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Global Agricultural Value Chains and Structural Transformation

Sunghun Lim

Department of APPLIED ECONOMICS

College of Food, Agricultural and Natural Resource Sciences

UNIVERSITY OF MINNESOTA

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Abstract

This paper studies how participating in agricultural global value chains affects structural transformation in modern economies. The rise of global value chains, wherein the different stages of the production process are located across different countries, has changed the nature of agricultural production around the world. However, little is known how global value chains change the structure of participating countries. In this paper, I develop a theoretical model to demonstrate how exports of intermediate inputs through agricultural value chains drive structural transformation under an open economy scenario. I then empirically study the effect of agricultural global value chain participation on structural transformation by using multi-region input-output data for 183 countries for the period 1990-2013. Results indicate that as more participating in agricultural global value chains, countries transform their economies from the agriculture sector directly to the service sector, by leapfrogging the manufacturing sector—which runs counter to conventional structural transformation narratives. My finding thus shows that trade liberalization through agricultural global value chains helps modern agrarian economies foster structural transformation that has been considered as a primary driver of sustainable economic growth.

Key Words: Global Value Chains, Structural Transformation, Agricultural Value Chains

JEL codes: O13, O47, Q17, Q19

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1. Introduction

Global value chains (GVCs) have changed the nature of production around the world. Conventionally, companies used to produce goods in one country and trade their finished goods with other countries; nowadays, it is rare that the transactions of international trade are based on the exchange of finished goods. Rather, sales of individual components of products and value-added intermediary services dominate most of the production in trade. Over 70 percent of international trade today involves GVCs wherein services, raw materials, parts, and components cross borders–often numerous times. Once incorporated into final products, they are shipped to consumers all over the world. The typical 'Made-in' labels have become archaic symbols of an old era because the disintegration of production processes across borders has gradually spread in the modern economy (Antràs, 2015).

In the modern production, a single finished product often results from a multi-national supply chain, with each step in the process adding value to the final product—so-called global value chains (GVCs). GVCs refer to the sequences of all dispersed activities over several countries involved in transforming raw materials into the final consumer product, including production, marketing, distributions, and support to the final consumers (Gereffi and Fernandez-Stark, 2011). In other words, GVCs are the sequence of all functional activities required in the process of value creation wherein more than one country is involved.

Since the mid-1900s, GVCs in agriculture and food industries have been rapidly growing.[1] In the 1950s through early 1980s, the agri-food industry went through pre-globalization–shifting from traditional small-scale informal industry to larger-scale formal industry. Then, since the early-1990s, when trade liberalization expanded more by China's emergence as a major participant in world trade, agricultural value chains have been modernized across countries (Reardon et al., 2009). Also, by rapidly spreading vertical integration, global leading grocery processors and retailers have emerged as dominant players in agricultural GVCs by linking farmers in upstream and customers in downstream (Sexton, 2012).

Although the rise of GVCs have changed modern agricultural production systems, however, little is known how agricultural GVCs affect each participating country's structure of economy.

[1] See the world map of agricultural global value chain participation in Figure 2 and 3.

Since Kuznets (1966), structural transformation—wherein a country reallocate its economic activities from the agriculture sector to the manufacturing and service sectors—has received a lot of attention in the policy debate of both developed and developing countries for sustainable economic growth. Given the emergence of GVCs challenges conventional wisdom on how we look at the relationship between agricultural trade and structural transformation.

This paper studies how participation in agricultural GVCs affect structural transformation of economies. I introduce international trade into a general equilibrium under an open economy scenario with two countries and three sectors. My model is based on the Ricardian motive, following Uy, Yi, and Zhang (2013). I first define a competitive equilibrium under an open economy and then show how exports of intermediate inputs through agricultural value chains drive structural transformation (i.e., reallocation of economic activities) at the competitive equilibrium.

For the empirical analysis, I look at whether participation in agricultural GVCs transforms the structure of economies by using cross-country data for 183 countries in the period 1990-2013. Specifically, I show whether participation in agricultural GVCs changes the GDP shares in each agriculture, manufacture, and services sectors. To do this, I begin by applying the bilateral gross exports decomposition method newly developed by Wang, Wei, and Zhu (2017) to the EORA multi-region input-output tables. I then rely on the country and year fixed-effects linear regression to study whether agricultural GVC participation is associated with structural transformation in terms of GDP share.

I find that participation in agricultural GVCs is significantly associated with a decrease in GDP share in the agricultural sector and an increase in GDP share in the service sector on average. I, however, find that there is no statistically significant effect of participation in agricultural GVCs on GDP share in the manufacturing sector. My finding suggests first evidence that modern agrarian economies are leapfrogging the manufacturing to directly develop their service sector as a consequence of greater participation in agricultural GVCs. In other words, modern day, agricultural GVCs transform the structure of economies by skipping the manufacturing sector that differs from the conventional structural transformation narratives—a sequential the development process in turn by the agricultural, manufacturing, and services sector over time (e.g., the United States, the United Kingdom, and other developed countries).

I check the robustness of my result as follows. First, to ensure that my result is robust when it accounts for agricultural policy changes over time (Balie et al., 2018), I successively include trade policy (FTA, CU, RTA) and domestic agricultural price policy proxy (DomAgToT; see Timmer and Akkus, 2009). I then include the neighboring countries' GVC participation, to ensure that my results are not driven by a violation of the stable unit treatment value assumption (SUTVA; see Pearl, 2009). For in an effort to ensure that my result is robust to different specifications, I additionally include linear time trends by regional level. Moreover, to ensure that my result is robust to the assumption of dynamic structural transformation (Carkovic and Levine, 2002; Vries et al, 2012), I furthermore estimate a dynamic panel regression using the Arellano-Bond GMM method. Lastly, to ensure that my result is robust to a different measure of structural transformation, instead of GDP share, I also estimate my result by using employment shares as an alternative measure of structural transformation (Herrendorf, Rogerson, and Valentinyi, 2014). Throughout my all efforts, I find that the result is statistically and significantly robust by providing evidence that modern economies transform their economies directly to service sector from the agricultural sector by participating in agricultural GVCs.

