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# The Declining Labor Income Shares Revisited: Intersectoral Production Linkage in Global Value Chains

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## Abstract

The decrease in labor income share has gained worldwide publicity given that it may affect income inequality and other macroeconomic aggregates. This chapter focuses on global value chains (GVCs) as an important determinant of changes in the labor income share and indicates the mechanism responsible for the share decline under GVCs, which has not been documented in prior studies. The mechanism of developing countries is of particular research interest. In such countries, the services sector promotes capital deepening and increased involvement in GVCs because nonservices (especially manufacturing) tasks are offshored from developed to developing countries, creating demand for services as intermediate input to these tasks in the recipient developing countries. As a result, capital deepening is promoted in the services sector, and this results in lower labor income share. We conclude that the intersectoral production linkage between the services and nonservices sectors plays a major role in the downward trend of labor income share in developing countries.

**Keywords:** labor income share, GVCs participation, capital deepening, intersectoral production linkage, developing economies

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## 1. Introduction

The decrease in labor income share has received worldwide attention given that it is frequently associated with income inequality and also affects macroeconomic aggregates. At the enterprise level, wages represent a cost and affect firms' investments. At the household level, wages are a determinant of household consumption [1]. Many studies that have documented the fall in the share have tried to understand the causes. Possible determinants of the changes include

globalization (the expansion of international trade and capital flows), technological change, capital deepening (the amount of real capital present in relation to labor increases), product and labor market institutions, and the bargaining power of labor, among others. This chapter focuses on the global value chains (GVCs) as an important determinant of changes in the labor income share and indicates the mechanism responsible for the share decline under GVCs, which has never been documented in prior studies. We analyze the mechanism by measuring the labor income share at the sectoral level in developing and developed countries.

The important point is that the amount of services input for nonservices production increases in developing countries where the nonservices production has started to be conducted by multinational enterprises (MNEs) from developed countries in GVCs. As a result, the services sector in developing countries actively accumulates capital to supply quality services to the nonservices sector effectively while the nonservices sector also promotes capital accumulation under severe international competition. The consequent macro-based capital deepening decreases labor income share in developing countries. In developed countries, on the other hand, many tasks of the nonservices sector with low elasticity of substitution between capital and labor are offshored to developing countries and the remaining nonservices sectors with relatively high elasticity of substitution accumulate capital at a rapid pace in an environment of low local relative cost of capital.

This mechanism of worldwide labor share changes can be analyzed by utilizing the data of sectoral labor income shares of developing and developed countries. Preceding studies have rarely used this kind of comprehensive dataset and rarely discussed intersectoral linkages between services and nonservices sectors as important determinants of the changes in macroeconomic labor income shares in developing countries.

## 2. Trends in the labor income share and basic drivers of the change

As summarized by Brada [2] and Young and Tackett [3], we find that labor income shares of world economies have shown a downward trend since the 1980s (especially since the 1990s), and this decline trend is shared by developed and developing countries equally. This chapter focuses on the period from 1995 to 2011 for which related data are available. The ratio of labor income share in 2011 to that in 1995 for developed countries (32 OECD countries) is 0.956 on average, and 0.932 for 23 developing countries (data source is Penn World Table Ver.9.0).

Theoretically, the key parameters that influence the factor shares of income are the elasticity of substitution between capital and labor, the accumulation of production factors, and labor- and capital-augmenting technology or directed technological changes [4]. If capital and labor are gross complements, as most empirical evidence suggests, and if the directed technological changes are not taken into account, then the labor income share increases as long as a relative cost of capital to labor decreases, as would be the case in many economies. However, this is not reality. The evolution of income shares thus depends especially on the above two factors: factor-augmenting technological changes and the rate of capital deepening. According to Alvarez-Cuadrado et al. [5], the basic theoretical overview is as follows.

Assuming that the elasticity of substitution within each sector is constant, the output for sector  $i$  is produced using the production function

$$Y_{it} = \left[ \alpha_i (B_{it} K_{it})^{\frac{\sigma_i - 1}{\sigma_i}} + (1 - \alpha_i) (A_{it} L_{it})^{\frac{\sigma_i - 1}{\sigma_i}} \right]^{\frac{\sigma_i}{\sigma_i - 1}} \quad (1)$$

where  $\alpha_i$  governs the relative importance of the two inputs,  $K_{it}$  and  $L_{it}$  are capital and labor used in sector  $i$  at time  $t$ , and  $\sigma_i$  is the elasticity of substitution between these two inputs.  $A_{it}$  and  $B_{it}$  are the levels of labor- and capital-augmenting productivity, respectively. With this production function, the ratio of the factor income shares in sector  $i$  is given by

$$\frac{KIS_{it}}{LIS_{it}} = \frac{\alpha_i}{1 - \alpha_i} \left( \frac{B_{it} K_{it}}{A_{it} L_{it}} \right)^{\frac{\sigma_i - 1}{\sigma_i}} \quad (2)$$

if the factor markets are competitive and firms choose inputs optimally. Here,  $KIS_{it}$  and  $LIS_{it}$  represent the capital and labor income shares, respectively, in sector  $i$  at time  $t$ .

The bias of technical change is given by  $g(B_{it}/A_{it})$ , where  $g()$  denotes a growth rate. If the bias is positive (negative), technical change is labor-biased (capital-biased) in the sense that it increases (decreases) the marginal product of labor ( $W$ ) relative to that of capital ( $R$ ) as indicated from Eq. (3).

$$\frac{R}{W} = \frac{\alpha_i}{1 - \alpha_i} \left( \frac{K_{it}}{L_{it}} \right)^{-\frac{1}{\sigma_i}} \left( \frac{B_{it}}{A_{it}} \right)^{\frac{\sigma_i - 1}{\sigma_i}} \quad (3)$$

The expression of Eq. (2) is potentially consistent with observed trends: if capital and labor are gross complements, that is,  $\sigma_i < 1$  as most empirical evidence suggests, then the labor income share in sector  $i$  decreases as long as technical change in that sector is sufficiently capital-biased relative to the rate of capital accumulation, that is,  $g(B_{it}/A_{it}) < 0 < g(K_{it}/L_{it})$  and the absolute value of  $g(B_{it}/A_{it})$  is larger than that of  $g(K_{it}/L_{it})$ .

As Acemoglu [4] has noted, from about the 1980s, when the labor share started a decline, the capital-augmenting technical change has dominated the labor-augmenting technical change. Using this theory and empirical evidence, one could predict that the high growth rate of capital accumulation coupled with capital-augmenting technical improvement may contribute to a downward trend of the worldwide labor income share.

Economic global integration, in terms of trade, finance, and international fragmentation of production, is widely viewed as a significant determinant of the evolution of labor shares. How is this global integration related to the abovementioned theoretical framework of the labor income share?

