trade, sl8: business service, sl9: finance, sl10: real estate, sl11: government service. Labor productivity = value added/ employment, constant local currencies. yl1: agriculture, yl3: manufacturing, yl5: construction, yl6: trade, yl8: business service, yl9: finance, yl10: real estate, yl11: government service.

We picked up eight major sectors, i.e. agriculture, manufacturing, construction, trade (wholesale, retail, hotels and restaurants), finance, real estate, business service, and government service. In industrializing China, reallocation is mostly from agriculture to trade and government service in the 1990s, to trade and construction in the 2000s, but not from manufacturing nor to manufacturing[12]. In de-industrializing Japan and Korea, reallocation is explicitly from manufacturing and agriculture to government and business services, but not to (narrow) finance, which is revealed only by ETD. We detect some non-monotonous labor-share changes in manufacturing and real estate in China, in trade, construction and finance in Korea, so that we should be careful in interpreting the result of our productivity growth decomposition.

Similarly, Figure 6, Panel b shows sectoral labor productivity levels of the same sectors of the four economies in the same period, at constant 2015 national prices in logarithm. Sectoral labor productivities show positive growth except for government service in Japan and real estate in Korea. Manufacturing's labor productivity growths (slopes of curves) are again generally higher than the other sectors across the economies. While finance's productivity is relatively high in levels but slow in growths, business service's is very slow in growths in Japan and Korea. In contrast, both are high in both levels and growths in China. Although we do not see any symptom of convergence in labor productivity among some sectors across economies, all sectoral labor productivity levels varied generally smoothly during the period.

Now we go into the result of productivity growth decomposition of three economies one by one: first, Japan, a typical de-industrializing industrializer, second, Korea, a typical late de-industrializing, industrializer and, third, China, a latest industrializer. We must note at the outset that the period of 2008-2018 may not be very suitable to discuss long-run structural transformation, not only because it is too short, but it suffers from post-GFC secular stagnation.

Japan

Table 5 shows the result of growth decomposition of Japan, which shows the metrics of sectoral components and contributions just like in the previous section. Japan's aggregate productivity growth was 0.94% for 1990-2010 based on ETD (2015 constant price), which is lower than 1.29% based on 10 sector database (2005 constant price). As a parallel result, we see lower sectoral productivity growth in general and particularly in agriculture and transportation.

[12] We can confirm this with the help of following decomposition results on individual economies in Tables 5-7.

Table 5: Productivity growth decomposition, Japan, 1990-2018, 12 sectors

jpn													
1990-2010	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	0.0087	-0.0196	0.0298	0.0093	-0.0232	0.0092	-0.0007	-0.0015	0.0100	0.0201	-0.0073	-0.0144	0.0094
initial relative productivity	0.2582	2.4739	0.8453	6.5380	1.1731	0.7184	1.1926	1.6785	6.8113	0.8566	1.0194	1.0692	
initial labor share	0.0879	0.0015	0.2285	0.0062	0.0960	0.2316	0.0482	0.0333	0.0146	0.0698	0.1300	0.0526	
labor share change	-0.0395	-0.0010	**-0.0697**	0.0005	-0.0179	-0.0015	0.0019	-0.0041	0.0014	**0.0477**	**0.0734**	0.0086	
contribution ratio:													
productivity growth	0.0235	-0.0068	**0.8455**	0.0447	-0.2307	**0.1821**	-0.0041	-0.0090	**0.1192**	**0.1599**	**-0.0991**	-0.0775	0.9475
reallocation	-0.0663	-0.0090	**-0.5804**	0.0213	-0.0721	**-0.0071**	0.0120	-0.0362	**0.0651**	**0.3334**	**0.3540**	0.0378	0.0525
2008-2018	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	-0.0097	-0.0759	0.0173	-0.0372	0.0173	0.0011	-0.0055	0.0204	-0.0010	-0.0112	-0.0049	-0.0140	0.0012
initial relative productivity	0.2793	1.9137	1.2147	7.0637	0.6314	0.7441	1.0864	1.3434	6.9017	1.1091	0.7415	0.6925	
initial labor share	0.0501	0.0006	0.1692	0.0064	0.0820	0.2263	0.0493	0.0288	0.0154	0.1145	0.1968	0.0605	
labor share change	-0.0093	0.0000	-0.0229	-0.0003	-0.0086	-0.0040	-0.0024	-0.0016	0.0016	0.0205	0.0257	0.0013	
contribution ratio:													
productivity growth	-0.1126	-0.0571	**3.3344**	-1.2385	0.8363	0.1603	-0.2476	0.7467	**-0.0884**	**-1.1677**	**-0.6028**	-0.4763	1.0865
reallocation	-0.2039	0.0015	**-2.8529**	-0.1310	-0.5542	-0.2634	-0.2157	-0.2316	**0.9722**	**1.7549**	**1.5716**	0.0659	-0.0865

Note: agr: agriculture, min: mining, manu: manufacturing, util: electricity, gas, water supply. const: construction, trade: trade & commerce, transp: transportation, finance: finance & insurance, r-estate: real estate, b-serv: business service, g-serve: government service, p-serve: private service. Data: GGDC ETD.

In the 10 sector database, its broadly defined finance sector significantly contributed to aggregate growth through both sectoral productivity growth and reallocation (labor absorption), following government service in 1990-2010 (Table 2).

In contrast, ETD reveals that, first, its narrowly defined financial service did not contribute to aggregate productivity growth, but, second, real estate did contribute through sectoral productivity growth (by 12% of the total), and, third, business service *including ICT* here did so through both sectoral productivity growth (16%) and reallocation (33%), which is almost as comparable to government service, as shown by Table 5. In other words, ETD revealed that business service, not financial service, replaced manufacturing as the leader of aggregate productivity growth under de-industrialization in the period of 1990-2010.

Despite the post-GFC slowdown in aggregate productivity growth from 0.94% (1990-2010) to mere 0.12% (2008-2018), structural transformation or de-industrialization of Japan continued in this period. Namely, sectoral productivity growth effects were led only by manufacturing, and reallocation effects led by business and government services were not enough, resulting in negative aggregate reallocation effect. As a consequence, ETD revealed that, in the post-GFC period of 2008-2018, government service and business service barely led aggregate productivity growth only through reallocation in Japan[13].

Korea

In contrast to Japan, Korea's aggregate productivity growth for 1990-2010 was higher in ETD (4.63%) than in 10 sector database (3.21%), while we see higher sectoral productivity growths in manufacturing, agriculture, while lower growths in transportation in ETD (Table 6).

Table 6: Productivity growth decomposition, Korea, 1990-2018, 12 sectors

kor													
1990-2010	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	0.0568	0.0511	0.0858	0.0631	-0.0007	0.0239	0.0312	0.0398	-0.0199	0.0147	0.0006	0.0233	0.0463
initial relative productivity	0.2671	1.9081	0.7474	3.3459	1.8052	0.6429	0.8742	1.5858	13.1265	2.0219	2.1181	0.6091	
initial labor share	0.1858	0.0045	0.2638	0.0065	0.0744	0.2165	0.0458	0.0237	0.0061	0.0305	0.0950	0.0474	
labor share change	-0.1198	-0.0036	-0.0941	-0.0005	-0.0008	0.0128	0.0078	0.0104	0.0154	0.0769	0.0690	0.0264	
contribution ratio:													
productivity growth	0.0794	0.0116	**0.6557**	0.0415	-0.0014	0.0666	0.0269	0.0353	**-0.0210**	**0.0166**	**0.0021**	0.0134	0.9268
reallocation	-0.0766	-0.0148	**-0.2898**	-0.0042	-0.0012	0.0105	0.0100	0.0286	**0.1077**	**0.1652**	**0.1175**	0.0203	0.0732
2008-2018	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	0.0302	-0.0193	0.0224	-0.0010	0.0040	0.0246	0.0173	0.0454	0.0154	0.0077	-0.0012	0.0132	0.0187
initial relative productivity	0.3511	2.5406	1.6729	4.5078	0.8326	0.4390	0.7215	1.4716	4.1786	1.2745	1.0581	0.4054	
initial labor share	0.0714	0.0010	0.1686	0.0066	0.0769	0.2406	0.0528	0.0351	0.0206	0.0998	0.1472	0.0795	
labor share change	-0.0215	-0.0003	-0.0004	0.0007	-0.0011	-0.0182	-0.0004	-0.0037	-0.0009	0.0212	0.0394	-0.0148	
contribution ratio:													
productivity growth	0.0427	-0.0022	**0.3448**	-0.0014	0.0128	0.1432	0.0351	0.1421	0.0701	**0.0499**	**-0.0095**	0.0223	0.8499
reallocation	-0.0500	-0.0028	**-0.0044**	0.0150	-0.0045	-0.0501	-0.0016	-0.0423	-0.0216	**0.1434**	**0.2026**	-0.0337	0.1501

Note: same as in Table 5.

In the 10 sector database, its broadly defined finance sector significantly contributed to aggregate growth through reallocation effect by 12% of the total, while significantly and negatively did so through sectoral productivity growth effect (-4%) in 1990-2010 (Table 3).

In contrast, ETD reveals that, first, out of the broadly defined financial service in 10 sector database, business sector did dominantly contribute through both sectoral productivity and reallocation effects (2% and 17% each), second, narrowly defined financial service also contributed in the same way but to the limited extent (4% and 3%), and, third, real estate contributed only through reallocation effect (-2% and 11%), as

[13] Note here that, because aggregate productivity growth is near zero, contributions of each component become unstable.

shown by Table 6. We also note from the Table that government service followed business service in contributing to aggregate productivity growth through reallocation (12%). As a consequence, while manufacturing contributed by 37% (= 66 - 29), business service and government service did so by as much as 18% and 12% each.

Despite some post-GFC slowdown in aggregate productivity growth from 4.63% (1990-2010) to 1.87% (2008-2018), sectoral productivity growth effects (85% of the total) were led by manufacturing (34%), supported by trade and financial service. However, de-industrialization appeared to stall and resources shifted only from agriculture and trade instead of manufacturing, while total reallocation effects (15%) led by government service (20%) and business service (14%) in this period. As a consequence, ETD revealed that, in the post-GFC period of 2008-2018, manufacturing held its labor share, holding to be a dominant contributor to aggregate productivity growth through sectoral productivity growth, with business and government services supporting through reallocation by expanding labor absorption in Korea.

China

In the period of 1990-2010, the previous GGDC 10 sector database showed that its broadly defined finance sector, whose labor share was mere less than 1%, did contribute to aggregate growth through both sectoral productivity growth and reallocation effects, being not large as 8.3% of the total, but comparable with construction, trade (12%) and government services (9%), mainly due to its high productivity level and its growth (Table 4).

Against this, ETD reveals that, first, its narrowly defined financial service contributed only through sectoral growth, second, real estate only through reallocation effect, third, business service did mostly through reallocation effect (Table 7), but, fourth, their contributions add up to 19%, instead of above 8.3% [14], of the total as against manufacturing's 34.5%.