The contribution of my study is fourfold. First, I contribute to the literature on agricultural trade by providing evidence that trade liberalization through agricultural GVCs transforms the structure of economies. Since the late 1940s, the world trade has been rapidly liberalized along with successive rounds of trade negotiation by the General Agreement on Tariffs and Trade (GATT) and its successor of the World Trade Organization (WTO). Unlike the progress in manufacturing or service sectors, the agricultural sector is, however, the most controversial sector in trade agreements[1], and it is also heavily protected by the national agricultural policies in developing countries as well as OECD countries (Reardon and Timmer, 2007; Sheldon, Chow, and McGuire, 2018). This tendency of anti-liberalization has still been widely spread over the last three decades—starting with the Doha Round in 2001 even up to the ongoing US-China trade war. Behind this tendency, both developed and developing countries consider trade liberalization in agriculture as a threat toward their economic development because there is a concern that the positive effects of trade liberalization are only for the non-agricultural sector or off-farm labors (Taylor et al., 2010). Also, countries are concerned about eventually losing their national food security.

In the response to this trade protectionism, an important body of literature explores the positive effects of trade liberalization in agriculture from the perspective of welfare, poverty and food security (Litchfield, McCulloch, Winters, 2003; Taylor et al., 2010; Magrini et al., 2017; Baylis, Fan, Nogueira, 2018). However, previous studies only describe the effect of trade liberalization through final goods trade, not intermediate goods trade. My research provides the first evidence that trade liberalization in the agriculture sector through GVCs fosters the development process by changing structures of agrarian economies.

Second, I contribute to the GVC literature by providing the first empirical evidence that GVCs transform the structure of economies. Since Gereffi (1994), the analysis of GVCs has been promoted as a potential instrument of development policy. While over 70 percent of world trade volume is involved in GVCs (Baldwin, 2011), the effects of GVCs on economic development has been still controversial.

GVC optimists argue that the emergence of GVCs represents a golden opportunity for economic development in poor countries. Gereffi et al. (2005) describe that as more countries participate in GVCs, the governance of the production environment shifts from local producers to international businesses. This ultimately results in local producers in developing countries participating in modernized value chain system—that essentially requires regulatory transparency and gaining more profits by the reduction of risks from quality, consistency, and safety issues (Eaton and Shepherd, 2001; Bellemare and Lim, 2018). For producers in rich countries, the outsourcing and off-shoring of production to low-wage countries accelerate the on-going transformation of an economy structure in rich countries by focusing on services-based tasks (e.g., design work, R&D, and marketing) (Gereffi et al., 2005; Goger et al., 2014; Greenville et al, 2016; Newfarmer, Page, and Tarp, 2019).

However, more recent literature has emerged that offers contradictory findings. Rodrik (2018) points out that the upside for GVCs undermines developing countries' economic performance. He explains that GVCs might make it harder for low-income countries to use their labor cost advantage to offset their technological disadvantage. As the technology progress in production is generally biased towards skilled workers in developed countries, the gains by GVCs might be weaker in developing countries. Another source of skepticism stems from the fact that GVC participation is not enough to ensure that small farmers and vulnerable workers will be better off without multi-faceted and strategic policy approaches (Goger et al., 2014).

My finding makes an important contribution to the literature of GVCs in two ways: (i) I explore GVCs particularly in the agriculture sector that has been less studied compared to the manufacturing and service sectors. I originally measure the extent of participation in agricultural GVCs in the world, and I then provide the geographical distribution of the extent of agricultural GVCs.[2] ; (ii) I also fill in the gap in the empirical literature on GVCs by providing original empirical evidence that GVCs are positively associated with the structural transformation that is required for sustainable development.

Third, my finding contributes to the literature on agricultural value chains. In the literature, numerous studies have looked at the effects of participation in agricultural value chains on economic outcomes—employment, income, better-remunerated jobs, use of resources, governance, farm productivity, and food system transformation (Webber, 2007; Mergenthaler, Weinberger, and Quaim, 2009; Minten et al., 2009; Bellemare, 2012; Cattaneo et al., 2013; Swinnen, 2014; Swinnen and Vandeplas, 2014; Montalbano et al., 2017). Although the literature on agricultural value chains has been abundant, there are few empirical studies that look at the effect of participation in GVCs (Balie et al., 2018). This is because conventional trade data are likely do not accurately present the extent of GVC participation, and measuring the extent of GVCs is in itself challenging (Koopman, Wang, and Wei, 2014). By relying on the newly developed method by Wang et al. (2017), combining newly released multi-regional input-output (MRIO) data, I provide the first empirical evidence about how participation in agricultural value chains affects economies from a global perspective.

Lastly, my finding contributes to the literature on structural economics and agricultural policy by documenting that modern agrarian economies transform their economies directly from agriculture to service in response to the increase in agricultural GVCs. In the early literature, a structural transformation was regarded as a key channel toward sustainable growth (Lewis, 1954; Kuznets, 1966; Chenery, 1986). As economies develop, poor countries reallocate their economic activities from agriculture to manufacturing and service, to attain higher productivity employment. Historically, most rich economies today have gone through a similar process of structural transformation—that is, the successive movement of economies from agriculture and natural resources to manufacturing, and further services (Rogerson, 2008). As a result, manufacturing was prioritized as a key driver of structural transformation in poor agrarian countries (e.g., East Asian in the 1980s).