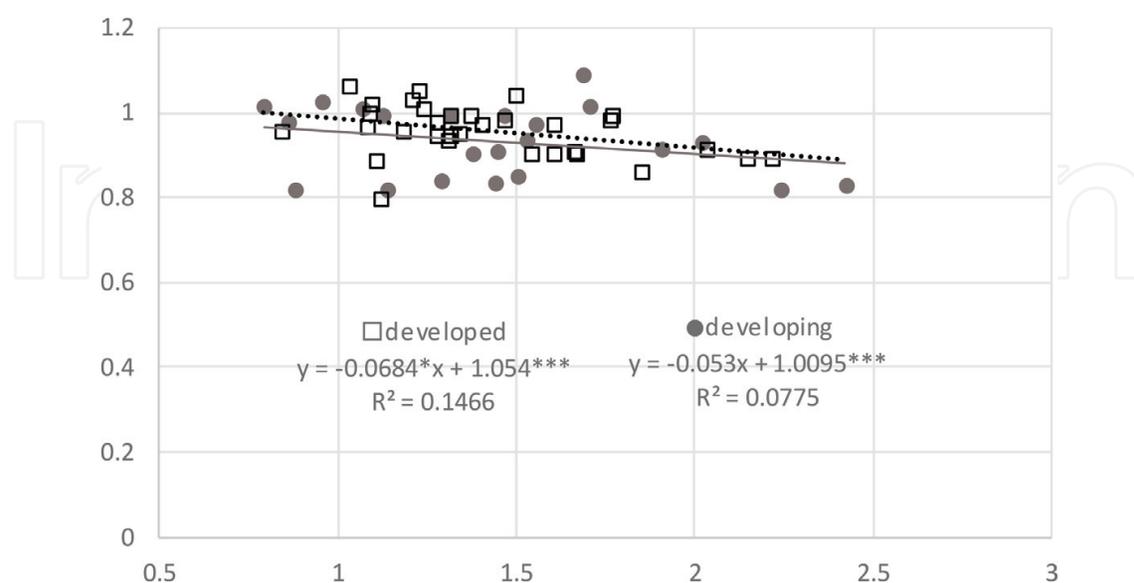
The Heckscher-Ohlin model predicts that trade integration will lead labor-abundant developing economies to specialize in the production of labor-intensive goods, leading to a rise in the labor income share in developing countries and a decrease of the share in developed countries. This model is at odds with the decline in labor shares of developing economies.

Financial integration, on the other hand, may play a major role in the evolution of the labor income share. Dao et al. [6] describe two distinct channels through which labor income share declines. First, capital mobility lowers labor's bargaining power. This is because globalization has made capital much more mobile internationally, while labor remains trapped behind national borders. The greater international mobility of capital has reduced the bargaining power of workers and increased that of the owners of capital. Second, financial integration lowers the cost of capital in capital-scarce countries, facilitating capital deepening and inducing greater substitution of capital for labor.

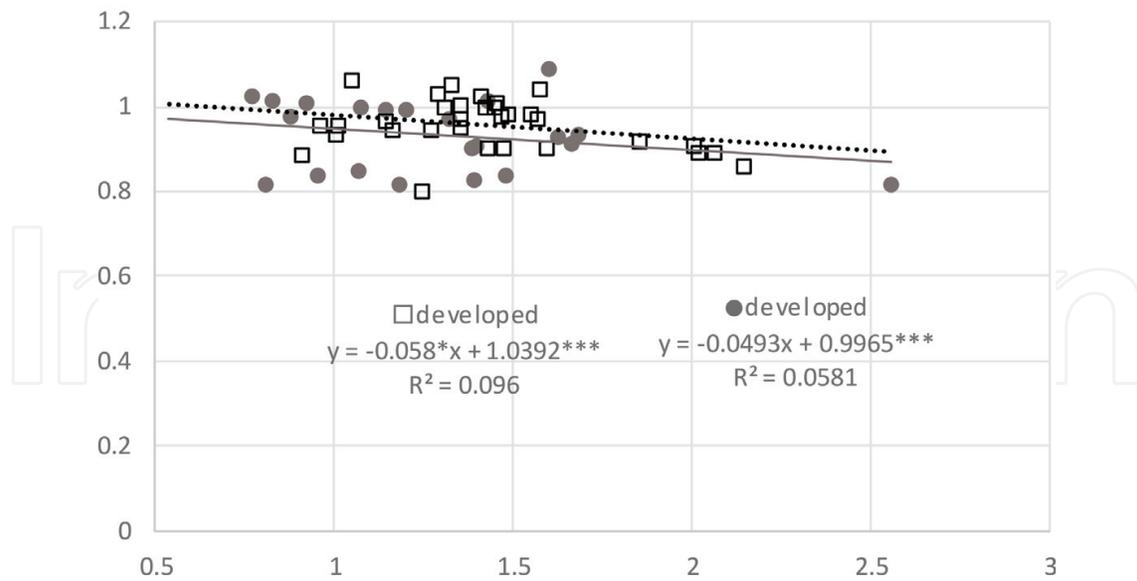
The economic globalization-based explanation for falling labor shares in developing countries thus rests on the relative size of the impact that trade and capital flows have on labor shares because increases in trade between developed and developing countries would increase labor income shares in the developing countries.

Financial integration includes two important capital flows: portfolio investment and foreign direct investment (FDI). Between them, FDI is closely related to the GVCs organized by MNEs that have been actively investing in developing countries through international fragmentation of production since the 1990s. The relation between labor income shares and international fragmentation of production through GVCs is discussed in detail in the next section.

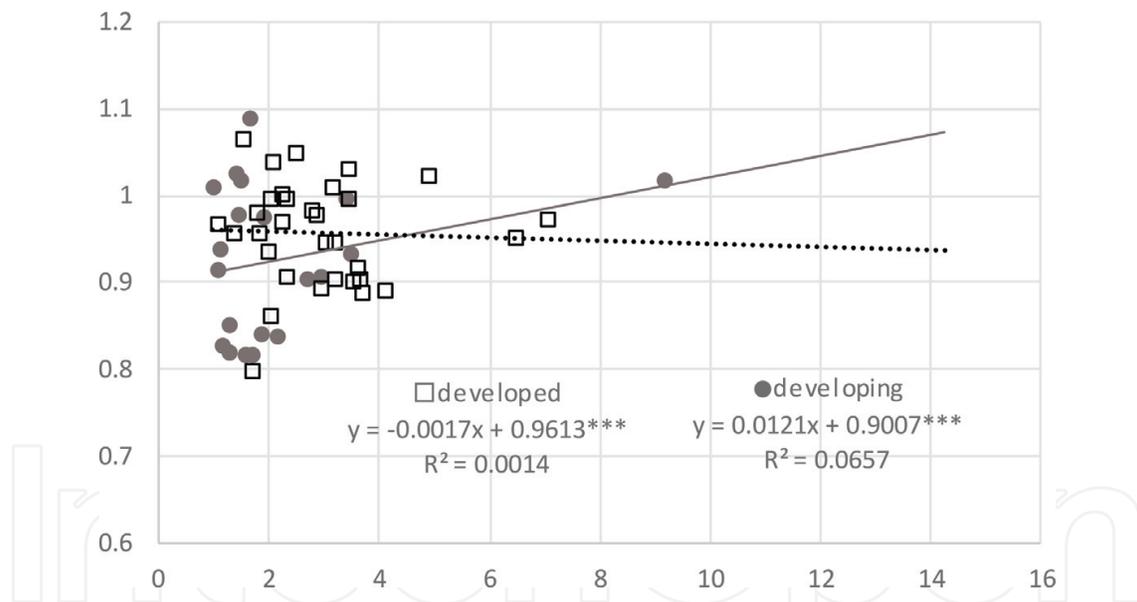
To assess the contribution of these globalization factors to the evolutions of labor income shares, we present some stylized evidence of the relation between them (**Figures 1–3**). In the following analyses, the growth rates of two different variables are compared in each figure because the main objective of this study is to identify the cause of labor income share changes. Moreover, variables used in this study, such as economic globalization, labor income share, capital deepening, and intersectoral production linkages, show that most variations are seen not over time but across countries and industries (fixed effects attributable to countries and



**Figure 1.** Changes in export GDP ratio (x-axis) and changes in labor income share (y-axis) for developed and developing countries.



**Figure 2.** Changes in import GDP ratio (x-axis) and changes in labor income share (y-axis) for developed and developing countries.