[14] The gap between the two figures may come from statistical discrepancy between the two data sets and/or from the definition of business service which includes ICT in ETD.

Table 7: Productivity growth decomposition, China, 1990-2018, 12 sectors

chn													
1990-2010	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	0.0516	0.1216	0.0992	0.0988	0.0379	0.0515	0.0334	0.1026	0.0261	0.0811	0.0703	0.1363	**0.0976**
initial relative productivity	0.5715	1.7589	1.2891	2.7181	2.5418	1.3852	3.0672	4.6156	22.1704	2.3232	1.5225	0.2929	
initial labor share	0.6010	0.0117	0.2087	0.0076	0.0206	0.0587	0.0174	0.0095	0.0019	0.0080	0.0311	0.0238	
labor share change	-0.2340	0.0018	-0.0085	0.0006	0.0445	0.0927	0.0258	0.0007	0.0065	0.0186	0.0449	0.0063	
contribution ratio:													
productivity growth	0.1373	0.0422	**0.3482**	0.0267	0.0133	**0.0324**	0.0114	0.0611	0.0066	0.0161	0.0314	0.0190	0.7456
reallocation	-0.0842	0.0071	**-0.0166**	0.0025	0.0547	**0.0806**	0.0351	0.0054	0.0559	0.0473	0.0612	0.0055	0.2544
2008-2018	agr	mining	manu	util	cons	trade	transp	**finance**	**r-estate**	**b-serv**	g-serv	p-serve	total
productivity growth	0.0673	0.0485	0.0640	0.0475	0.0064	0.0435	0.0452	0.1074	-0.0003	0.0423	0.0998	0.1107	0.0713
initial relative productivity	0.3049	3.8489	1.6011	3.0711	1.0625	0.7743	1.2294	4.5050	7.7742	2.8737	1.0896	0.6361	
initial labor share	0.3960	0.0136	0.1974	0.0085	0.0560	0.1374	0.0426	0.0097	0.0069	0.0221	0.0788	0.0309	
labor share change	-0.1349	-0.0052	-0.0026	-0.0003	0.0619	0.0508	0.0049	0.0032	0.0089	0.0143	0.0001	-0.0011	
contribution ratio:													
productivity growth	0.1118	0.0319	**0.2743**	0.0157	0.0040	**0.0569**	0.0294	**0.0783**	-0.0001	**0.0329**	**0.1376**	0.0369	0.8096
reallocation	-0.0796	-0.0323	**-0.0079**	-0.0013	0.0707	**0.0608**	0.0095	**0.0399**	0.0694	**0.0629**	**0.0004**	-0.0021	0.1904

Note: same as in Table 5.

Despite some slowdown in aggregate productivity growth from 9.76% (1990-2010) to 7.13% (2008-2018), major characteristics of structural transformation of China in this post-GFC period appeared qualitatively similar to those in the previous period, Namely, sectoral productivity growth effects (81% of the total) were led by manufacturing (27%) and then government service (14%), supported by finance, trade, private service and business service, while reallocation effects (19%) from agriculture to services led by construction, real estate, business service, and trade, but not by government service in this period. As a consequence, ETD showed that manufacturing remained the (a bit less) dominant contributor to aggregate productivity growth through sectoral productivity growth (but not reallocation as against the previous result), followed by government service, trade, financial service and business service. In other words, de-industrialization was not visible yet in China, the last industrializer[15].

[15] We note that the previous GGDC 10 sector database shows no symptom of de-industrialization, but ETD picked up a slight decline in manufacturing's labor share then and it remained in 2008-2018, which reflected its non-monotonous changes during the period as easily seen in Figure 8. Accordingly,

To sum up: Overall, ETD revealed: Throughout the three economies, business and financial services are steadily increasing importance in both sectoral productivity and reallocation, separately, since the 1990s, although its presence in labor share is minimal in China. Also, in the post-GFC period, while industrialization in China continued, de-industrialization appeared to slow down in Japan and to strand in Korea. The latter may be temporary, but whether industrialization in China maintains or not in the era of de-industrialization remains to be seen.

3.2 Recent medium-run structural transformation based on WIOD Social Economic Accounts, 2000-2014

WIOD Socio Economic Accounts (SEA) published in 2018 provides basic data on sectoral value added, prices and employment as well as gross output and many others across 56 sectors, 43 economies over the period of 2000-2014, which enables us to conduct more disaggregated decomposition of productivity growth. Particularly, we can now go into one new sector, ICT, and 19 subsectors of manufacturing and their individual contributions to aggregate productivity growth, although its time span is a bit shorter than that of ETD. We divide the entire period into two, i.e. pre-GFC period of 2000-2008 and post-GFC period of 2008-2014.

As to the decomposition results, we refer to the four economies we discussed with 10 sector GDCC database, namely, the US, Japan, and Korea, and China, again. Figure 7. Panel a shows sectoral labor shares of the four economies in the period of 2000-2014. For exposition, we summarized 56 sectors into 14, out of which we picked up 6 major sectors, i.e. manufacturing (19 sectors, s5-23, Appendix Table 1), trade (4 sectors, s28-30, s36), ICT (4 sectors, s37-40), finance (3 sectors, s41-43), business service (6 sectors, s45-50), and government service (3 sectors, s51-53)[16]. Reallocation is from manufacturing to government service in the US, from manufacturing to both business and government services in de-industrializing Japan and Korea, while it is from agriculture (not shown) to manufacturing and government service in still industrializing China. Except for non-monotonous changes in manufacturing and trade in China, other sectoral labor shares changed generally monotonously.

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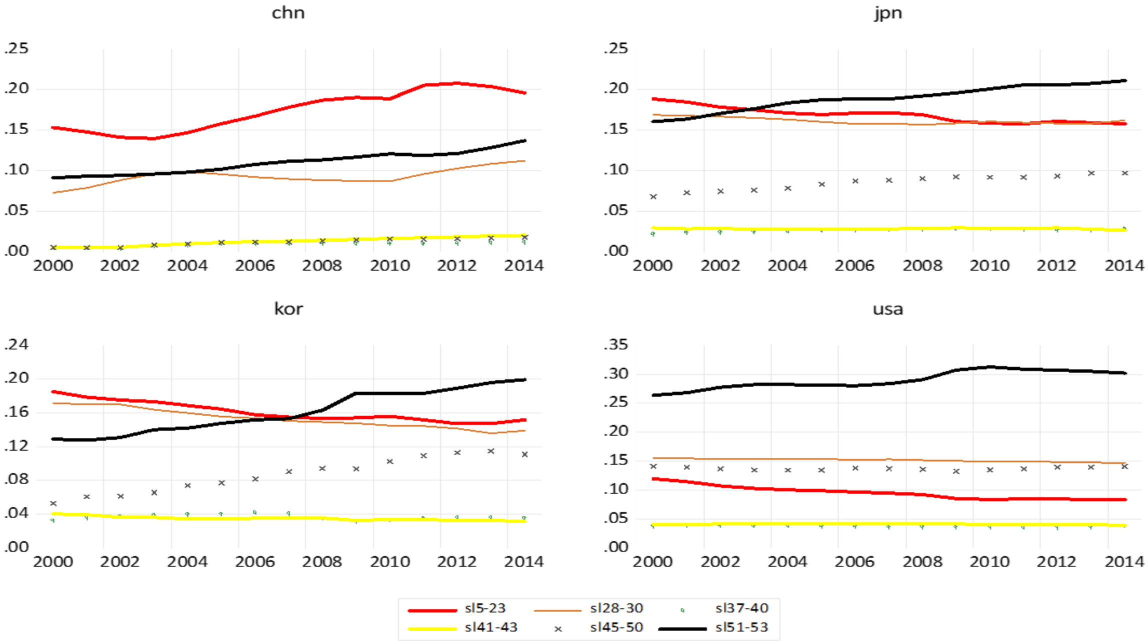
it would be too early to say that this is a symptom of de-industrialization of China.

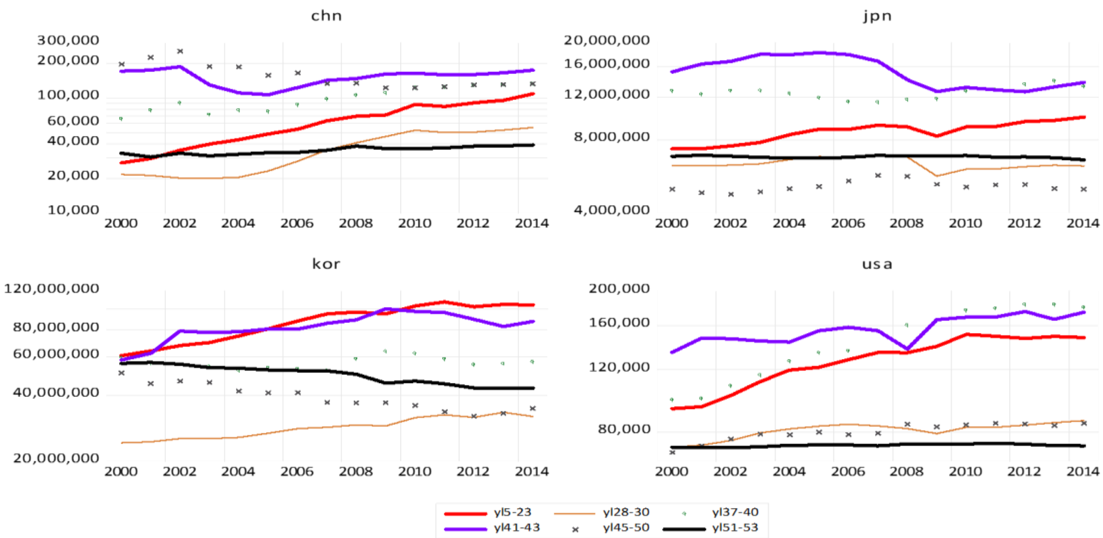
[16] Note that, as compared to ETD, business service is now excluding ICT.

Figure 7: Sectoral labor share and productivity, 2000-2014

a. Sectoral labor share



b. Sectoral labor productivity



Note: Labor shares are sl5-23: manufacturing, sl28-30: trade, sl37-40: ICT, sl41-43: finance, sl45-50: business service, sl51-53: government service. Labor productivities are yl5-23: manufacturing, yl28-30: trade, yl37-40: ICT, yl41-43: finance, yl45-50: business service, yl51-53: government service. Data: World Input-Output Data (WIOD), Socio-Economic Accounts (SEA).

Similarly, Figure 7, Panel b shows sectoral labor productivity of the same sectors of the four economies in the same period, at constant 2010 national prices in logarithm. Except for financial service in the US, Japan and China, sectoral labor productivities in other sectors show no anomaly (non-monotonous changes) in the 2000s, but some significant downturns due to the GFC in 2008-2009. Financial service's labor productivity level is mostly higher than the other sectors, followed by ICT's, but manufacturing's is higher in Korea and business service's is higher in China. As to their growths, manufacturing's labor productivity growths are again generally higher than the other sectors across the economies, except that ICT's is even higher in the US. Except for the post-GFC downturns, all sectoral labor productivity levels varied generally monotonously.