However, more recent studies provide evidence that the conventional path of structural transformation has been less observed in developing economies over the last two decade (Diao, McMillan, and Rodrik, 2017; Newfarmer, Page, and Tarp, 2019). With the rise of GVCs, many developing countries need to make more complex decisions about whether to prioritize manufacturing or attempt to leapfrog straight to services, which dominantly influences their agricultural policy both domestically and internationally (Dasgupta and Singh 2007; Rodrik 2016). While many scholars have discussed this new paradigm of structural transformation, few studies empirically show what drives the leapfrog phenomena. In this study, I provide an initial empirical finding illustrating how modern economies leapfrog in the context of GVCs, which runs counter to conventional structural transformation narratives.

The remainder of this paper proceeds as follows. Section 2 discusses the theoretical framework. Section 3 and 4 describe the data and the empirical strategy, respectively. Empirical results and robustness checks are presented in Section 5 and 6. Before concluding, Section 7 provide extension analysis. I conclude in Section 8.

2. Theoretical Framework

I introduce international trade into a general equilibrium under an open economy scenario with two countries and three sectors. My model is based on the Ricardian motive, following Uy, Yi, and Zhang (2013). In the model, one of the sectors in the economy is the agriculture sector and agricultural goods are tradable. Manufacturing and service goods are both tradable and non-tradable in the global value chains. In the agricultural sector, the production uses both labor and intermediate inputs to present the characteristics of global sourcing. Preferences are non-homothetic, which makes consumers spend a large fraction of their income in the agricultural good when they are poor. Trade is balanced each period. I first define a competitive equilibrium under an open economy and then show how exports of intermediate inputs drive structural transformation.

2.1. Preferences

In the model, there is a representative household in country $i \in (1,2)$ and its utility is given by

$$U_i(C_{ia}, C_{it}, C_{in}) = (C_{ia} - \overline{C_{ia}})^{\theta_a}(C_{it})^{\theta_t}(C_{in})^{\theta_n} \quad (1)$$

where $\theta_a, \theta_t, \theta_n > 0$ and $\theta_a + \theta_t + \theta_n = 1$. The variable C_{ia} denotes consumption of agricultural composite good (a). The variables C_{it} and C_{in} denote consumption of non-agricultural composite goods that are tradable (t) and non-tradable (n), respectively. The non-negative parameter of $\overline{C_{ia}}$ is a subsistence requirement for consumption of agricultural composite good in country i. For $\overline{C_{ia}} = 0$, the preferences are homothetic; otherwise, the preferences are non-homothetic that ensures a country will drive up the budget share for non-agricultural goods as its income increases (i.e., income elasticity for agricultural good is less than one).

The utility optimization problem of a representative household consists on choosing $[C_{ia}, C_{it}, C_{in}]$ to maximize Eq. (1) subject to the following budget constraint:

$$P_{ia}C_{ia} + P_{it}C_{it} + P_{in}C_{in} = w_i L_i \quad (2)$$

where w_i and P_{ik} denote the wage rate and the price of the sector-k $(k = a, t, n)$ composite good and L_i denotes the total labor factor endowment in country i. The budget constraint (2) ensures that balanced trade holds period-by-period.

2.2. Technologies

There are domestic sectors producing each of the three goods in both countries. The production function for good-k in country i is given by

$$Y_{ik} = A_{ik}(L_{ik})^{\alpha}\left(\prod_{m=a,t,n} M_{ikm}^{\gamma_m}\right)^{\beta} \quad (3)$$

where Y_{ik} denotes the amount of output, A_{ik} denotes exogenous technology in production of goods, L_{ik} denotes labor inputs in production, all in sector-k. The variable $M_{ikm} > 0$ denotes sector-m composite goods used as intermediate inputs in the production of sector-k good in country i. I set the parameters $\alpha, \beta, \gamma_m \in (0,1)$ to be identical across countries and sectors. The parameter α and β denote the value-added share between labor and intermediate inputs, and γ_m denotes the share of intermediate inputs sources from each sector-m where $m = a, t, n$. Note that if $\alpha + \beta > 1$, there will be decreasing returns to scales; if $\alpha + \beta = 1$, constant returns to scale; if $\alpha + \beta > 1$, increasing returns to scale.

In a close economy, intermediate input M_{ikm} is only sourced from country i itself. In an open economy, however, agricultural intermediate (M_{ika}) and tradable non-agricultural intermediate (M_{ikt}) can be sourced from both country i and j where $i \neq j$. This is because both composite goods are tradable across countries to be used as intermediate inputs by GVCs in production of final good in sector-k. Thus, M_{ikm} can be decompose into

$$M_{ikm} = M_{iikm} + M_{ijkm} \tag{4}$$

where M_{iikm} and M_{ijkm} denote sector-m ($m = a, t$) intermediate inputs sourced from country i itself and sourced from country j to i, respectively, to produce good-k. To simplify my results in the context of agricultural GVCs, I abstract intermediate production in non-agricultural sectors by assuming $\beta = 0$.

The profit optimization problem of agricultural sector (a) in country i consists on choosing $[L_{ia}, M_{iam}]$ in the following profit function, $R_{ia}(L_{ia}, M_{iam})$,

$$R_{ia(L_{ia}, M_{iam})} = P_{ia}Y_{ia} - w_i L_{ia} - \sum_{m=a,t,n} P_{im}M_{im} \tag{5}$$

Similar to Eq. (5), non-agricultural sectors (t, n) maximize their profit by choosing $[L_{ih}]_{h=t,n}$ in the following profit functions, $R_{ih}(L_{ih})$,

$$R_{ih(L_{ih})} = P_{ih}Y_{ih} - w_i L_{ih} \tag{6}$$

2.3. Competitive Equilibrium in an Open Economy

By following a Ricardian model (Eaton and Kortum, 2002), countries own incentive to trade their goods based on comparative advantage across countries. In my model, there are two countries ($i = 1, 2$) and thus if country i has a comparative advantage in agricultural production (a), then country 2 necessarily has a comparative advantage in non-agricultural tradable production (t). Recall that non-agricultural and non-tradable good (n) can be only produced and consumed within a country. Labor is perfectly mobile across sectors (a, t, n) within a country but immobile across countries (i.e., no international migration).