**Figure 3.** Changes in the external assets and liabilities GDP ratio (x-axis) and changes in labor income share (y-axis) for developed and developing countries.

industries). Thus, it is reasonable to compare growth rates of these variables to detect causal relationships. The available data cover the years 1995–2011.

**Figure 1** illustrates the relation between changes in export GDP ratios (horizontal axis, gross rate between 1995 and 2011) and changes in labor income share (vertical axis, gross rate between 1995 and 2011) for 55 countries. These 55 countries include 32 developed and 23 developing countries. We can find significant negative relation between the two variables in

developed countries; however, we cannot find any relation in the case of developing countries. The same conclusion is obtained in **Figure 2**, which compares the import GDP ratio and labor income share changes.

**Figure 3** indicates the relation between the external assets and liabilities GDP ratio (financial globalization index) and labor income share in the same manner as in **Figures 1** and **2** (data source is [7]). In this case, we cannot find any significant relationship. These three figures are a very simple analysis that just compare one economic globalization-related variable and labor income share. One reason to take such a simple method is that it is difficult to consider these variables as distinct drivers of labor shares. In reality, the effects of these three factors on labor shares cannot be fully isolated. More elaborate studies should be conducted in the future. At this moment, it can be concluded that trade and financial integrations as economic globalization factors do not affect labor income share evolution with the exception of trade (export and import) in developed countries. The negative relation between changes in trade GDP ratios and those in labor income shares is consistent with the prediction of Heckscher-Ohlin model as mentioned earlier in this section.

### 3. GVCs and labor income share

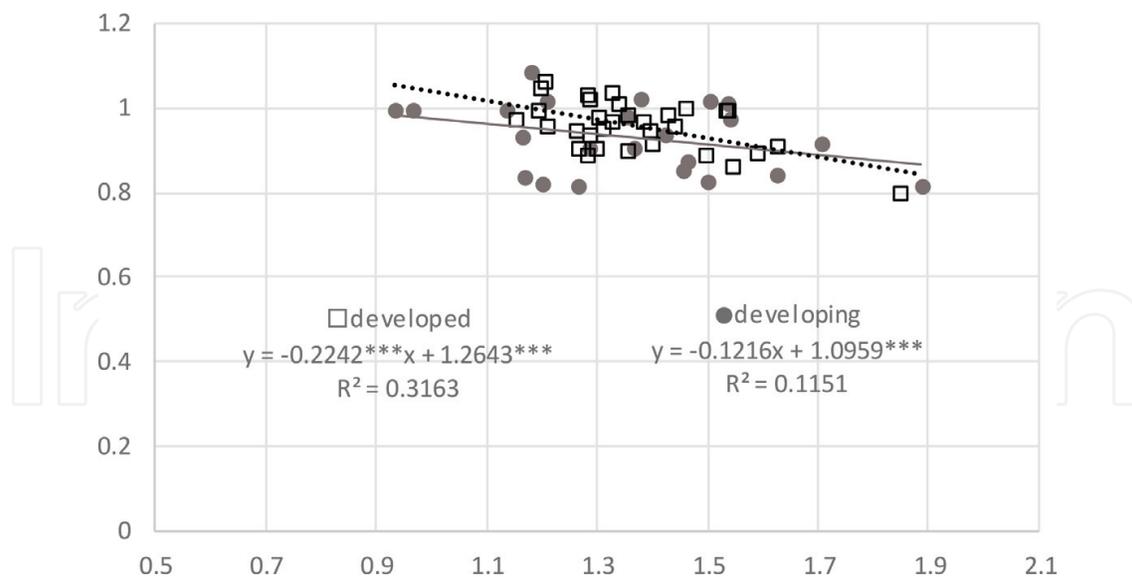
Participation in GVCs is regarded as another important factor in reducing labor income share; several works have focused on this issue (e.g., [6, 8]).

A value chain is a series of value-added processes that are involved in the production of any goods or service. GVCs or production networks are divided into discrete steps—moving from upstream to downstream production stages—and locate in different countries that actively trade intermediate (partially finished) goods. This type of production is known as fragmentation, and the trade of intermediate goods is categorized as intraindustry and intrafirm trade.

The degree of GVCs expansion is usually measured by the “GVCs participation index.” This index is calculated as a sum of the forward participation index—the share of exported goods and services used as imported inputs to produce other countries’ exports—and the backward participation index—the share of imported inputs in the overall exports of a country. In GVCs, a supplier in a country exports and imports half-finished goods; therefore, the extent of its participation in the GVCs can be measured as a sum of its forward and backward linkages. These data are derived from the OECD-WTO Trade in Value-Added (TiVA) database.

As Takeuchi [9] has documented, GVCs have been expanding worldwide since the late 1990s, especially in East Asian countries. This coincides with the period of a significant downward trend of labor income share, as pointed out by Young and Tackett [3]. This chapter also analyzes the same period.

**Figure 4** indicates the relation between the changes in the GVCs participation index and those in labor income share in the same manner as **Figures 1–3**. The R-squared values are relatively higher than those in the previous figures, and it is observed that expanding GVCs has a significant negative impact on labor income shares in developed countries.



**Figure 4.** Changes in the GVCs participation index (x-axis) and changes in labor income share (y-axis) for developed and developing countries.

In the case of developing countries, the R-squared value is low and GVCs do not have a significant impact on labor income shares. This does not mean there is no relationship between GVCs and labor income shares in developing countries. In fact, the participation index should be modified to make a comparison with labor income share evolution. This aspect will be discussed later.

What is the mechanism whereby GVCs expansion changes labor income shares? Dao et al. [6] hypothesize that a participation in GVCs can reduce labor income share through the mechanism described as follows:

1. In developed countries, many tasks for which labor is substitutable by capital are automated with a steep decline in the relative price of investment goods. Thus, the degree of capital deepening increases and the labor income share decreases. This implies that tasks with low elasticity of substitution between capital and labor are likely to be offshored in GVCs.
2. In developing countries, the offshored tasks from developed countries with low substitutability between capital and labor will have a high capital share. It follows that GVCs can shift the composition of production to tasks with higher capital shares, thus lowering the average labor share in developing countries.

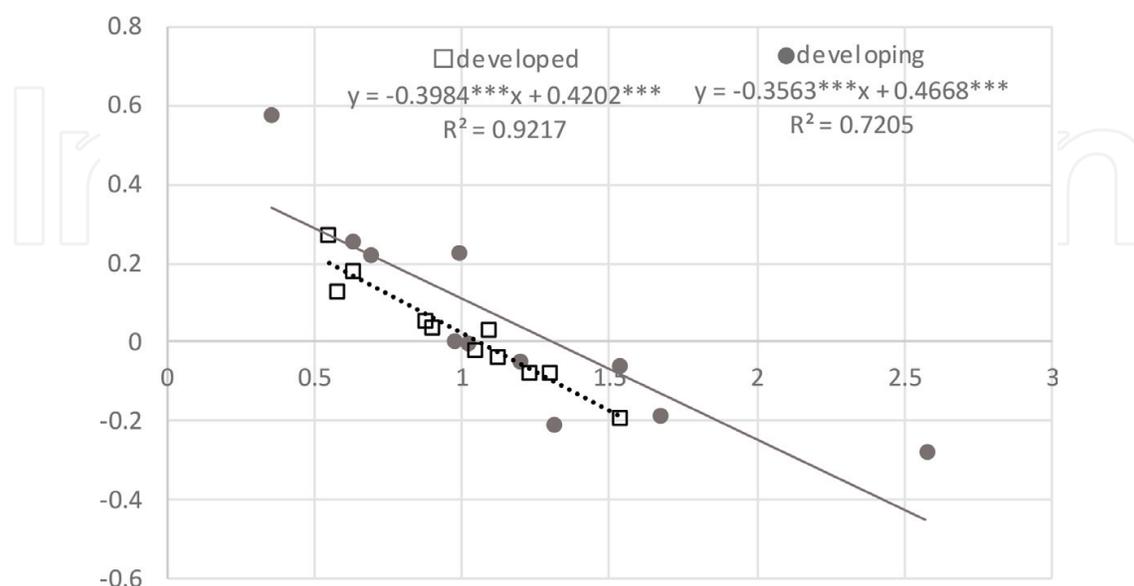
Dao et al. [6] examine the empirical relation between the trend in labor shares and technology, economic global integration, and other factors. As explanatory variables, they adopt (1) the relative price of investment goods to proxy for firms' incentives for capital-labor substitution, (2) the extent of initial exposure to routinization (high initial exposure to routinizable jobs will lead to greater adoption of routine technology and thereby lower labor income shares), (3) the evolution of globalization (exports and imports in percent of GDP, GVCs participation, and changes in financial globalization), and (4) policy and institutional factors (e.g., changes in labor union density, employment protection legislation). As for