Now we go into the result of productivity growth decomposition of the four economies one by one: Japan, Korea and the United States experienced severe slowdowns in aggregate productivity growths in the post-GFC period, Japan from mere 0.87% (2000-2008) to almost 0% (2008-2014), Korea from 2.13% to 0.73%, and US from 1.42% to 0.95%. Accordingly, we must remember again that the periods of 2000-2008 and 2008-2014 may not be very suitable to discuss long-run structural transformation, not only because it is too short, but it suffers from post-GFC secular stagnation.

United States

Table 8 shows the result of productivity growth decomposition of US for the period of 2000-2008 and 2008-2014. As expected, United States, as one of the most de-industrialized economies, took a different path from the above two de-industrializing economies. In the pre-GFC period of Great Moderation, manufacturing (at 4.68%) led aggregate productivity growth (1.42%), contributing by 43% of the total, only relative to ICT (26%), real estate, business service excluding ICT (17% each) through sectoral productivity growth effect, while government service contributed through reallocation by 17% of the total. As financial service slowed down sharply in 2008 (Figure 11), its contribution to aggregate productivity growth became minimal. As a consequence, government service took the lead by 23% of total in growth contribution through both sectoral productivity growth and reallocation, supported by real estate (21%) and business service (15%) out of previous broad financial service, and also by ICT (20%), followed by manufacturing (43-31=12%).

Table 8: Productivity growth decomposition, US, 2000-2014, 14 summarized sectors

usa															
2000-2008	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0295	-0.0143	0.0468	-0.0122	-0.0271	0.0152	0.0119	-0.0096	0.0626	0.0027	0.0228	0.0233	0.0027	-0.0021	0.0142
initial relative productivity	0.6018	5.2620	1.0708	4.0702	1.0073	0.8338	0.9065	0.4357	1.1348	1.5464	6.9772	0.8052	0.8328	0.6788	
initial labor share	0.0155	0.0035	0.1195	0.0062	0.0573	0.1554	0.0321	0.0688	0.0379	0.0404	0.0149	0.1410	0.2637	0.0438	1.0000
labor share change	-0.0018	0.0012	-0.0276	-0.0001	0.0025	-0.0038	0.0003	0.0078	-0.0015	0.0006	0.0005	-0.0053	0.0271	0.0003	0.0000
contribution ratio of:															
productivity growth	0.0221	-0.0169	**0.4289**	-0.0091	-0.0952	0.1285	0.0305	-0.0186	**0.2619**	0.0123	**0.1722**	**0.1650**	0.0586	-0.0038	1.1365
reallocation	-0.0133	0.0473	**-0.3133**	-0.0151	0.0169	-0.0199	-0.0037	0.0261	-0.0607	0.0066	0.0343	-0.0165	**0.1733**	0.0013	-0.1365
2008-2014	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0254	0.0461	0.0164	-0.0043	0.0086	0.0087	0.0084	-0.0025	0.0198	0.0409	0.0240	0.0011	-0.0020	0.0126	0.0095
initial relative productivity	0.6782	4.1874	1.3787	3.2944	0.7218	0.8401	0.8897	0.3602	1.6468	1.4110	7.4632	0.8644	0.7598	0.5963	
initial labor share	0.0137	0.0047	0.0918	0.0061	0.0598	0.1515	0.0325	0.0765	0.0364	0.0410	0.0154	0.1357	0.2908	0.0441	1.0000
labor share change	0.0009	0.0005	-0.0085	0.0001	-0.0097	-0.0047	0.0007	0.0061	0.0017	-0.0023	-0.0007	0.0050	0.0111	0.0000	0.0000
contribution ratio of:															
productivity growth	0.0267	0.1054	**0.2158**	0.0015	0.0390	0.1277	0.0318	-0.0072	**0.1943**	**0.2670**	**0.3017**	-0.0104	0.0039	0.0348	1.3320
reallocation	0.0108	0.0425	**-0.2140**	-0.0062	**-0.1269**	-0.0835	0.0041	0.0372	-0.0115	-0.0692	**-0.1075**	**0.0987**	**0.0929**	0.0006	-0.3320

Note: agr: agriculture, min: mining, manu: manufacturing, util: electricity, gas, water supply. const: construction, trade: trade & commerce, transp: transportation, ict: information, communication and telecommunication, finance: finance & insurance, r-estate: real estate, b-serv: business service excluding ict, g-serve: government service, p-serve: private service. Data: WIOD SEA.

In the post-GFC period, real estate and finance led productivity growth by 30% and 27% each of the total, supported by manufacturing and ICT by 22% and 19% each, while business and government services could not wholly absorb labor from manufacturing, construction and real estate. As a consequence, financial service took the lead by 27-7=20% of the total seconded by real estate (30-11=19%) and ICT (18%) in growth contribution. Meanwhile, manufacturing (sectoral growth at 1.64%) became just one of main contributors to aggregate productivity growth through sectoral productivity growth comparable to ICT (2.0%), financial service (4.09%), and real estate, while business and government services contribute through labor absorption. We remain to see if this is a long-run trend. In other words, SEA reveals that the two new productivity-growth leaders, i.e. ICT and financial service, are low labor absorbers as expected, contrasting to the old manufacturing.

Japan

In the pre-GFC period of 2000-2008, just like in the period of 1990-2010, Japan's slight aggregate productivity growth (0.87%) was led by manufacturing (2.6%), followed by trade and real estate, through sectoral productivity growth, contributing by 47%, 25% and 21% each of the total, and government and business services (now excluding ICT) supported it through reallocation, by 34% and 24% each (Table 9). As a consequence, government service took the lead by 8+34=42% of the total in growth contribution, followed by business service (9+24=33%) and real estate (25-7=18%) out of the broad financial service and then by manufacturing (47-20=27%).

Along with the post-GFC slowdown with aggregate productivity growth of only 0.05%, financial and business services suffered from negative productivity growth, -0.4% and -2.04% each, while ICT grew at 2.08% and manufacturing maintained 1.56% growth. Despite this, manufacturing kept shrinking or de-industrialization continued, but business and government services as well as ICT, a low labor absorber, could not absorb labor enough. As a consequence, positive growth contributions were made primarily by government service only through reallocation, supported by ICT, real estate and then manufacturing.

Table 9: Productivity growth decomposition, Japan, 2000-2014, 14 summarized sectors

jpn															
2000-2008	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0225	-0.0360	0.0262	0.0051	-0.0031	0.0097	0.0153	0.0118	-0.0104	-0.0094	0.0187	0.0157	0.0003	-0.0063	0.0087
initial relative productivity	0.2222	12.6137	1.0188	3.6033	0.8032	0.8703	0.8255	0.4340	1.7667	2.1132	7.1622	0.6923	0.9473	0.6904	
initial labor share	0.0593	0.0013	0.1886	0.0068	0.0979	0.1689	0.0559	0.0723	0.0216	0.0292	0.0160	0.0679	0.1606	0.0538	1.0000
labor share change	-0.0092	-0.0005	-0.0196	-0.0004	-0.0159	-0.0122	-0.0011	-0.0014	0.0059	-0.0004	-0.0006	**0.0224**	**0.0316**	0.0014	0.0000
contribution ratio of:															
productivity growth	0.0347	-0.0564	**0.4692**	0.0772	-0.0271	0.2133	0.1121	0.0429	0.0367	-0.0524	**0.2547**	**0.0928**	**0.0778**	-0.0251	1.2504
reallocation	-0.0329	-0.0628	**-0.1962**	-0.0838	-0.1733	-0.2086	-0.0440	-0.0090	0.0545	-0.0214	**-0.0652**	0.2374	**0.3426**	0.0122	-0.2504
2008-2014	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0207	-0.1739	0.0156	-0.0089	0.0204	-0.0140	0.0047	0.0029	0.0208	-0.0042	0.0035	-0.0204	-0.0060	0.0015	0.0005
initial relative productivity	0.2476	8.7781	1.1691	3.5019	0.7307	0.8772	0.8693	0.4448	1.5158	1.8285	7.7492	0.7314	0.8855	0.6121	
initial labor share	0.0501	0.0008	0.1690	0.0064	0.0820	0.1567	0.0548	0.0709	0.0276	0.0288	0.0155	0.0903	0.1922	0.0551	1.0000
labor share change	-0.0024	-0.0002	-0.0110	-0.0004	-0.0097	0.0053	-0.0036	-0.0037	0.0005	-0.0023	0.0004	0.0067	0.0188	0.0014	0.0000
contribution ratio of:															
productivity growth	0.4832	-1.5350	**5.5799**	-0.5599	2.5174	**-3.7665**	0.7575	0.1772	1.7358	-0.5897	0.8254	-2.4007	**-0.1368**	0.0571	3.1446
reallocation	-0.1764	-0.1407	**-3.9077**	-0.2416	-2.6013	1.5295	-1.3547	-0.5394	0.3510	-1.1874	1.0685	1.3104	**3.4223**	0.3228	-2.1446

Note: same as in Table 8.

Korea

Korea followed the qualitatively similar track to Japan's, but quantitatively to a lesser degree. In the pre-GFC period of 2000-2008, manufacturing (at 5.9% growth) dominantly led aggregate productivity growth, contributing by 73% of the total, through sectoral productivity growth, supported by finance and trade, 16% and 11% each, business and government services contributed through reallocation effect, both by 20% (Table 10). As a consequence, manufacturing remained the lead by 73-27=46% of the total in growth contribution, supported by government service (12%), business service (11%) and financial service (10%).