In an open economy, the tradable goods have world prices, denoted by p_a^w and p_t^w ($p_{1a} = p_{2a} = p_a^w$, $p_{1t} = p_{2t} = p_t^w$). Because the price of the non-tradable good (n) is determined endogenously in each country, there is no single world price of non-tradable good (p_{1n}, p_{2n}) and wage rate (w_1, w_2).

I model any incurred trade costs between country 1 and 2 as iceberg costs, denoted by φ_{ik}. I define $\varphi_{ik} = 1$ if country i consumes domestically produced outputs of good-k and $\varphi_{ik} \in (0, 1)$, if country j transports good-k to country i where $i \neq j$. For example, if one unit of agricultural good (a) is transported from country 2 to country 1, then φ_{1a} units of agricultural good—less than one units—arrive in country 2. There is no trade costs within a country.

Finally, the following factor market clearing conditions hold in each country $i = 1, 2$. For labor market, we have

$$L_i = L_{ia} + L_{it} + L_{in} \tag{7}$$

For tradable goods, the market clearing conditions holds for agricultural good and non-agricultural good, respectively, by incorporating trade costs:

$$Y_{1a} + Y_{2a} - \overline{C_{1a}} - \overline{C_{2a}} = \varphi_{1a}(C_{1a} + M_{1aa}) + \varphi_{2a}(C_{2a} + M_{2aa}) \tag{8}$$

$$Y_{1t} + Y_{2t} = \varphi_{1t}(C_{1t} + M_{1at}) + \varphi_{2t}(C_{2t} + M_{2at}) \tag{9}$$

For non-tradable good, the following market clearing condition holds in each country $i = 1, 2$.

$$Y_{in} = C_{in} + M_{ian} \tag{10}$$

Based on the discussion so far, I define a unique competitive equilibrium in an open economy with two countries and three sectors as follows:

Definition 1. A *competitive equilibrium* is a set of prices $\{P_a^w, P_t^w, P_{1n}, P_{2n}, w_1, w_2\}$ and allocations $\{Y_{1a}, Y_{2a}, Y_{1t}, Y_{2t}, Y_{1n}, Y_{2n}, M_{1ak}, M_{2ak}, C_{1a}, C_{2a}, C_{1t}, C_{2t}, C_{1n}, C_{2n}\}$, such that the allocations solve the household's utility optimization problem associated with Eq. (1)-(2) and the producers' profit optimization problem associated with Eq. (3)-(6) by satisfying the market clearing conditions associated with Eq. (7)-(10), given that structural parameters of total labor endowment (L_1, L_2), the subsistence requirement for agricultural consumption $(\overline{C_{1a}}, \overline{C_{2a}})$, and trade cost $(\varphi_{1k}, \varphi_{2k})$ with the exogenous technologies (A_{1k}, A_{2k}) where $k = a, t, n$.

2.4. Structural Transformation in an Open Economy with GVCs

I now derive the partial effect of intermediate inputs sourcing across countries on structural transformation. Since structural transformation refer a reallocation of a country's resource from agriculture sector to manufacturing, and further to service sectors (Timmer and Akkus, 2008), in my model, I define structural transformation is a decreasing pattern of agricultural labor share in a sector, similarly to previous literature (Timmer, 2009; Herrendorf, Rogerson, and Valentinyi, 2014). I denote labor share in sector-k as l_{ik} in country i where $l_{ia} + l_{it} + l_{in} = 1$. For simplicity, I set the subsistence requirement for agricultural consumption $(\overline{C_{1a}}, \overline{C_{2a}})$ are zero.

I begin by derive labor share of each sector in terms of sector-k intermediate input across countries to capture the effect of intermediate goods export on labor share in each sector. Given that non-tradable non-agricultural good (n) is by definition only produced domestically, the total expenditure on good n must identical to the total value of production at the competitive equilibrium,

$$w_i L_{in} = P_{in} Y_{in} \tag{11}$$

By multiplying $w_i L_i$ in both sides, it can be rewritten as

$$l_{in} = \frac{w_i L_{in}}{w_i L_i} = \frac{P_{in} Y_{in}}{w_i L_i} = X_{in} \quad (12)$$

where X_{ik} denotes country i's expenditure on the sector-k good. By Eq. (10), the labor share of non-tradable sector (n) is not directly affected by sourcing intermediate good across countries.

Similarly, we have the following condition at the competitive equilibrium for agricultural good.

$$w_i L_{ia} = P_a^w Y_{ia} = \pi_{iia}\{P_a^w (C_{ia} + M_{iaa})\} + \pi_{jia}\{P_a^w \big(C_{ja} + M_{jaa}\big)\} \quad (13)$$

where π_{ijk} is the share of country i's expenditure share on sector k goods from country j ($i, j = 1, 2$). For example, the total value of production of agricultural good in country 1 ($w_1 L_{1a}$) is the sum of the total expenditure of agricultural good in country i that are used as the final consumption (C_{1a}) and the intermediate inputs (M_{1aa}) and the total expenditure of agricultural good in country j that are used as the final consumption (C_{2a}) and the intermediate inputs (M_{2aa}).