economic globalization factors, financial integration and GVCs participation appear to matter for labor shares, but trade factor does not.

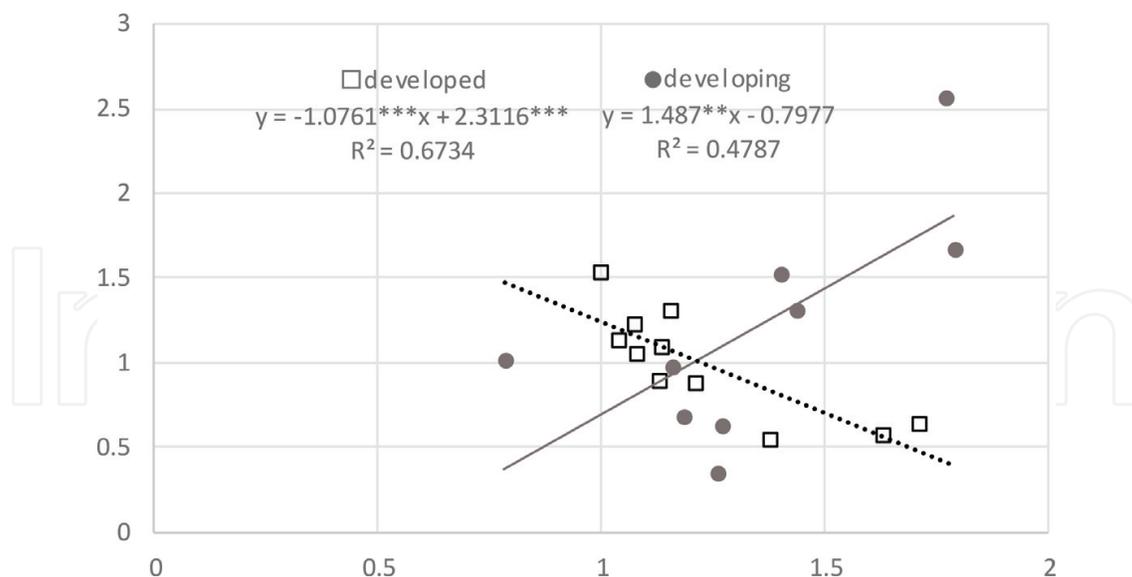
The researchers' regressions examine the empirical relationship between labor shares and GVCs by adopting only the GVCs participation index and not including other variables like the elasticity of substitution between capital and labor, factor-augmenting technological changes, and the rate of capital deepening, which are theoretically related to labor shares as previously mentioned. Instead, their paper compares changes in GVCs participation and those of the rate of capital deepening for developed and developing countries separately. The result shows that a rising GVCs participation is associated with rising capital deepening in both developed and developing countries, but the degree of impact of GVCs is larger in developing countries. What could be the reasons for that?

This study examines the mechanism of how GVCs participation works to promote capital deepening in developing and developed countries. This is an important innovation and contribution of this study. We use data of labor income shares and capital deepening for two different sectors (services and nonservices) for this analysis. For developing countries, there are significant data constraints; however, by using GDP, GDP deflators, and employment data for each industry, we can analytically calculate sectoral factor shares and relative capital deepening rates. The details of calculation procedures and data sources are presented in Appendix.

**Figure 5** shows the relation between changes in the relative rate of capital deepening of the services sector to the nonservices sector (horizontal axis, gross rate between 1995 and 2011) and relative labor income shares (vertical axis, gross rate between 1995 and 2011) for 22 countries (South Africa, China, India, Japan, South Korea, Malaysia, Philippines, Taiwan, Thailand, Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, the United States, Denmark, Spain, France, the United Kingdom, Italy, and the Netherlands). Among them, 11 countries are OECD members (categorized as developed countries).



**Figure 5.** Changes in the relative rate of capital deepening of the services sector to the nonservices sector (x-axis) and changes in the relative labor income share (y-axis) for developed and developing countries.



**Figure 6.** Changes in the GVCs participation index (x-axis) and changes in the relative rate of capital deepening of the services sector to the nonservices sector (y-axis). Gross rate between 1995 and 2011.

The estimated coefficients are almost identical between developed and developing countries, as shown in the figure. Also, the relation between the two variables is statistically significant and the R-squared values are relatively high. We have already overviewed the theoretical relation between the rate of capital deepening and labor income shares in the previous section. These results affirm the importance of analyzing this relationship by separating the services and nonservices sectors.

In comparison, what is the relationship between expansion of a GVCs and the relative capital deepening rate of the services sector? There is a positive relation between these two in the case of developing countries, and conversely, there is a negative relation in the case of developed countries. These opposite results between the two country groups seem to be important in the light of their statistical significances and high R-squared values (as shown in **Figure 6**).

The analytical results can be summarized as follows. The expansion of GVCs has a potential to account for a decline in the rate of capital deepening and thus increases the labor income shares of the services sector relative to the nonservices sector in developed countries. In the case of developing countries, the opposite mechanism works: the GVCs participation increases the relative rate of capital deepening and decreases the relative labor income shares.

#### 4. What are reasons behind the differences between developed and developing countries?

Why are there differences between developed and developing countries in terms of the relations among GVCs participation, capital deepening, and labor income shares? To answer this question, we analyze the effect of GVCs participation on the rate of capital deepening in the services and nonservices sectors separately. The results are as follows. In developed countries,