Table 10: Productivity growth decomposition, Korea, 2000-2014, 14 summarized sectors

kor															
2000-2008	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0508	-0.0075	0.0593	-0.0261	0.0040	0.0239	0.0262	0.0196	-0.0018	0.0544	-0.0323	-0.0390	-0.0141	-0.0063	0.0213
initial relative productivity	0.2666	3.3397	1.4426	2.6146	0.8957	0.5737	0.7056	0.3857	1.4127	1.3768	7.7294	1.2032	1.3277	0.4726	
initial labor share	0.1158	0.0009	0.1852	0.0072	0.0719	0.1712	0.0528	0.0753	0.0322	0.0403	0.0117	0.0525	0.1288	0.0542	1.0000
labor share change	-0.0376	-0.0001	-0.0319	0.0061	-0.0005	-0.0221	-0.0064	-0.0038	0.0032	-0.0050	0.0048	0.0416	0.0344	0.0173	0.0000
contribution ratio of:															
productivity growth	0.0801	-0.0010	**0.7287**	0.0071	0.0112	0.1117	0.0454	0.0265	-0.0036	0.1595	-0.1137	-0.1018	-0.0762	-0.0069	0.8672
reallocation	-0.0795	-0.0019	**-0.2739**	0.0433	-0.0023	-0.0838	-0.0291	-0.0093	0.0241	-0.0572	0.1554	0.2064	**0.1982**	0.0423	0.1328
2008-2014	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0383	-0.0238	0.0125	0.1408	-0.0062	0.0152	0.0442	0.0080	-0.0051	-0.0029	-0.0079	-0.0098	-0.0243	0.0294	0.0073
initial relative productivity	0.3350	2.6562	1.9325	1.7883	0.7810	0.5855	0.7333	0.3805	1.1763	1.7771	5.0204	0.7395	1.0013	0.3796	
initial labor share	0.0782	0.0008	0.1533	0.0133	0.0714	0.1492	0.0463	0.0715	0.0353	0.0353	0.0165	0.0942	0.1632	0.0715	1.0000
labor share change	-0.0197	-0.0002	-0.0017	-0.0055	-0.0070	-0.0101	0.0099	-0.0047	-0.0002	-0.0041	0.0008	0.0166	0.0362	-0.0103	0.0000
contribution ratio of:															
productivity growth	0.1397	-0.0067	**0.6973**	0.2974	-0.0458	0.1872	**0.2424**	0.0299	0.1567	0.0179	-0.0861	**-0.0762**	**-0.4324**	0.1156	1.2372
reallocation	-0.1766	-0.0126	**-0.2642**	-0.1390	-0.1177	-0.1475	**0.1940**	-0.0420	-0.1898	**-0.2030**	0.0892	**0.2456**	**0.6302**	-0.1038	-0.2372

Note: same as in Table 8.

In the post-GFC period, however, while manufacturing barely kept leading productivity growth through sectoral productivity growth at 1.25% supported by transportation, both financial and business services seriously suffered from GFC, with ICT being not reliable enough yet. As it turned out, transportation took the lead by 44% of the total in growth contribution, seconded by manufacturing (43%), government service (20%) and business service (17%).

China

Despite some post-GFC slowdown in aggregate productivity growth (from 7.89 to 6.69%) in China, structural transformation during these two periods looks more similar each other than those in the two periods of 1990-2010 and 2008-2018 with ETD[17]. Throughout both periods of 2000-2008 and 2008-2014, Table 11 shows that manufacturing (12.4% and 7.8% growths each) continued to be a leading sector contributing to aggregate productivity growth through sectoral productivity growth above all (35% and 31% of aggregate productivity growths, respectively), as well as through reallocation in both periods (9% each), followed by trade sector (10% and 13%). Finance, real estate, and business service also contributed but only through reallocation (20% in total) due to their higher sectoral productivity levels.

Table 11: Productivity growth decomposition, China, 2000-2014, 14 summarized sectors

chn															
2000-2008	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	0.0397	0.0094	**0.1237**	**0.1531**	0.0479	0.0826	**0.1245**	0.0782	0.0616	-0.0186	-0.1430	-0.0458	0.0179	0.0289	0.0789
initial relative productivity	0.4491	5.7868	1.1417	2.8586	1.3009	0.9050	1.2775	0.7394	2.7494	7.1695	33.8330	8.2247	1.3840	0.4040	
initial labor share	0.4566	0.0185	0.1534	0.0045	0.0635	0.0726	0.0301	0.0212	0.0045	0.0050	0.0015	0.0050	0.0911	0.0725	1.0000
labor share change	-0.1148	-0.0017	0.0336	0.0005	0.0035	0.0156	-0.0041	0.0065	0.0057	0.0090	0.0093	0.0081	0.0222	0.0066	0.0000
contribution ratio of:															
productivity growth	0.0896	0.0099	**0.3486**	0.0326	0.0449	0.0697	0.0716	0.0155	0.0090	-0.0060	-0.0444	-0.0155	0.0129	0.0090	0.6474
reallocation	-0.0842	-0.0123	**0.0912**	0.0057	0.0078	0.0318	-0.0159	0.0104	0.0302	0.0665	0.1101	0.0547	0.0525	0.0040	0.3526
2008-2014	agr	mining	manu	utility	const	trade	transp	hotel	ict	finance	r_estate	b_serv	g_serv	p_serv	total
productivity growth	**0.0815**	0.0258	**0.0779**	**0.1236**	0.0256	0.0518	0.0512	0.0658	0.0389	0.0288	-0.0005	-0.0022	0.0037	0.0388	0.0669
initial relative productivity	0.3339	3.3960	1.5813	4.8680	1.0306	0.9303	1.7796	0.7357	2.4167	3.3601	5.3616	3.0791	0.8691	0.2764	
initial labor share	0.3418	0.0168	0.1870	0.0050	0.0669	0.0882	0.0260	0.0277	0.0102	0.0141	0.0109	0.0131	0.1132	0.0791	1.0000
labor share change	-0.1039	0.0058	0.0091	-0.0012	0.0167	0.0241	0.0019	-0.0016	0.0013	0.0061	0.0032	0.0047	0.0240	0.0098	0.0000
contribution ratio of:															
productivity growth	0.1443	0.0199	**0.3097**	0.0520	0.0238	**0.0612**	0.0341	0.0200	0.0133	0.0185	-0.0004	-0.0011	0.0051	0.0118	0.7123
reallocation	-0.1169	0.0482	**0.0914**	-0.0246	0.0421	**0.0639**	0.0095	-0.0035	0.0085	0.0515	0.0358	0.0303	0.0445	0.0071	0.2877

Note: same as in Table 8.

[17] We should note that there was a significant decline in manufacturing's labor share in the early 2000s and its recovery afterwards.

SEA reveals that, as contrast to not only US, but Japan and Korea, potential main players as ICT, financial and business services were yet in the shadow of ever-growing manufacturing in both sectoral productivity growth and labor reallocation throughout both the pre- and post-GFC periods in China.

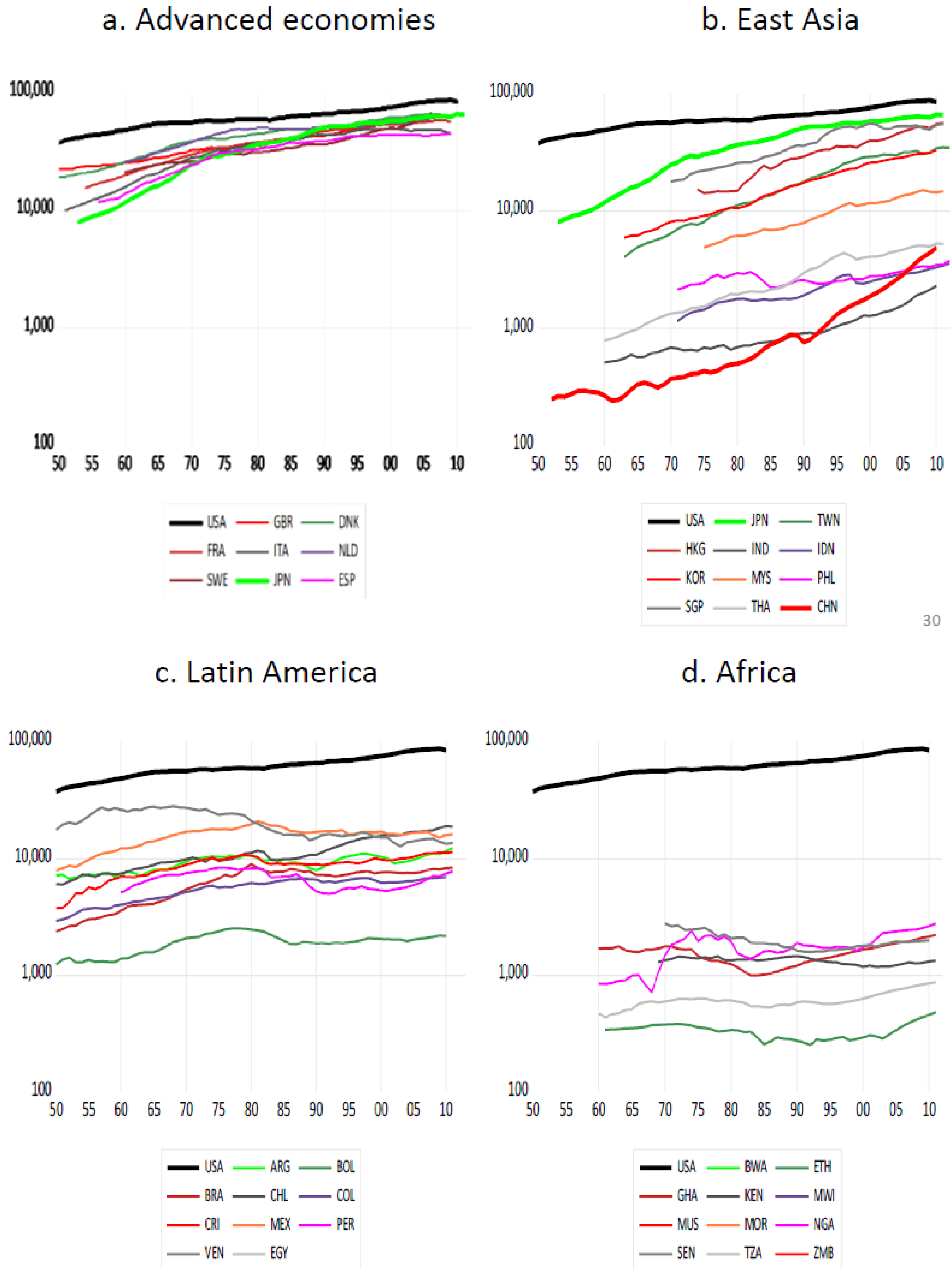
To sum up: We had observed that business and financial services are steadily increasing importance in both sectoral productivity and reallocation throughout Japan, Korea and China since the 1990s, although its presence in labor share is minimal in China. Also, in the post-GFC period, while industrialization in China continued, de-industrialization appeared to slow down in Japan and to strand in Korea. On top of this, SEA revealed more about individual sectors' roles in contributing to the aggregate productivity growth, particularly ICT between pre- and post-GFC periods among our three de-industrializing industrializers and one still industrializing industrializer. Looking through several occasions in our samples, ICT sector, being a low labor absorber, could contribute to the aggregate productivity growth through sectoral productivity growth just like manufacturing. In contrast, business service could also contribute through reallocation effect. The same holds true for financial service with high productivity. We note, however, that these new developments by ICT, finance, and business services reflect de-industrialization, being most conspicuous in US, modest in Japan and Korea, and still minimal in China. We already confirmed these by examining the relative contributions of individual manufacturing sectors across four economies.