Eq. (13) can be rewritten by multiplying $w_i L_i$ as

$$l_{ia} = \frac{w_i L_{ia}}{w_i L_i} = \frac{P_a^w Y_{ia}}{w_i L_i} = \frac{\pi_{iia}\{P_a^w (C_{ia} + M_{iaa})\} + \pi_{jia}\{P_a^w \big(C_{ja} + M_{jaa}\big)\}}{w_i L_i} \quad (14)$$

For non-agricultural tradable good (t), the following equation similarly holds,

$$l_{it} = \frac{w_i L_{it}}{w_i L_i} = \frac{P_t^w Y_{it}}{w_i L_i} = \frac{\pi_{iit}\{P_t^w (C_{it} + M_{iat})\} + \pi_{jit}\{P_t^w \big(C_{jt} + M_{jat}\big)\}}{w_i L_i} \quad (15)$$

To show the partial effect of cross-country intermediate input in agricultural production (i.e., agricultural GVCs) on structural transformation in an exporting country, it is useful to decompose the origin of each intermediate inputs by using Eq. (4) to track intermediate inputs sourced only from the other country (M_{jiak}). This suggests the two following propositions.

Proposition 1. *Suppose there exist a competitive equilibrium in an open economy with agricultural GVCs between two countries (i, j). If country i increases the export amount of agricultural intermediate input for country j's agricultural production, then country i reallocate its labor from the non-agricultural tradable sector (t) to the agricultural sector (a).*

<u>Proof</u>. Since the labor share of non-tradable sector (l_{ia}) is not associated with intermediate good trade by Eq. (12), the sum of labor shares in country i can be written as $l_{ia}(M_{jiaa}) + l_{it}(M_{jiat}) + l_{in} = 1$ by assuming the final consumption and domestically produced and consumed intermediate inputs are constant at the competitive equilibrium given parameters and price vector. By Eq. (13)-(14), the derivative of the labor shares of tradable sectors with respect to cross-country intermediate agricultural inputs, we have $\frac{dl_{ia}}{dM_{jiaa}} = \frac{\pi_{jia}P_a^W}{w_i L_i} > 0$ and $\frac{dl_{it}}{dM_{jiaa}} = -\frac{\pi_{jia}P_a^W}{w_i L_i} < 0$. ■

Proposition 1 shows that the marginal effect of agricultural intermediate input from country i to j on the country i's labor share of the agricultural sector is positive but the marginal effect of its labor share of non-agricultural trade sector is negative.

Proposition 2. *Suppose there exist a competitive equilibrium in an open economy with agricultural GVCs between two countries (i, j). If country i increases the export amount of non-agricultural intermediate input for country j's agricultural production, then the country i reallocate its labor from the agricultural sector (a) to the non-agricultural sector (t)*

<u>Proof.</u> Similar to Proposition 1 proof by using Eq. (15) instead of Eq. (14). Then we have $\frac{dl_{ia}}{dM_{jiat}} = -\frac{\pi_{jit}P_t^W}{w_i L_i} < 0$ and $\frac{dl_{it}}{dM_{jiat}} = \frac{\pi_{jit}P_t^W}{w_i L_i} > 0$ (i.e., the marginal effect of non-agricultural intermediate input from country i to j on the country i's labor share of the agricultural sector is negative but the marginal effect of its labor share of non-agricultural trade sector is positive). ■

Proposition 1 and 2 summarize the relationship between agricultural GVCs and structural transformation as follows: a country reallocates their endowed resources more on a tradable sector when the country increase its intermediate input of the sector in other country's agricultural production. Intuitively, a country has incentive to concentrate on their economic resources on a specific tradable sector where the country has a competitive advantage against the other importing country in the case that the traded good is used as intermediate production by the importing country. For example, if country j's demand of country i's tradable manufacturing or service goods increases, then country i allocate more resources on manufacturing or service sectors that leads structural transformation from agriculture to non-agriculture sector in country i. This is consistent with Uy, Yi, Zhang (2013) and Teignier (2018), which stated that trade in agricultural goods can accelerate structural transformation.

In terms of size of marginal effect, there are three factors: (i) the marginal effect of a country i's global sourcing to an importing country (j) on its labor share in sector-k (l_{ik}) is positively related to the share of the importing country's expenditure on the country (π_{jik}). For example, if country j's agricultural trade dependence on country i increases, then the marginal effect of country i's global sourcing non-agricultural tradable good (t) on labor share in non-agricultural sector (t) is proportionally increases. (ii) The marginal effect is also positively related to the world price of the trade sector. (iii) Lastly, the marginal effect in country i has an inverse relationship with the country's size of economy ($w_i L_i$).

By Proposition 1 and 2, I define the country i's total effect of intermediate input sourcing for country $j's$ agricultural productions on country i's labor share of agricultural sector as G_{jia} such that

$$\underbrace{G_{jia}}_{TE\ of\ global\ sourcing} = \underbrace{\frac{dl_{1a}}{dM_{jiaa}}}_{ME\ of\ ag.\ sourcing} + \underbrace{\frac{dl_{1a}}{dM_{jiat}}}_{ME\ of\ non-ag.\ sourcing} = \frac{1}{w_i L_i}\left(\pi_{jia} P_a^w - \pi_{jit} P_t^w\right) \tag{16}$$

Proposition 3. *Suppose country i has comparative advantage in non-agricultural sector against to country j at the competitive equilibrium. If the world price of non-agricultural good is higher than the world price of agricultural good (i.e., $P_a^w < P_t^w$), then country i transform its economy out of agriculture sector as their overall global sourcing for agricultural production in country j increase.*

Proof. Since $w_iL_i > 0$, the sign of $(\pi_{jia}P_a^w - \pi_{jit}P_t^w)$ is equal to the sign of G_{jia} by Eq. 16. Given that country i has competitive advantage in non-agricultural sector (t), it holds that $\pi_{jia} < \pi_{jit}$. This is because country j's expenditure share on country i's non-tradable good is higher than its expenditure share on country i's agricultural good. Thus, if $P_a^w < P_t^w$, then we have $G_{jia} < 0$. ■

According to proposition 3, a country whose has comparative advantage on non-agricultural good transforms its economy from agriculture sector to non-agriculture sector such as manufacturing or service by reallocating its endowed resources when the world price of non-agriculture good is higher than the world price of agriculture good.