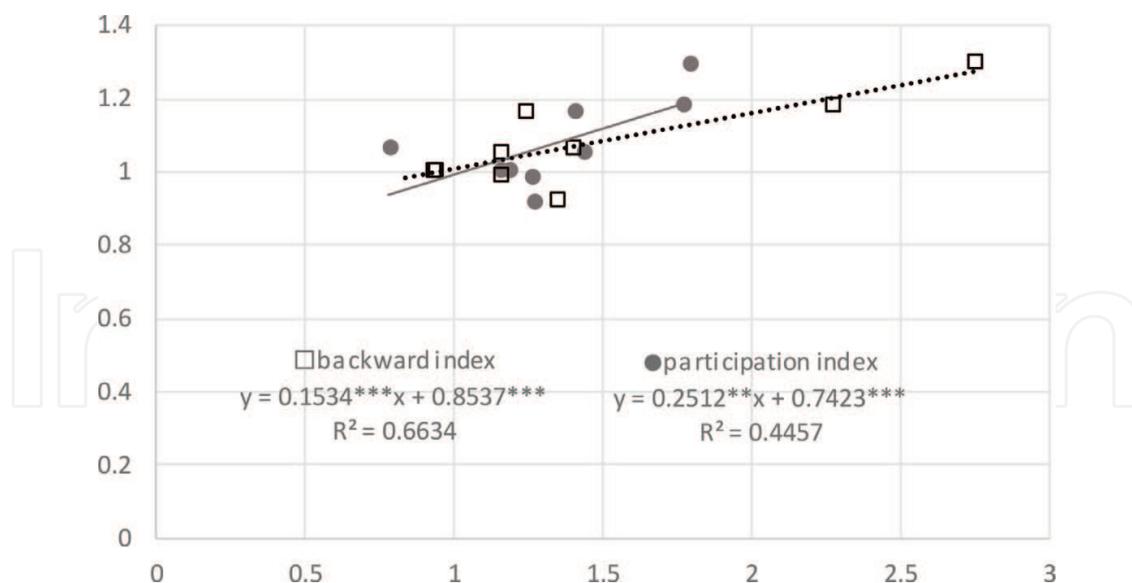
GVCs participation raises the rate of capital deepening only in the nonservices sector and not in the services sector. (The correlation of the coefficient between the GVCs participation change and the capital deepening change is 0.8129 in the nonservices sector and  $-0.072$  in the services sector.) In developing countries, the opposite relationship is observed. The rate of capital deepening in the services sector increases along with GVCs participation, but in the nonservices sector, it does not. (The correlation of the coefficient between the GVCs participation change and the capital deepening change is 0.097 in the nonservices sector and 0.739 in the services sector.) If GVCs expansion is measured by a backward index (the share of imported inputs in the overall exports of a country), not by participation index (the sum of backward and forward indices) in the case of developing countries, it is revealed that GVCs participation raises the rate of capital deepening of both the services and the nonservices sectors. For developing countries, the main contributions of being involved in GVCs are making them depend on imported foreign intermediate goods to make exports. This is just a role of backward linkage. In this respect, we can conclude that developing countries can increase the rate of capital deepening of both sectors by becoming involved in GVCs. **Figure 6** indicates that the impact of GVCs on capital deepening is larger in the services sector than in the nonservices sector in developing countries. As a result, there is a positive correlation between GVCs participation and the relative capital deepening rate of the services sector to the nonservices sector in developing countries. There is a negative correlation between them in developed countries because GVCs participation raises the rate of capital deepening only in the nonservices sector in developed countries.

Consequently, the next question is why does GVCs participation have a different impact on capital deepening between developed and developing countries? The results found for developed countries are intuitive. Tasks in the nonservices sector are relatively labor intensive and are likely to be offshored from developed to developing countries. For developed countries, the composition of production in the nonservices sector becomes more capital intensive.

What needs careful examination is the mechanism for how GVCs enhance capital deepening of the services sector in developing countries. The key is the intersectoral production linkage in which nonservices, especially manufacturing sector activities, are increasingly service dependent. This close production linkage between services and nonservices sectors is called “servicification” [10].

On the supply side, the increased internationalization of production has intensified reliance on services. When products can be sourced, made, and sold anywhere in the world, services become especially critical. For example, design, R&D, and prototyping services help decrease the cost of production failure and shorten the product development cycle. For sourcing of intermediate inputs, logistics and transportation services, as well as supply chain management services, make the geographic dispersion of GVC operations possible [10].

This study uses the Trade in Value Added (TiVA) database to measure the shares of inputted services embodied in the total final demand. This database contains indicators measuring the value-added content of international trade flows and the final demand. We check the relation



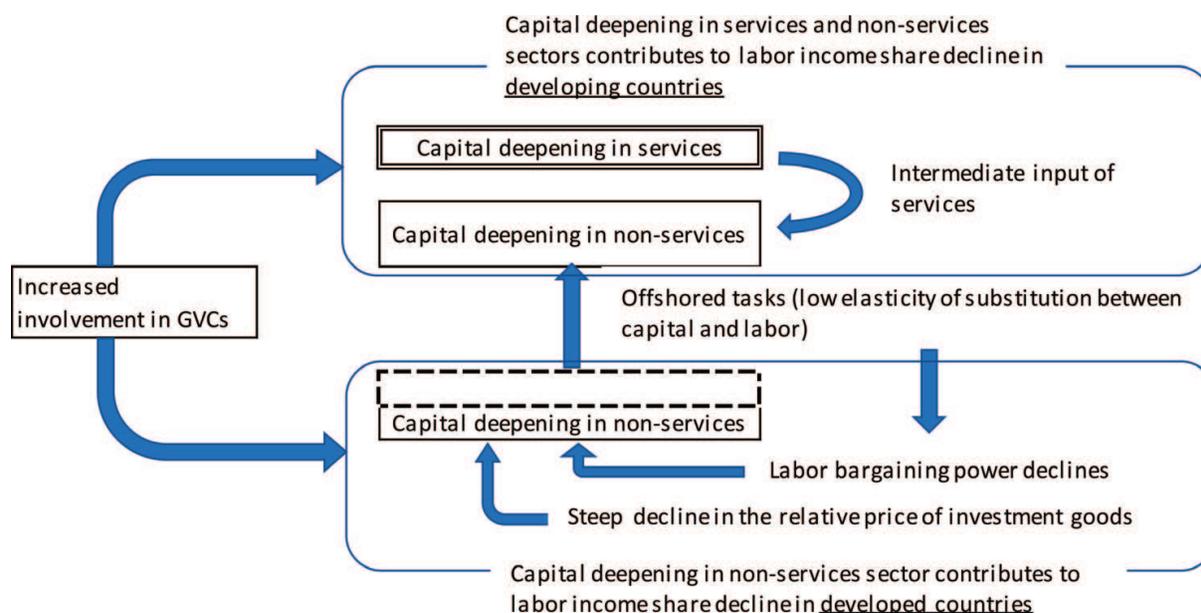
**Figure 7.** Changes in the GVCs participation (participation and backward indices, x-axis) and changes in the share of inputted services embodied in the total final demand (y-axis) in developing countries. Gross rate between 1995 and 2011.

between the changes in services value added share to total final demand and the changes in GVCs participation throughout the years of 1995 until 2011. The results are shown in **Figure 7**.

As indicated in **Figure 7**, services input shares to final demand and the degree of GVCs participation have a positive correlation in developing countries. The R-squared value is higher when the degree of GVCs participation is measured by the backward index rather than by the participation index (backward + forward indices). As mentioned before, the forward index is a measure of domestic value added embodied in foreign exports and the backward index is a measure of foreign value added embodied in domestic exports. Many developing countries in GVCs are primarily involved in backward linkages with developed countries. This is why the positive correlation between the services input shares and GVCs participation is clearly recognized when using backward index. The same positive correlation between the degree of services input and that of GVCs participation can be observed when shares of services input are measured not only to total final demand but also to the demand of the nonservices sector and exports.

This intersectoral input-output linkage between the services sector and the nonservices sector works to enhance the relative capital deepening of the services sector in developing countries. (The correlation of the coefficient between the degree of intersectoral linkage and the relative rate of capital deepening of the services sector to the nonservices sector in developing countries is 0.776.) From these analyses, we can conclude that for the nonservices tasks offshored from developed to developing countries, demand for services as intermediate input to these tasks increases and this enhances capital deepening in recipient developing countries.