4. PRODUCTIVITY CONVERGENCE AND STRUCTURAL TRANSFORMATION

Thus far we have observed industrial structural transformation along with productivity growth, confirming the nexus of the two, particularly by looking at sectoral productivity growth as well as resource reallocation between sectors. The decomposition of aggregate productivity growth showed that, even under de-industrialization, shrinking manufacturing sector has mostly dominantly led aggregate productivity growth through its sectoral productivity growth, while growing non-manufacturing sectors as well as agriculture also significantly supported it. Nevertheless, of course, non-manufacturing sectors have to cope with reallocation by absorbing resource factors from manufacturing as well as agriculture under de-industrialization.

In fact, in both industrialization and de-industrialization, industrial structural transformation appears to go hand in hand with income as well as productivity convergence among these economies. As we have seen in Figure 4 with respect to GDP per capita, we can also see visible labor productivity convergence among advanced economies and also more or less convergence among East Asian economies (Figure 8, Panels a and b), but no symptom of productivity convergence in other developing economies (Panels c and d). Specifically in Figure 8, we find only few explicit productivity convergers such as Hong Kong, Korea, Singapore, Taiwan, AND China even in East Asia. We will discuss how secure their positions are as productivity convergers in their processes of structural transformation along with productivity growth.

Figure 8: Aggregate labor productivity, 1950-2011



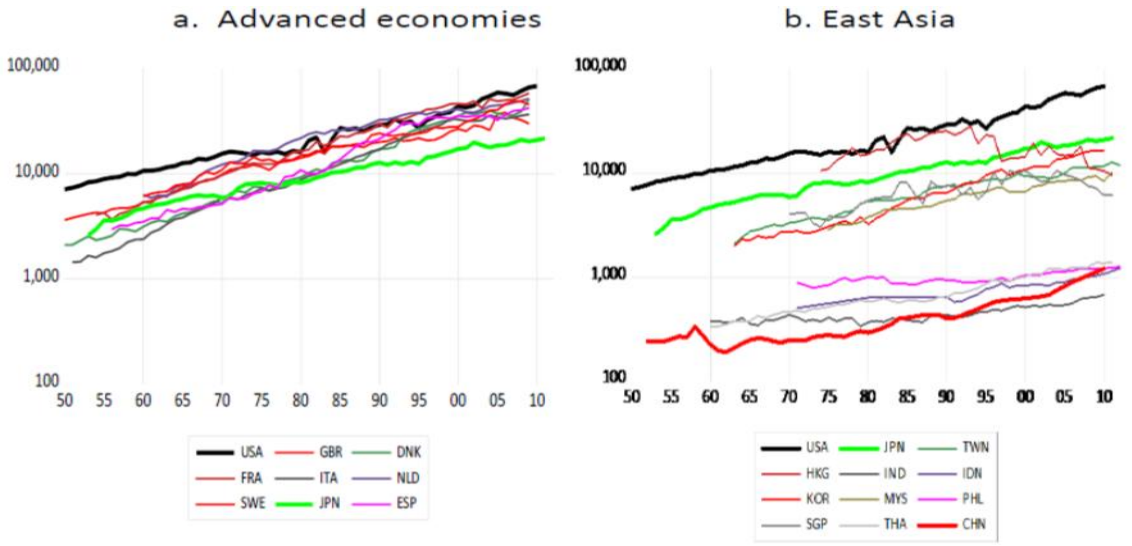
Note: 2005 constant US$. data: GGDC 10SD, hereafter.

Sectoral productivity convergence

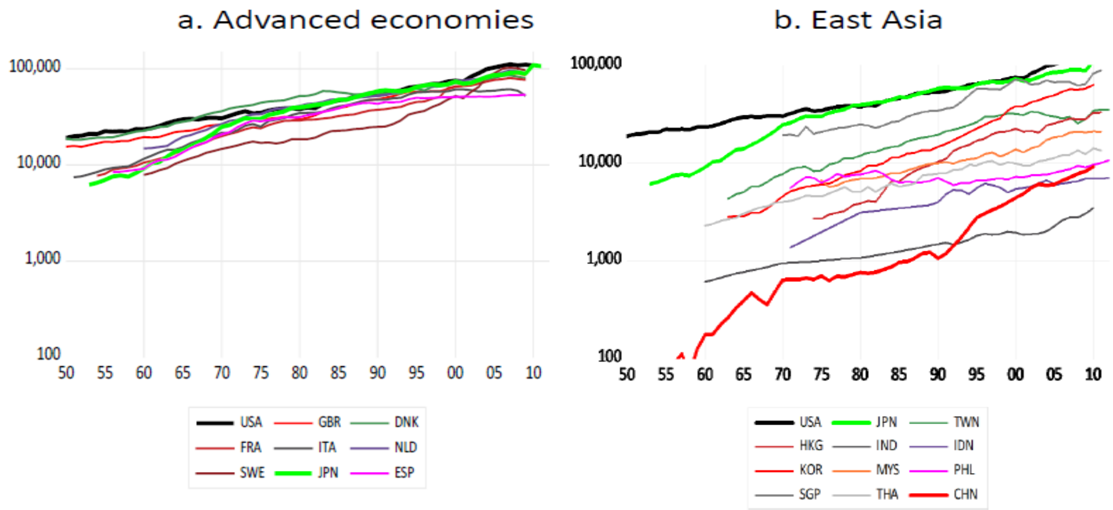
Now, let us look at sectoral productivity convergences between two groups of income convergers, particularly how different they are from aggregate productivity convergence. Figure 9, Panel a shows the case of agriculture. We find steady long-run productivity growth in both advanced and some East Asian economies, and then find rather narrow differences in productivity levels and strong convergence in productivity each other in advanced economies, with some level difference for Japan. Meanwhile, in East Asia, there are wide differences in productivity levels and very weak convergence in productivity.

Figure 9: Sectoral labor productivity, 1950-2011

a. Agriculture



b. Manufacturing

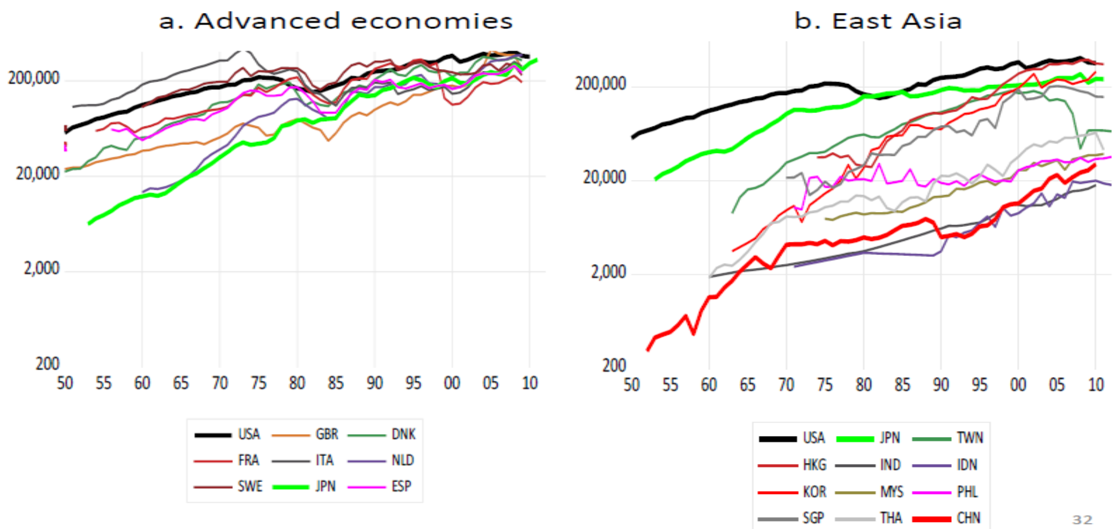


Note: labor productivity = real value added/employment, 2005 constant US$. Data: GGDC 10SD.

In manufacturing, in addition to steady productivity growth, we can detect very narrow differences in productivity levels and close convergence in productivity in advanced economies, whereas wide differences in the levels with some strong convergence in East Asia, as represented by China (Figure 9, Panel b). Moreover, we find qualitatively similar characteristics in utilities, trade and transportation in steady productivity growth, differences and convergence in productivity levels across two groups of economies (Figure 10).