3. Measuring GVCs and Structural Transformation

3.1. Measuring Global Value Chains

In trade literature, there has been two barriers to developing a consistent statistical and conceptual portrait of GVCs. First, unlike conventional trade data that accounts for the final product transaction, data for measuring GVCs essentially requires industry-level data which enables us to track all value-added activities by industries or countries involved in global production. The national accounts data (e.g., gross import or export of final products) are, however, not suitable for measuring GVCs because the national accounts data lack information of value-added intermediate input transaction.[2] National input-output account data that describe value chain linkage across industries can be considered as alternative data but it only provide value added transactions within a country, not across countries (Johnson, 2017). To overcome this, a multi-country input-output table—that combines the national input-output tables of various countries at a given point of time—is required to provide a comprehensive map of international transactions of goods and services (Inomata, 2017).

Secondly, there was lack of agreement of a coherent measure of GVCs. Researchers have struggled to conceptually define what types of value-added activities should be taken account for GVCs measure (Hummels, Ishii, and Yi, 2001; Chen et al., 2004; Daudin, Rifflart, and

[2] Balié et al. (2019) elaborate the difference between conventional trade and value-added trade statistics. See their appendix (section 1).

Schweisguth, 2006; Johnson and Noguera, 2012; Bems and Johnson, 2012).[3] As international trade in value-added goods or services has become complicated to track, the flows of GVCs are heterogeneous depending on products and industries. As a result, decomposition of gross exports into various sources of value-added has been recognized as a methodologically challenging job.

To succeed in dealing with these difficulites, in this study, I adopt a recent method developed by Wang et al. (2017) to measure participation in GVCs by using UNCTAD-Eora GVC Database. Following Wang et al. (2017), a general cross-country input-output table can be theoretically decomposed into multiple value-added activities by using Leontief inverse matrix. The primary advantages of their measure of GVCs are characterized in two parts. First, the measure can capture all complicated sources of value-added activities across more than two countries, which are often missed in other measures of GVCs. Secondly, they provide an empirical method to extract value-added exports from gross exports that enable users to recover each value-added activity by using cross-country input-output data.

By Wang et al. (2017), the gross exports can be decomposed into four broad value-added activities—that are futher disaggregated into sixteen value-added activities: (i) Domestic value-added absorbed abroad (DVA), (ii) Domestic value-added first exported then returned home (DVX), (iii) Foreign value added (FVA), and (iv) Pure double-counted terms (PDC). Figure A2 graphically describes the components of GVCs wherein gross exports are decomposed into four broad activities.[4]

For the purpose of the analysis in this study, each activity can be interpreted in the following way: First, DVA is excluded to measure GVCs because this is a conventional transaction of final products between two countries.[5] Second, DVX measures forward GVC participation (or downstream participation). DVX reflects producer perspective by addressing what extent of production factors employed in a country that have been involved in cross country production activities. the share of a country's domestic value added that is exported to other countries embodied in intermediate goods. Third, FVA measures backward GVC participation (or upstream participation). FVA reflects consumer perspective by addressing what extent of final products

[3] See Inomata (2017) for more detailed literature review of the development of measures of GVCs.
[4] Figure A2 shows their more recent revised framework where gross exports are decomposed into 7 activities for simplicity (Inomata, 2017).
[5] I elaborate the difference between conventional trade of final goods and GVC production in trade account in Appendix A3.

produced by a country that is sourced from GVC activities. Lastly, PDC is an accounting component generated where value-added products cross borders multiple times and thus PDC needs to be included when measuring the total GVCs. As a result, I measure the GVC participation (D_{it}) for country i in year t by Wang et al. (2017) by calculating the following equation:

$$D_{it} = \frac{DVX_{it}+FVA_{it}+PDC_{it}}{Gross\ Export_{it}} \tag{17}$$

To generate D_{it}, I use UNCTAD-Eora GVC Database, a recently released multi-country input-output data. This data tracks the four value-added activities (i.e., DVA, DVX, FVA, and PDC) by industries not only within a country but also across countries input-output value-added activities in 26 industries for 183 countries from 1990 to 2013. I use the industry classification of 'agriculture' industry to measure agricultural GVCs.

In Figure 1, it is observed that there exists an increasing trend of participation in agricultural GVCs in the given time period. Figure 2 provides the average level of agricultural GVC participation at the regional levels.