**Figure 8** describes the mechanism by which GVCs participation decreases labor income shares in developing and developed countries as a summary of the previous analyses. Tasks that are relatively labor intensive and low elasticity of substitution between capital and labor are likely



**Figure 8.** The mechanism by which GVCs participation promotes capital deepening and decreases labor income share in developed and developing countries.

to be offshored from developed to developing countries. For developed countries, because the offshored tasks are labor intensive, the composition of production in these countries becomes more capital intensive. As Dao et al. [6] point out, many tasks left in developed countries are substitutable by capital, contrasting to offshored tasks with low elasticity of substitution between capital and labor. As a result, the tasks left in developed countries are automated with the help of a steep decline in the relative price of investment goods, and thus, the labor income share decreases.

On the other hand, in developing countries, the services sector promotes capital deepening and an increasing involvement in GVCs. This is because nonservices tasks are offshored from developed to developing countries and demand for services as intermediate input to these tasks increases in recipient developing countries. The capital deepening is promoted also in the nonservices sector, and thus, total economy experiences a progression of capital deepening. As discussed in Section 2, capital deepening results in lower labor income share.

In **Figure 4** indicating the relation between the changes of GVCs participation index and those of macrolabor income shares, we found that expanding GVCs has a significant impact on labor income share in developed countries. In developing countries, however, the same negative relationship cannot be clearly observed. The reason for this result can be interpreted as follows. In developing countries, GVCs have a profound capital deepening effect on the services sector but not the nonservices sector. Developing countries vary in terms of the share of services in the total economy, and thus, the capital deepening effect that GVCs have on the macroeconomy may become large in economies with a large share of services and small in economies with a small share of services.

As a modified version of **Figure 4** in which changes in labor income shares are compared with the changes in the GVCs participation index, the following estimation for developing countries

includes the interaction term in which the changes of GVCs participation index and those of the share of services in the total economy are multiplied as follows:

$$\Delta \log (\text{labor income share}) = \underset{(.000)}{1.064} + \underset{(.845)}{0.016\Delta \log (\text{GVCs})} - \underset{(.044)}{0.108\Delta \log (\text{GVCs})} \times \Delta \log (\text{services share})$$

R-squared:0.3712

(4)

Figures in parentheses are *p*-values. As clearly shown in this estimation, the modified explanatory variable (the changes in GVCs participation index multiplied by changes in services share of GDP) explains the change in labor income share well. Also, the R-squared value escalates from 0.1151 to 0.3712. From these analyses, we can conclude that intersectoral production linkage spurred by GVCs between the services sector and the nonservices sector plays a major role in the downward trend of labor income share in developing countries.

## 5. Conclusion

This chapter focuses on GVCs as an important determinant of changes in the labor income share and analyzes the mechanism responsible for the share decline under GVCs in developing countries. This mechanism has not been documented in prior studies. The crucial mechanism is that intersectoral production linkage between the services and nonservices sectors promotes capital deepening in the services sector, and this leads to the decline of the macrolabor income share. In developing countries, labor-intensive nonservices (especially manufacturing) tasks have been offshored from developed countries in GVCs since the late 1990s. The services sector in developing countries actively accumulates capital to supply quality services to the inflowing nonservices tasks, while the nonservices sector also promotes capital accumulation under severe international competition. As a result, a developing country raises its rate of capital deepening significantly in this period and thus, decreases the labor income share, as the theory predicts. This mechanism can be analyzed by utilizing the data of sectoral labor income shares and the sectoral rate of capital deepening for developing and developed countries. Preceding studies have rarely used the kind of comprehensive dataset used in this study and have rarely discussed intersectoral linkages between the services and nonservices sectors as important determinants of changes in macroeconomic labor income shares.

### A. Appendix

This appendix describes the calculation procedures and data sources for labor income shares and the rate of capital deepening for two different sectors (services and nonservices) in developing and developed countries. We use a static growth model, and by using GDP, GDP deflators, and employment data for each industry, we can analytically calculate factor shares of income and the rate of capital deepening for the two sectors. We review the effectiveness of the model by comparing the actual data with our calculations for developed countries and some developing countries where these data are available to use.

## A.1. The model

Our model focuses solely on the implications for optimal consumption and production behavior within each period. The advantage of this static approach is that the first-order conditions for the stand-in household and the stand-in firm are given only by observed current variables and we do not have to take a stand on the exact nature of intertemporal opportunities available to households and firms (i.e., the appropriate interest rates for borrowing and lending). In what follows, subscript  $t$ , which indicates time period, is omitted in each variable.

The model has two sectors of activity—the nonservices sector ( $T$ ) and the services sector ( $S$ ). The nonservices sector includes agriculture and manufacturing. The production function in each sector is assumed to be Cobb-Douglas with constant returns to scale. The static approach allows all variables to change in each period without any exceptions. Then, capital income shares of two sectors,  $\theta_T$  and  $\theta_S$ , are also assumed to change in each period. The output of services can be used for consumption ( $C_S$ ) and investment ( $I_S$ ). The output of the nonservices sector can be disaggregated into consumption ( $C_T$ ), investment ( $I_T$ ), and net exports ( $NEX_T$ ). The shares of investments and net exports in each sector are exogenously determined in this model. The production structures and their market clearings in the product markets are as follows:

$$\begin{aligned} Y_S &= A_S K_S^{\theta_S} L_S^{1-\theta_S} = C_S + I_S \\ Y_T &= A_T K_T^{\theta_T} L_T^{1-\theta_T} = C_T + I_T + NEX_T \end{aligned} \quad (5)$$

where  $Y_i$ ,  $A_i$ ,  $K_i$ ,  $L_i$  are the value added, total factor productivity (TFP), capital stock, employment in  $i = T, S$ , respectively. All resources for production ( $K_i$ ,  $L_i$ ) are fully used, as shown:

$$\begin{aligned} K_S + K_T &= K \\ L_S + L_T &= L \end{aligned} \quad (6)$$

We assume the period utility function,  $u(C_S, C_T)$  is of the form:

$$u(C_S, C_T) = \left[ \omega^{\frac{1}{\epsilon}} C_S^{\frac{\epsilon-1}{\epsilon}} + (1-\omega)^{\frac{1}{\epsilon}} C_T^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \quad (7)$$

## A.2. Optimality conditions for production side

Production side efficiency that is used for deriving factor shares of income and the rate of capital deepening for the two sectors is now derived. There is perfect factor mobility across the two sectors if sector-specific distortions to production factors (capital and employment) are cleared. The first-order conditions for the stand-in firm in sector  $i$  are given by:

$$\begin{aligned} R &= \frac{1}{1+d_S} P_S \theta_S A_S \left( \frac{K_S}{L_S} \right)^{\theta_S-1} = \frac{1}{1+d_T} P_T \theta_T A_T \left( \frac{K_T}{L_T} \right)^{\theta_T-1} \\ W &= \frac{1}{1+d_S} P_S (1-\theta_S) A_S \left( \frac{K_S}{L_S} \right)^{\theta_S} = \frac{1}{1+d_T} P_T (1-\theta_T) A_T \left( \frac{K_T}{L_T} \right)^{\theta_T} \end{aligned} \quad (8)$$

$P_i$  is the price of sector  $i$ , while  $R$  and  $W$  denote rental rates of capital and employment, respectively, both expressed in nominal currency. The term  $d_i$  ( $d_i \geq 0$ ) denotes a sector-specific distortion.