Figure 10: Sectoral labor productivity, 1950-2010

a. utilities



b. trade

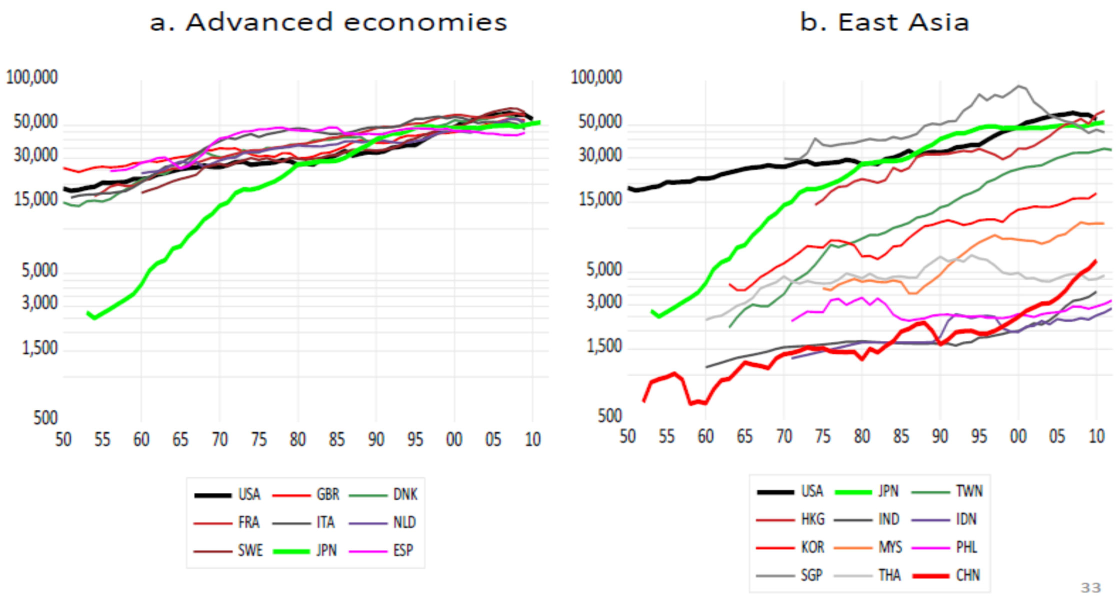
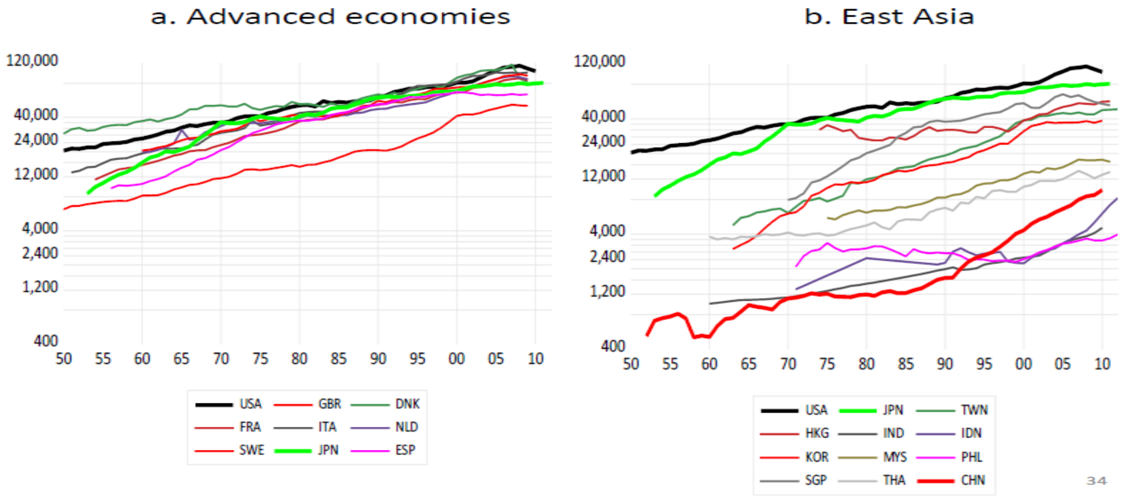
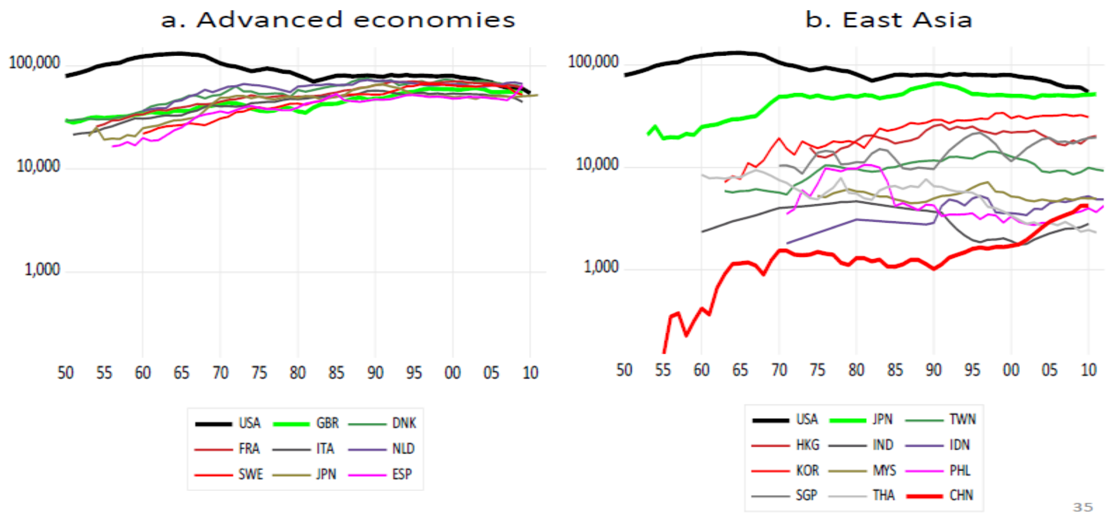


Figure 10 continued:

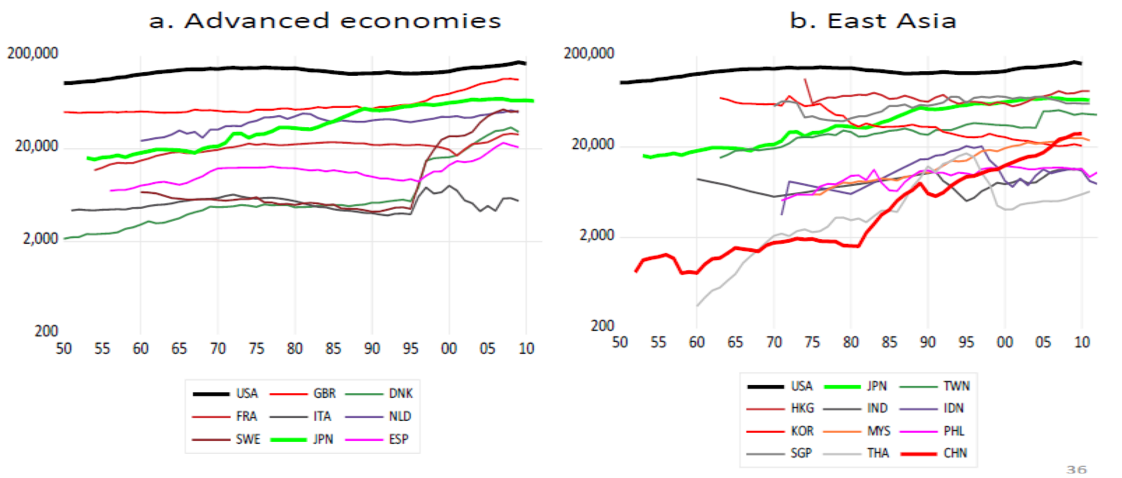
c. **transportation**



d. **construction**



e. **finance (including real estate and business service)**



In contrast, we see some different features in construction. First of all, its growth appears very slow in most cases and is sometimes negative as in the US[18]. Their level differences are narrow in advanced economies as opposed to very wide differences in East Asia, so that it is hard to see productivity convergence in the latter except for China. Finally, we cannot characterize productivity developments in finance except for some symptom of productivity convergence in both groups, probably because of its heterogeneous composition of subsectors, i.e. financial intermediation and insurance, real estates, business service across economies in GGDC 10STD (Figure 10, Panel e).

Years for convergence

In order to obtain a perspective for productivity convergence[19], we can calculate years needed to converge to some target productivity levels. Suppose the target is the US and its labor productivity growth g^{US} is expressed as:

$$y_T^{US} = y_0^{US}\exp(g^{US}T),$$

where y_0 is an initial productivity. Thinking about China's catching up, we set T when convergence is completed, i.e.

$$y_T^{US} = y_0^{US}\exp(g^{US}T) = y_T^{CH} = y_0^{CH}\exp(g^{CH}T),$$

or,

$$T = (\ln y_0^{US} \text{- } \ln y_0^{CH})/(g^{CH} - g^{US}).$$

Namely, T is the number of years needed for China's productivity to converge to US's.

Table 12 shows how many years are needed to narrow the productivity gap between US and China in 2010 at their productivity growths during 1990-2010. For example, in the case of agriculture, since labor productivities in 2010 are \$68, 342 (US) and \$1,212 (China) and productivity growths for 1990-2010 are 4.32% (US) and 5.71% (China), it would take 289 years for China's productivity to converge to the US's at this pace, Even in manufacturing, China needs to grow by 8% (= 11.4 – 3.6) higher than the US for as long as three decades (32 years). The Table shows it holds also for aggregate productivity convergence between China and the US (34 years). All this implies that it would not be an easy job even for such a high-growth economy as China to attain productivity convergence to front runners as the US in productivity growth.

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18 Goolsbee and Syverson (2023) brings some new evidence to bear on the industry's measured productivity problems and suggests that measurement error is probably not the sole source of the stagnation.

19 'convergence' is used interchangeably with 'catch up' hereafter.

Table 12: Years converging to US

chn, 2010	agr	mining	manu	utilities	const	trade	transp	finance	g-service	p-service	aggregate
productivity, us, 2010	68341.9	372689.0	108324.4	360113.8	54324.6	54922.8	102331.1	166269.1	58750.0	50278.4	85535.6
productivity, ch, 2010	1211.7	18431.2	9266.1	30156.9	4250.9	6009.6	9660.7	27992.1	7595.6	888.9	4862.9
p. growth, ch, 1990-2010	0.0571	0.1376	0.1136	0.0938	0.0741	0.0679	0.0921	0.0790	0.1001	0.0409	0.0971
p. growth, us, 1990-2010	0.0432	0.0107	0.0357	0.0181	-0.0188	0.0263	0.0265	0.0120	-0.0030	-0.0008	0.0126
conv. Yrs	288.9	23.7	31.5	32.8	27.4	53.2	36.0	26.6	19.8	96.7	34.0
jpn, 1970	agr	mining	manu	utilities	const	trade	transp	finance	g-service	p-service	aggregate
productivity, us, 1970	15494.7	334915.1	30541.8	172607.5	106035.6	26098.1	36030.2	145579.0	64814.2	36604.3	56616.1
productivity, jp, 1970	5898.6	45354.6	24929.0	103643.5	49061.5	14303.4	36331.1	21264.9	45607.8	46260.4	24920.8
p. growth, jp, 1950-1970	0.0491	0.1356	0.0851	0.0996	0.0517	0.1022	0.0892	0.0169	0.0261	0.0241	0.0683
p. growth, us, 1950-1970	0.0396	0.0533	0.0237	0.0567	0.0145	0.0167	0.0289	0.0177	0.0017	0.0099	0.0204
conv. Yrs	102.2	24.3	3.3	11.9	20.7	7.0	-0.1	-2326.0	14.4	-16.5	17.1
kor, 1990	agr	mining	manu	utilities	const	trade	transp	finance	g-service	p-service	aggregate
productivity, us, 1990	29359.5	301171.2	53745.6	251575.1	79469.6	32705.0	60627.4	130936.9		51124.7	66567.2
productivity, kr, 1990	6470.3	26081.2	14858.4	71130.1	29167.7	10957.4	16614.5	33259.9		32070.9	17519.8
p. growth, kr, 1970-1990	0.0446	0.0460	0.0601	0.1047	0.0208	0.0328	0.0521	-0.0287		0.0071	0.0393
p. growth, us, 1970-1990	0.0325	-0.0053	0.0287	0.0190	-0.0143	0.0113	0.0264	-0.0053		0.0168	0.0081
conv. Yrs	125.2	47.7	40.9	14.7	28.6	51.0	50.2	-58.6		-47.7	42.9

Note: e.g. for China in 2010, the years converging to US: $T = (\ln y_{2010}^{US} - \ln y_{2010}^{CH})/(g^{CH} - g^{US})$ where y_{2010}: productivity in 2000, g: productivity growth for 1990-2010. Data: GGDC 10SD.

For comparison purposes, we show two more convergence experiments using our GDCC 10 sector dataset (Table 12). First, Japan's convergence from 1970 at growth differentials for 1950-1970 and, second, Korea's from 1990 at growth differentials for 1970-1990. In Japan's case, her aggregate productivity would converge to US's in 17 years, while manufacturing's in only 3 years, but agriculture's in as long as 102 years. In Korea's case, both its aggregate and manufacturing's productivities need about 40 years to converge to the US's.

All these suggest that initial productivity gaps play a significant role to determine the pace of productivity convergence, that the convergence is well within a reach particularly in manufacturing, and that agriculture, the largest sector in labor share, is a treasure of future aggregate productivity growth. The last point is closely related to the US' success in its long-run productivity growth, which demands more than 100 years for the other economies to converge.