Figure 1. Trend of Agricultural GVCs, 1990 - 2013

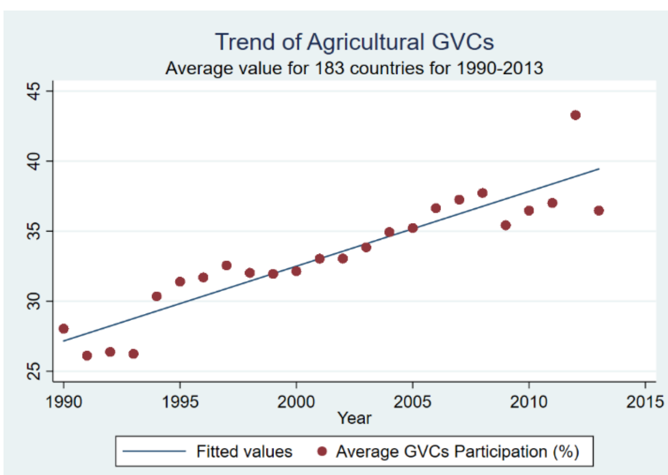


Figure 2. Trends of Agricultural GVC Participation by country groups, 1990-2013

Figure 2.a. OECD countries

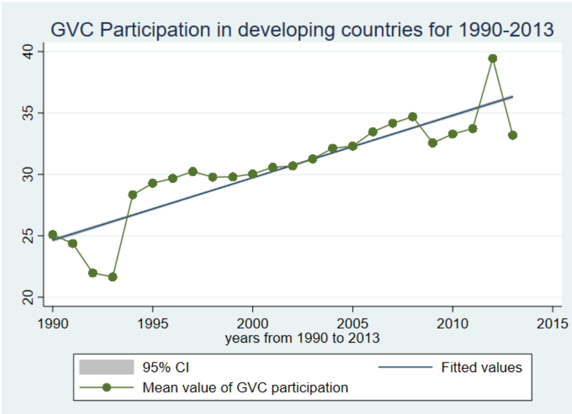


Figure 2.b. Developing countries†

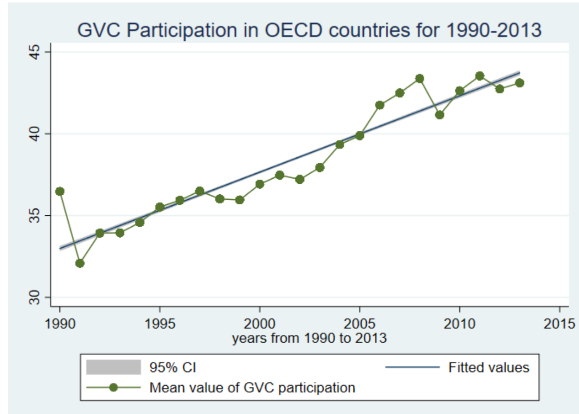


Figure 2.c. Sub-Saharan Africa countries

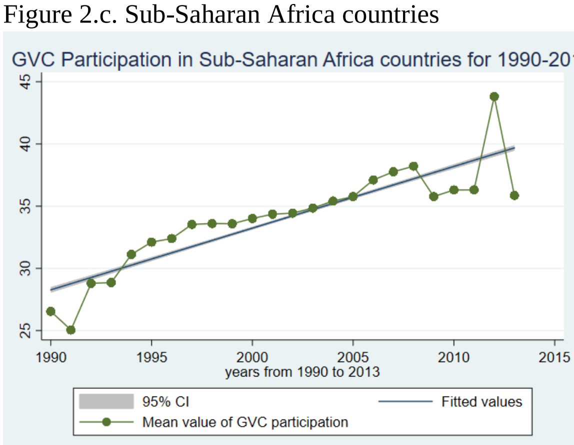


Figure 2.d. South Asia

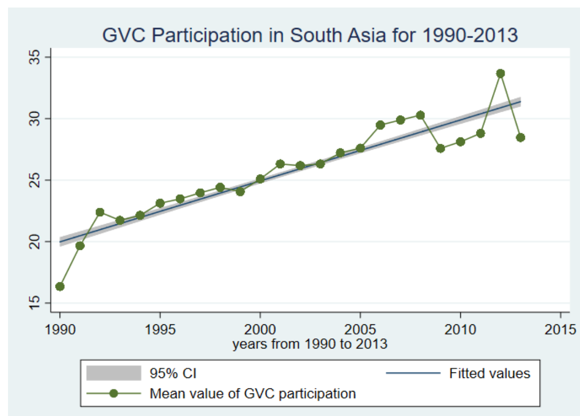


Figure 2.e. Latin American and the Caribbean countries

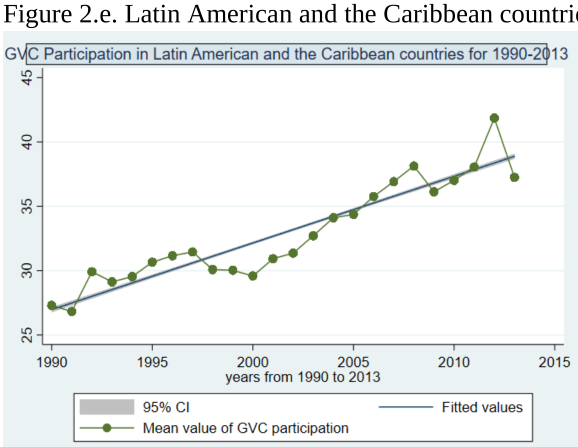
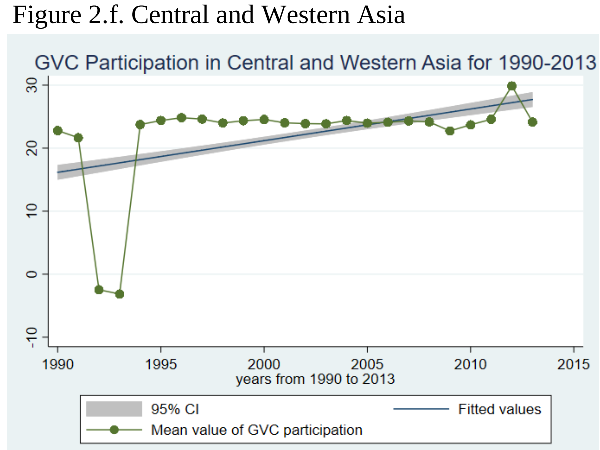