Dividing these two equations by each other gives:

$$\frac{1 - \theta_S}{\theta_S} \left( \frac{K_S}{L_S} \right) = \frac{1 - \theta_T}{\theta_T} \left( \frac{K_T}{L_T} \right) \quad (9)$$

From the second equation in Eq. (8), the implications for relative prices can be derived as:

$$\frac{P_S}{P_T} = \frac{1 - \theta_T}{1 - \theta_S} \frac{A_T}{A_S} \frac{k_T^{\theta_T}}{k_S^{\theta_S}} \frac{1 + d_S}{1 + d_T} \quad (10)$$

In the above equation,  $k_S = K_S/L_S$  and  $k_T = K_T/L_T$  (the rates of capital deepening for two sectors). The labor income shares of two sectors,  $1 - \theta_S$  and  $1 - \theta_T$ , and the rates of capital deepening for two sectors,  $k_S$  and  $k_T$ , are calculated analytically using the model and some basic sectoral data.

From Eq. (10) in the model, relative labor income share,  $(1 - \theta_T)/(1 - \theta_S)$ , can be calculated by dividing relative price  $P_S/P_T$  by relative labor productivity  $(Y_T/L_T)/(Y_S/L_S) = A_T (K_T/L_T)^{\theta_T} / A_S (K_S/L_S)^{\theta_S}$  with the assumption  $d_i = 0$ . The relative price  $P_S/P_T$  should be the absolute relative price in order to obtain relative labor income share  $(1 - \theta_T)/(1 - \theta_S)$ .

With macroeconomic labor income share ( $\theta_N$ ), the ratio of the nonservices sector GDP to total GDP ( $\alpha_T$ ) and the ratio of nonservices sector labor compensation to total labor compensation ( $\beta_T$ ),  $\beta_T$  is obtained as  $\beta_T = \theta_{LT}/\theta_N^* \alpha_T = \theta_{LS}/\theta_N^* \alpha_T + (1 - \theta_{LS}/\theta_N)$ . Then,  $\alpha_T$  is obtained as  $\alpha_T = (\theta_N - \theta_{LS})/(\theta_{LT} - \theta_{LS})$  where  $\theta_{LT}$  and  $\theta_{LS}$  are the labor income shares of the nonservices and services sectors, respectively. Among the variables in this equation,  $\alpha_T = (\theta_N - \theta_{LS})/(\theta_{LT} - \theta_{LS})$ ,  $\alpha_T$  and  $\theta_N$  are the known data. Then, by solving the system of equations involving two variables,  $\theta_{LT}$  and  $\theta_{LS}$  or  $\alpha_T = (\theta_N - \theta_{LS})/(\theta_{LT} - \theta_{LS})$  and  $\theta_{LT}/\theta_{LS} (= (1 - \theta_T)/(1 - \theta_S))$ , the labor income shares of the two sectors,  $\theta_{LT}$  and  $\theta_{LS}$ , are obtained. By substituting these labor income shares into Eq. (9), the relative capital deepening rate  $(K_T/L_T)/(K_S/L_S)$  can be calculated. The two sectors' employment data,  $L_T$  and  $L_S$ , are available and then the capital ratio,  $K_T/K_S$ , across the two sectors can be calculated. By using total capital stock data  $K$  ( $K = K_S + K_T$ ), the capital stock of the sectors,  $K_T$  and  $K_S$ , are obtained. At this stage, we can calculate the rates of capital deepening of two sectors,  $k_S = K_S/L_S$  and  $k_T = K_T/L_T$ , respectively.

We calibrate the distortion parameter ( $d_i$ ) as follows. As mentioned above,  $d_i = 0$  is set with the assumption that there is perfect factor mobility across the two sectors, and we factorize the relative price changes into relative labor income share and relative labor productivity changes, referring to Eq. (10). The result is disappointing, especially for the period up to the 1970s in Japan and up to the 1980s in Korea, when the per-capita incomes of these countries were relatively low. The analytically calculated relative labor income share and the relative capital deepening differ greatly from the actual data. Based on the result of this simulation, we assume that the degree of distortion depends on the per-capita income level ( $x$ ) and redefine  $(1 + d_S)/(1 + d_T)$  in Eq. (10) as follows:

$$\frac{1 + d_S}{1 + d_T} = \exp(\alpha x + \beta) \quad (11)$$

where  $\alpha$  assumes a negative value as the degree of the distortion diminishes along economic development. We calibrate values of  $\alpha$  and  $\beta$  to dissipate the difference between the simulated results and the real data of relative labor income share and relative capital deepening. The results are  $\alpha = -0.0001$  and  $\beta = 0.4$ . Eq. (11) is called the “implied distortion index” and is applied to all sample countries.

### A.3. Data

We use the datasets for 22 countries for which all of the below data are available. The 22 countries are South Africa, China, India, Japan, South Korea, Malaysia, Philippines, Taiwan, Thailand, Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, the United States, Denmark, Spain, France, the United Kingdom, Italy, and the Netherlands. Among them, 11 countries are OECD members.

Numerous data sources support the calculations. Sectoral relative prices and relative labor productivity are calculated using the sectoral nominal GDP, real GDP, and employment data from the 10-Sector Database provided by the Groningen Growth and Development Centre. The available data cover the years 1950–2012; however, depending on the country, the periods are different. The 10 sectors are agriculture, mining, manufacturing, utilities, construction, wholesale and retail trade, transport services, business services, government services, and personal services. In accordance with the sectoral assignment by the World Development Indicators (the World Bank) and Inklaar and Timmer [11], which provides the data of absolute relative value-added prices ( $P_S/P_T$ ), agriculture, mining, manufacturing, utilities, and construction combine to categorize the nonservices sector and the other sectors comprise the services sector.

Inklaar and Timmer [11] provided data of absolute relative value-added prices of 2005 for 42 countries. Other countries’ data which are not provided by Inklaar and Timmer [11] are obtained by estimation. Absolute relative price of services sector to that of nonservices sector can be linearly estimated by log-transformed per-capita income for sample countries owing to the Balassa-Samuelson effect.

The macro-based data of labor income share, and capital stock are obtained from Penn World Tables version 9.0 (Groningen Growth and Development Centre) and UNCTAD STAT (United Nations Conference on Trade and Development).

For calibration of the distortion parameter ( $d_i$ ), we take per-capita income data ( $x$ ) from Penn World Tables version 9.0 by Groningen Growth and Development Centre. Per-capita income is calculated by dividing expenditure-side real GDP at chained PPPs (in millions 2011 US\$) by population (in millions).

Finally, we demonstrate the comparison results between the analytically calculated variables from the model and the actual data for relative labor income share  $\theta_{LT}/\theta_{LS} = (1 - \theta_T)/(1 - \theta_S)$ , the