5. DISCUSSION AND POLICY IMPLICATION

Discussion

Previous studies suggest a few engines of structural transformation, one being the shift of demand across sectors due to their different income elasticities along with income growth (e.g. Comin et al., 2021) and another coming from differential productivity growth based on technological advances across sectors, which affect and are affected by demand shifts (e.g. Sposi et al., 2021). We should also be reminded, however, that the transformation is a relatively recent phenomenon in economic history (Clark, 2007)[20].

That is, we must add one more engine, the polity. Remember that the Industrial Revolution (IR) and modern economic growth could not have been realized without fundamental changes in political power structures, including the birth of nation states in the 19th century. Nation states can be viewed as products of wealth accumulation of private businesses, who were desperate for individual property rights and the freedom of business. Both of them are what nation states are supposed to protect under the name of public law and order. Even if we do not go that far historically, it is clear that export industrialization could not have prevailed without global trade liberalization. Hence the first globalization with the IR and modern economic growth toward WWI, and then the second globalization re-born under multilateral trade liberalization since WWII.

It is only after the IR that more people have become able to consume manufacturing products and enjoy leisure time during the process of industrialization and urbanization driven by modern economic growth. There, people have spent less on food and more on manufacturing products and services due to their high income elasticity. Services are more demanded not only by themselves, but also by agriculture and manufacturing sectors to supplement them through communications, transport and storage, trade and commerce, and finance, insurance and real estates. These input-output linkages between services and other sectors could be regarded as an original form of value chains.

IR-related technological progress facilitated global market integration through declining costs of transportation and telecommunication. The above discussions can explain well the major role played by export industrialization for modern economic growth. First of all, industrialization in labor intensive products contributes to expanding domestic employment and per capita income levels significantly. Furthermore, manufacturing products are tradable, allowing international trade to make good use of both economies of scale toward overseas markets and technology spillovers through

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[20] It had been thought that per capita income growth had been almost zero until modern economic growth in the 19th century, but recent studies in economic history reveal that a sustained growth of around 1 % started in the 17th century after the Age of Discovery (Bouscasse et al. (2021)).

international transactions (Rodrik, 2013).

These are the patterns evident in modern economic growth in advanced economies in the 19th and early 20th centuries, as well as in the East Asian Miracle in the late 20th century. Both employment expansion and productivity growth through international competition create a virtuous loop, realizing rapid structural transformation through differential income elasticities across sectors.

Successful industrialization, however, inevitably leads to de-industrialization through demand shifts from manufacturing to services driven by their differential income elasticities. Furthermore, technological innovation towards the end of 20th century such as ICT and the digital revolution tends to favor *process technology*, optimizing manufacturing's production and transportation processes using IoT, robots and 3D printers, which are intrinsically labor-saving and knowledge- and skill-intensive.

Just like US agriculture in the early 20th century, process technology would switch manufacturing from labor and capital intensive industry to labor saving and knowledge intensive one, while externalizing parts of production processes toward services, known as *servicification*. Consequently, particularly since the 1990s, services (such as preproduction constituted by design, marketing and delivery, and postproduction by transportation, storage, e-commerce platform and after-service as well as embedded services within production devoted to *smart factory's cyber physical system*) have become separated from but closely linked to manufacturing. This is the process of de-industrialization, just like industrialization was the process of *de-agriculturalization* in the last century. Servicification of manufacturing would grow cumulatively because smart factories accumulate big data as ever. Furthermore, information, communication, financial and business services became tradable now, being able to enjoy economies of scale and network effect on their marginal cost through international competition and technology transfer.

Policy implication

Now, what could be the implication of our findings above for the development strategy of such late industrializer as China under global de-industrialization? The feasibility of export industrialization would be constrained but not entirely rejected, because of the significant presence of the Global South and the sheer market size of China itself. Nevertheless, its advantage of one-stone-two-birds-ness for productivity growth and job creation would be significantly reduced because of labor-saving technological progress. Meanwhile, productivity growth of services may not directly create job opportunities, though indirectly do so through income effects of higher aggregate productivity growth.

Hence, usual policy priorities such as those suggested by Hallward-Driemeier and

Nayyar (2017) appear warranted for not only China. They go as:

For competitiveness, i.e. the ease of doing business, the rule of law, and the use of mobile technologies to complete financial transactions: a. Facilitate firm entry and exit, and the reallocation of capital and workers; improve bankruptcy procedures and universal coverage of social protection to facilitate worker mobility and to lower costs of disruption, b. Set competition policy framework for network platforms; adjust regulations for new business forms, c. Facilitate contracting, to enable greater use of sharing economy on production side,

For capabilities, i.e. information and communication technology (ICT) use, tertiary school enrollment rates, and the share of royalty payments and receipts in trade: a. Develop programs to strengthen more advanced skills, creativity. b. Emphasize the use of data and data processes within production, c. Support the development of a data ecosystem (access to ICT, policies on localization, network security, IPR)

For connectedness, combining the dimensions of logistics performance, restrictions on trade in manufactured goods, and the restrictions on trade in professional services: a. Further facilitate trade in services, including removing restrictions on FDI, b, Support IoT logistics systems, c. Develop regulatory frameworks to support cross-border data flow.

Observing relatively slow industrial transformation in China, we may be able to point out agricultural development as one of potential priorities for its long-term development strategy. Both the reallocation of capital and workers, as well as worker mobility, are focal points here. We observed agriculture's declining relative productivity level and its persistently lower productivity growth (Tables 4 and 7). As a consequence, we see no symptom of productivity convergence both domestically as compared to other sectors and internationally as compared to fellow economies. The international productivity gap appears too large to narrow within a century (Table 12). Of course, it would be a cause and a result of China's pattern of economic development, deeply rooted to her institutions, policies and history. Nevertheless, as in the frontier case of the steady productivity growth and structural transformation, i.e. the US, agricultural development could be one important key for its development strategy as well.

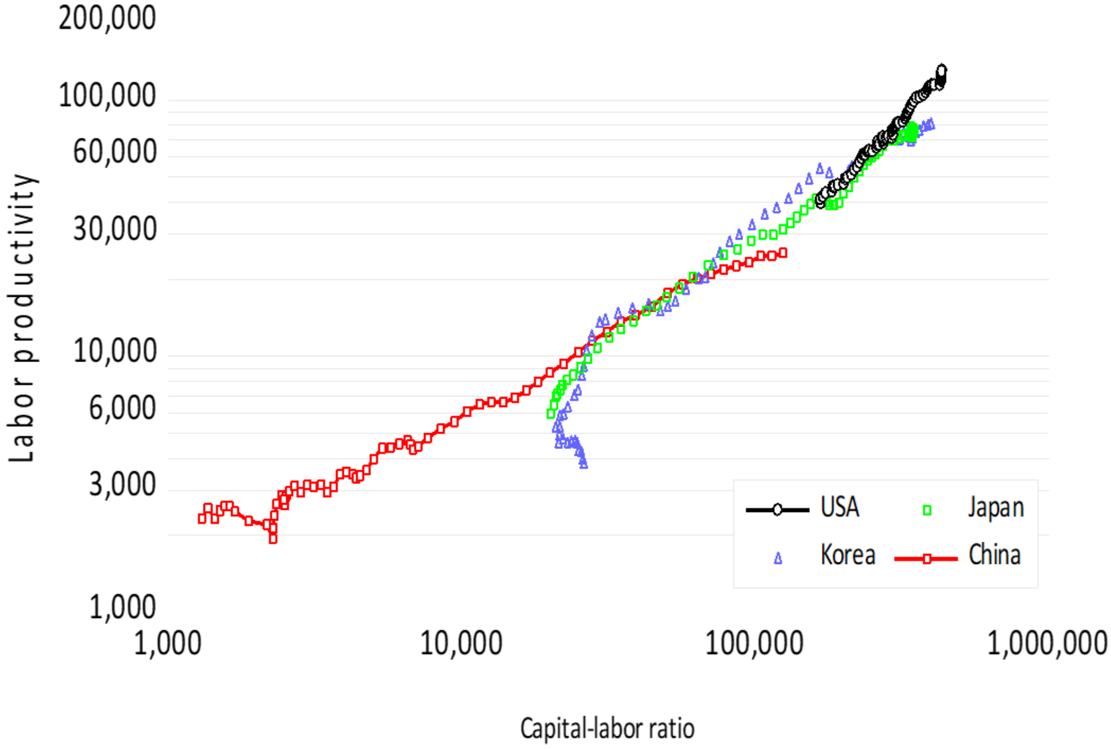
In fact, US agriculture metamorphosed fundamentally in the 20th century, producing far more products through technological innovation with far less farm land and labor (Alstone and Pardey, 2020). During the process, farm land reduced in number, expanded in scale and specialized in activity, while agriculture continued to grow, but its relative importance dwindled. US agriculture externalized its many production activities such as agricultural machine, seeds, fertilizers, energy and other inputs including contracting. This is a mirror image of servicification of manufacturing toward the 21st century.

The structural transformation of US agriculture has resulted from growing non-agricultural labor demand on one hand and labor-saving, farmland-expanding technological progress on the other. The former has raised farmers' opportunity costs and labor costs of employment, while the latter has incentivised farmland consolidation and labor- and land-saving technological innovation, supported by government and other public sectors. As a result, labor productivity and TFP in US agriculture have continued to grow significantly, even relative to non-agricultural sectors throughout the 20th century. Our Table 1 revealed that the relative productivity level of agriculture kept increasing from 18.9% of the entire economy's average level (1950) to 44.1% (1990), in sharp contrast to China (Table 4), which has shown persistent declines.

We also note developments in food supply chains, including generic, chemical, machinery and digital industries upstream of dwindling agriculture in the US, and food products and related services, including transportation and retailing downstream. The US experience in agriculture underscores the importance of market responses to supply and demand interactions as well as public support not only for technological innovation but also for institutional reforms that help market responses to these structural transformations through significant resource reallocation across sectors.

In view of still significant international gaps in sectoral productivity levels in China (Figures 8-10), we cannot overstate the importance of capital deepening to promote and sustain sectoral labor productivity growth. Figure 11 demonstrates economic growth paths of the US, Japan, Korea and China, plotting a combination of aggregate labor productivity and capital-labor ratio during the period of 1950-2019, based on Penn World Table 10.01. The US started with an outstanding capital-labor ratio of $168,166 to generate a labor productivity or GDP per worker of $39,412 in constant 2017 PPP US$ in 1950, which corresponds to $15,854 for GDP per capita. Note that her capital-output ratio in 1950 was 4.27 = 168,166 / 39,412. Subsequently, however, Japan started rapid capital deepening (by increasing its capital-output ratio) with labor productivity level of $10,810 around 1960 and attained this US 1950 level of labor productivity at the capital-output ratio of 3.91 by 1980, while Korea started with labor productivity level of $13,510 around 1975 and attained the US 1950 level by 1993.