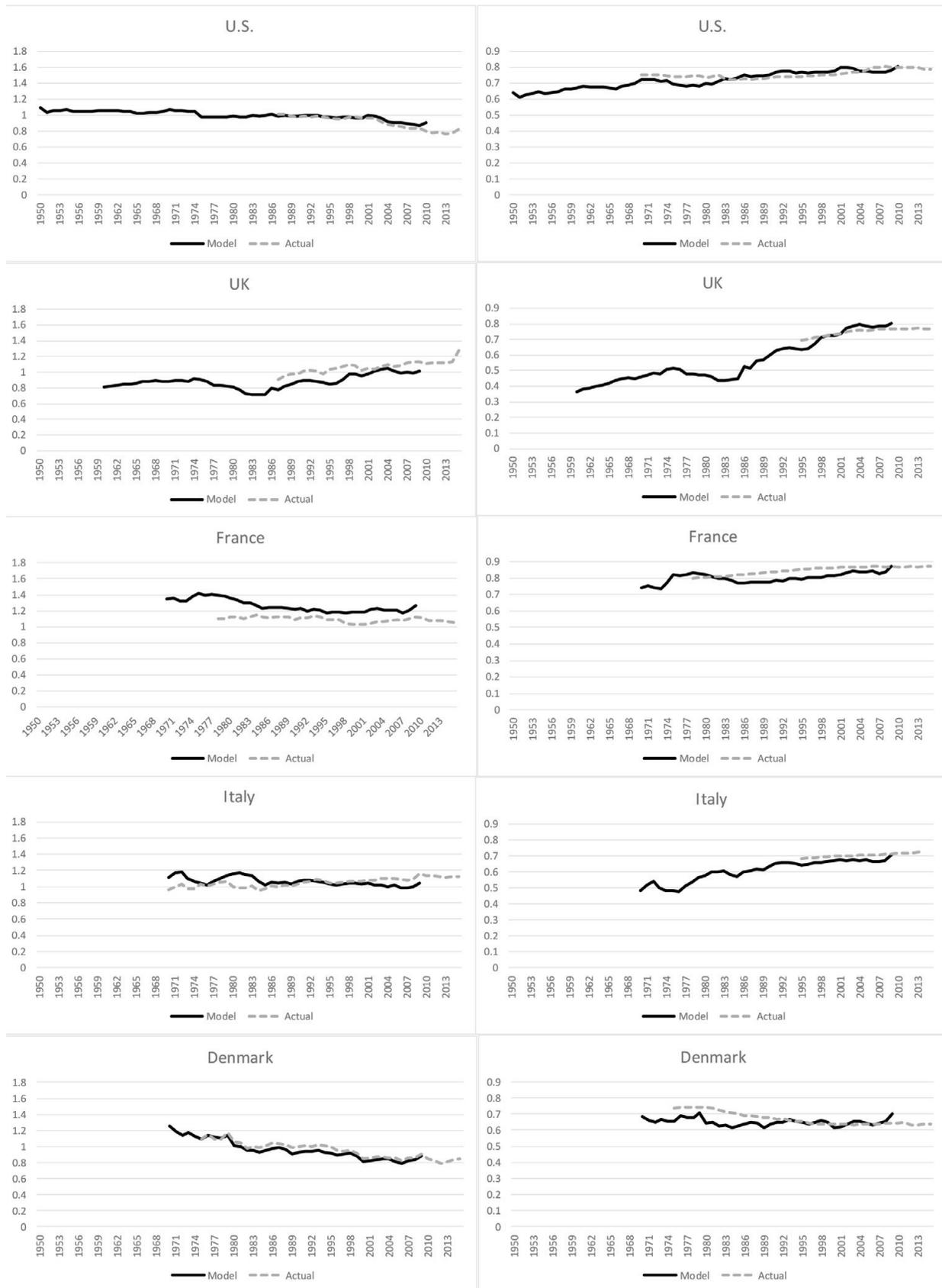


Figure 9. The relative labor income share (left) and the capital stock share of services (right).

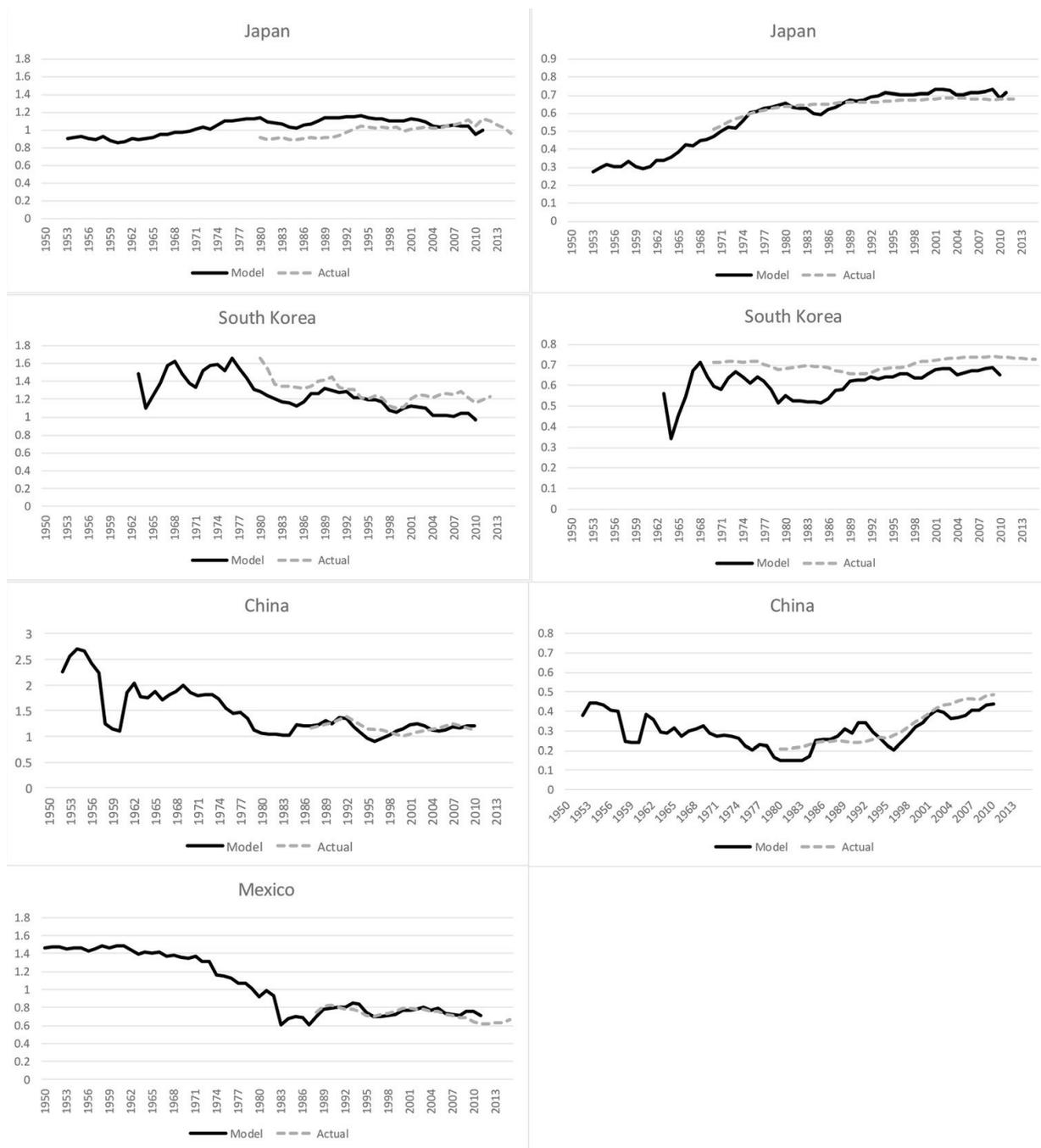


Figure 10. The relative labor income share (left) and the capital stock share of services (right).

capital stock share of services ( $K_S/K$ ) to ascertain the usefulness of the model. **Figure 9** indicates the comparison results for the United States, the United Kingdom, France, Italy, and Denmark. Actual data are obtained from EU KLEMS (The Conference Board). The data of these five countries are available in the newest version of EU KLEMS (September 2017 release). **Figure 10** makes comparisons in the same manner for Japan, South Korea, China, and Mexico, using different data sources, including the STAN database (OECD), the JIP database (RIETI), and EU KLEMS (2012 release) for Japan, the World KLEMS, the STAN database (OECD), and EU KLEMS

(2008 release) for South Korea, the CIP database 2015 (RIETI) for China, and the STAN database (OECD) for Mexico. Due to data constraints, we compare actual and model-derived series only of relative labor income share for Mexico. We find that the model with the distortion factor can explain the actual data well in almost all countries.

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