Figure 11. Economic growth paths: US, Japan, Korea and China, 1950-2019



Note: labor productivity=GDP/employment, capital-labor ratio=capital stock/employment, 2017 PPP US$. Data: Penn World Table 10.01.

As to China, it started rapid capital deepening with labor productivity of $4,325 around 1990 at a capital-output ratio of around 1.5 and then, by 2019, attained Korea's labor productivity level of 1987 and Japan's of 1970, i.e. $25,360 but her capital-labor ratio turns out to be 4.92, significantly larger than those of Korea's and Japan's, i.e. 2.99 and 3.15, respectively. As a matter of fact, as shown by Figure 11, although China's capital deepening has been remarkably faster than that of the US, stretching from $1,297 to $124,697 over 70 years of 1950-2019 as opposed to from $168,166 to $436.258 in the US, their absolute gaps in levels have been widening. In addition, as shown by its less steep growth path toward the end in Figure 9, China's capital-labor ratio has appeared to diverge rather than converge to that of the US, suggesting a deteriorating capital efficiency, particularly after the GFC.

Of course, these aggregate figures do not always apply to individual sectoral productivity growth paths straightforwardly, i.e. some productivity converging sectors such as manufacturing could have done better relative to global productivity frontiers. Observing significant international gaps in sectoral productivity levels shown by the Figures, however, further capital deepening appears undoubtedly necessary, while improving capital efficiency is also indispensable.

In this regard, how to activate corporate businesses throughout sectors is the key for sustained productivity growth. *Japanization* started in the 1990s from the financial bubble-burst, with financial service plunging into negative growth, followed by declines in transportation and trade during 1990-2010 (Table 5). its slow and prolonged financial rehabilitation with prolonged monetary accommodation, turned out not only to weaken aggregate demand (reflected in negative growths in trade and transportation), but to distort resource allocation or to retard structural transformation, by failing to distinguish between profitable and unprofitable firms, resulting in very low firm entry and exit ratios. Misallocation leads to lower investment, which leads to weaker demand, which leads to weaker investment, i.e. a vicious cycle. As a result, both capital deepening and labor productivity growth of Japan literally ceased in the 2000s (Figure 9). Although both Japan and Korea suffered from the GFC, Korea has surpassed Japan in terms of both capital-labor ratio and labor productivity level since around 2015.

In China, private firms had increased their presence in both sales and employment until the mid-2010s and the average age of listed firms is comparably young to that of the US. Whereas, state-owned enterprises (SOEs) still hold substantial assets and some of them are occasionally of low profitability. Also, Chinese firms heavily rely on bank intermediation, where SOEs have been dominant borrowers. Under the present unfavorable and adversary international business environments, there could be strong temptations for China to prolong financial rehabilitation and accommodative monetary and fiscal policies. But, such approach may suffocate corporate dynamism or entrepreneurship and preserve inefficient incumbents. In order not to follow the wake of Japanization, China may better listen to what the recent combination of slower productivity growth and increasing capital-output ratio forewarn.

CONCLUDING REMARKS

In this chapter, we confirmed that we can see some common patterns of industrial structural transformation allowed only for a group of income convergers including advanced economies and some selected emerging market economies such as those in East Asia. They appeared to grasp the chance at a crossroad of income growth, technological innovation and economic globalization. Among them, we picked up representative four (de-)industrializers and put them on the decomposition framework of aggregate productivity growth, using internationally comparable databases such as GGDC 10 sector database and others. Particularly, these enable us to disaggregate services and to come up with their differential roles in and contributions to aggregate productivity growth along with manufacturing.

As expected, we observed usual trend rises and falls of sectors' labor shares, but with significantly different timing across economies, earlier in the US and latest in China. We realized that China not only started late, but also transformed rather slow in this process. Sectoral productivities occasionally showed acceleration and deceleration across economies, of which acceleration of those almost across the board in China since the 1990s was surely remarkable, but we note that it was also the case in Japan during its postwar rapid growth period of 1953-1970.

On the one hand, we identified sometimes a dominant role of manufacturing to lead aggregate productivity growth even under de-industrialization across time and economies in the long run such as in Japan during 1970-1990 and in Korea since 1990s. But, on the other, we observed manufacturing's losing dominance in contribution to aggregate productivity growth not only through its declining labor share but through its less remarkable sectoral productivity growth. most conspicuous case is, of course, the US. There, manufacturing started as the tertiary contributor during the postwar period of 1950-1970 and ended up as No.5 by 2010 surpassed not only by financial service, but by trade, government service and transportation.

Financial service including real estate and business service has led US' postwar aggregate productivity growth, and it has increased presence in growth contribution in Japan since the postwar period and surpassed manufacturing together with government service during the lost decades. These are straightforward reflection of differential income elasticities on the demand side. Demand for manufacturing tends to be replaced by those for services in advanced economies along with their per capita income growth, while manufacturing demand may persist or even expand in developing economies along with population growth, urbanization and/or per capita income growth.

Once we extend our analysis to additional databases such as GGDC ETD and WIOD

SEA, we detected new developments and their contributions by newly disaggregated sectors such as business service and ICT in more recent periods. Most remarkable is, of course, in the US, the top de-industrializer, where manufacturing has been far behind trade and business service in labor share and behind (narrow) financial service and ICT in productivity for years. Out of broad financial service above, business service including ICT replaced manufacturing as the top growth contributor in Japan during the period of 1990-2010 and then broad financial service including this business service, financial intermediation, insurance, and real estate overwhelmed manufacturing in growth contribution during the post-GFC stagnation period of 2008-2018. Even in Korea, they contributed to aggregate productivity growth almost as comparably as manufacturing then.

On this front, these sectors are still relatively small in labor share in China as against Japan and Korea, but their growth contributions increased to as comparably large as that of manufacturing in the most recent period of 2008-2018. Meanwhile, most (particularly higher-skilled) manufacturing sectors have kept increasing productivities and labor shares as well in China, contrasting to Japan, Korea, and the US.

Last, despite remarkable productivity growths, we still observe significant gaps in all sectoral productivity levels between China and the others. We examined how fast these gaps can be narrowed with the present sectoral productivity growth experimentally. Agriculture looks almost impossible. But, other sectors, particularly some manufacturing sectors are concerned, more recent data suggests that productivity convergence appears within a reach, although this simple extrapolation is admittedly too easy to go.

Technological innovation, being basically irreversible, is expected to continue the present trend for globalization despite geopolitical uncertainties looming these days. Process technology in manufacturing production would reduce trade and coordination costs, enhancing global value chains or vertical process-division-of-labor and eroding the advantage of cheap labor and labor intensive processes. Meanwhile, tradability revolution of services enables such productivity growth effects as scale economy, competition and technology transfer for services, and dynamically complements manufacturing, but their labor absorption is limited. Namely, apart from the demand side, there would be less room for the advantage of backwardness in the supply side.

As industrial structures evolve along with modern economic growth, the presence of agriculture in employment and output has declined significantly. This is simply because the income elasticity of demand for agriculture is less than those for manufacturing and services. However, if one regards this as the end of agriculture, it is very wrong. Rather, US agriculture with only less than 1.5% share of total employment sustains not only domestic demand of the US, one of the highest income economies, but also those of foreign countries through exports. This is really the ultimate outcome of successful labor productivity growth in agriculture, which has become almost comparable to those in non-agricultural sectors. It does suggest a process of national market integration in output as well as input factors.

In other words, modern economic growth can be viewed not only as industrialization but as de-agriculturalization. Importantly, de-agriculturalization does not necessarily imply the demise of agriculture, but rather a transformation of agriculture and its input-output linkage with other sectors. Likewise, it would not be wrong if we presume similar process of structural transformation in the case of de-industrialization. Manufacturing will not cease to exist. Instead, it will seriously transform itself, becoming disbundled and externalized into services with production processes majorly automatized. Manufacturing envisioned in the Fourth Industrial Revolution (Industry 4.0) shows little resemblance to that of the early 20th century. De-industrialization is also transforming sectoral input-output linkages in a global scale through GVCs, driving global market integration. This would be an analogy of national market integration under de-agriculturalization and industrialization via modern economic growth.

Furthermore, if we think twice, transformation would go beyond industrial structures. Industries themselves metamorphose, just like manufacture in an agricultural society progressed into manufacturing in an industrial society. When discussing structural transformation over the past 200 years, we often tend to presume that exiting sectors have existed as they are throughout these years, but it is not true. Two centuries ago, we had no automobiles nor electricity, while we already had such services as bars, barbers and doctors. Even these services could take completely different forms in the very near future, without human involvement, perhaps.

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Appendix table 1:

WIOD, Socio-Economic Accounts	
sector	**description**
s1	Crop and animal production, hunting and related service activities
s2	Forestry and logging
s3	Fishing and aquaculture
s4	Mining and quarrying
s5	Manufacture of food products, beverages and tobacco products
s6	Manufacture of textiles, wearing apparel and leather products
s7	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
s8	Manufacture of paper and paper products
s9	Printing and reproduction of recorded media
s10	Manufacture of coke and refined petroleum products
s11	Manufacture of chemicals and chemical products
s12	Manufacture of basic pharmaceutical products and pharmaceutical preparations
s13	Manufacture of rubber and plastic products
s14	Manufacture of other non-metallic mineral products
s15	Manufacture of basic metals
s16	Manufacture of fabricated metal products, except machinery and equipment
s17	Manufacture of computer, electronic and optical products
s18	Manufacture of electrical equipment
s19	Manufacture of machinery and equipment n.e.c.
s20	Manufacture of motor vehicles, trailers and semi-trailers
s21	Manufacture of other transport equipment
s22	Manufacture of furniture; other manufacturing
s23	Repair and installation of machinery and equipment
s24	Electricity, gas, steam and air conditioning supply
s25	Water collection, treatment and supply
s26	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
s27	Construction
s28	Wholesale and retail trade and repair of motor vehicles and motorcycles
s29	Wholesale trade, except of motor vehicles and motorcycles
s30	Retail trade, except of motor vehicles and motorcycles
s31	Land transport and transport via pipelines
s32	Water transport
s33	Air transport
s34	Warehousing and support activities for transportation
s35	Postal and courier activities
s36	Accommodation and food service activities
s37	Publishing activities
s38	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
s39	Telecommunications
s40	Computer programming, consultancy and related activities; information service activities
s41	Financial service activities, except insurance and pension funding
s42	Insurance, reinsurance and pension funding, except compulsory social security
s43	Activities auxiliary to financial services and insurance activities
s44	Real estate activities
s45	Legal and accounting activities; activities of head offices; management consultancy activities
s46	Architectural and engineering activities; technical testing and analysis
s47	Scientific research and development
s48	Advertising and market research
s49	Other professional, scientific and technical activities; veterinary activities
s50	Administrative and support service activities
s51	Public administration and defence; compulsory social security
s52	Education
s53	Human health and social work activities
s54	Other service activities
s55	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
s56	Activities of extraterritorial organizations and bodies