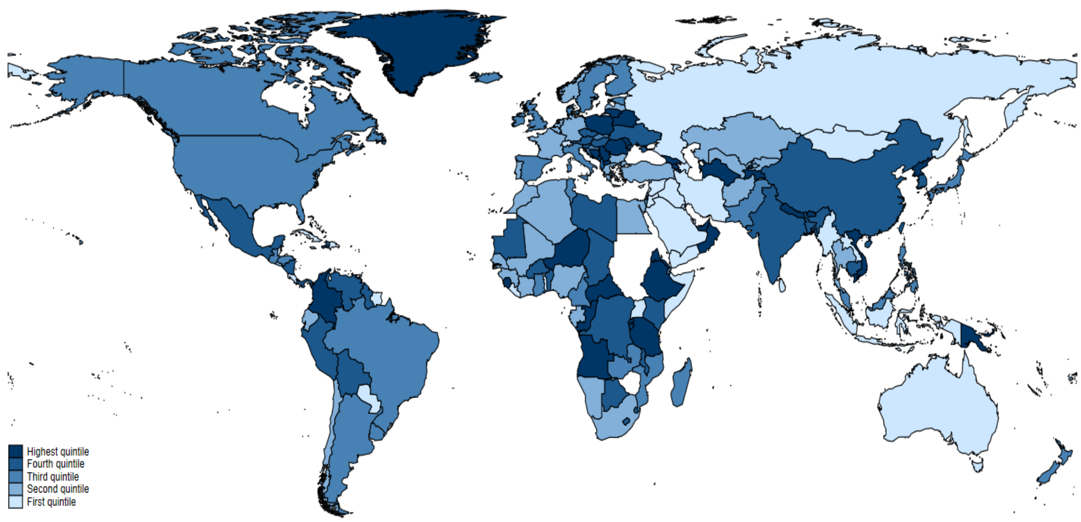
Figure 2.f. Central and Western Asia



† Developing countries include Sub-Saharan Africa, South Asia, Latin America and the Caribbean, and Central and Western Asia.

In terms of geographical distribution across the world and the growth rate, the data provides evidence that developing countries have increasingly participated in GVCs of both agriculture and food industries (See Figure 3).

Figure 3. World Map of Agricultural GVC Participation Growth Rate between 1990 and 2013



Source: Author's own calculation

3.2. Measuring Structural Transformation

The structural transformation of countries involves a variety of features. By Timmer (2009), structural transformation is characterized in a country by following economic changes: (i) a falling share of agriculture in economic output and employment, (ii) a rising share of urban economic activity in industry or services, (iii) the migration trend from rural to urban, (iv) a demographic transition from high birth rates to low death rates, and (v) a rising female labor participation from agriculture to service.

In the literature of economic growth and development, three measures of national economic activities by the sectors ─ agriculture, manufacture, and service ─ have been widely used: (i) GDP shares, (ii) employment shares, and (iii) final consumption shares (Herrendorf, Rogerson, and Valentinyi, 2014). For example, one can measure structural transformation in a country by addressing the share of agricultural activities decreases while the share of non-agricultural activities increases in an economy over years.

In my study, GDP shares of agriculture, industry, and service in each country are used as the main measure of structural transformation. To perform the robustness check, the employment shares by the sectors are also used. However, this study excludes the final consumption shares as an alternative measure of structural transformation because of two reasons. First, it is difficult to obtain credible data of expenditure estimates in numerous developing countries such as Sub-Saharan Africa or South Asia (Ravallion, 2001). Also, final consumption in the service sector has been proved perpetually challenging and underestimated not only for developing countries but also developed countries (Landerfeld, Seskin, and Fraumeni, 2008). Hence, the measure of structural transformation in this study is inevitably limited to production approach.

The data source of structural transformation used as dependent variables is the World Development Indicators database (WDI). The cross-country data contains the value-added GDP shares by the agriculture, industry, and service sectors for 183 countries from 1990 to 2013.[6] Total GDP is measured at purchaser prices. It is not allowable to have the sum of GDP shares over one by its definition. Thus, I dropped 28 observations whose sum of GDP shares by three sectors is larger than one to avoid measurement error

4. Empirical Framework

I start this section by presenting my preferred empirical specification based on standard linear methods. I then discuss alternative specifications. Lastly, I discuss my identification strategy by explaining how my empirical approach addresses the main sources of endogeneity.

4.1 Baseline

My equation of interest is such that

$$y_{it} = \alpha + \beta D_{it} + X_{it}\delta + \alpha_i + \mu_t + \varepsilon_{it} \tag{18}$$

[6] Value added is the value of the gross output of producers less the value of intermediate goods and services consumed in production, before accounting for consumption of fixed capital in production.

where y_{it} is the GDP shares by each sector ─ agriculture, manufacturing, and service ─ by country i in year t. This is percentage outcome, taking on the value from 0 to 100. D_{it} is the treatment variable of the participation level of agricultural GVCs by country i in year t. X_{it} denote time-varying control variables, α_i denotes a vector of country fixed effects and μ_t denotes a vector of year fixed effects. ε_{it} is an error term with mean zero.

In applying the fixed effects framework to data, I estimate Eq.(18) by the ordinary least squares.[7] The country fixed effects (α_i) are included to control time invariant unobserved heterogeneity within each country i. The year fixed effects (μ_t) controls for all the country-invariant unobserved heterogeneity within each year. Also, I cluster my standard errors at the country level to correct my results robust to heteroskedasticity and autocorrelation by following the recommendations in Bertrand et al. (2004), Angrist and Pischke (2009), Athey, Abadie, Imbens, and Wooldridge (2017).

The objective of empirical framework in this study is estimating the coefficient of β to show the effect of participation in agricultural GVCs by testing the null hypothesis $H_0 : \beta = 0$ and the alternative hypothesis $H_A : \beta \neq 0$.

4.2 Alternative specifications

Although the baseline model controls for country fixed effects, regional fixed effects, and year fixed effects, the time effects often differ across regions in cross-country analysis. For example, the effects of climate shocks or oil price shock (Baumeister et al., 2010) in a year may be limited to specific regions. To ensure that findings are robust, I also estimate comparable alternative specifications by controlling for (i) a linear time trend, (ii) a linear time trend squared, (iii) region-specific time trend, and (iv) region-specific time trend squared.

4.3 Identification Strategy

It is important to discuss potential treats to identification. Because the extent of GVCs participation by a country is not randomly assigned, and so the treatment is not exogenous to the structural transformation measured in GDP shares by the sectors.

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[7] In this study, I estimate by using a fixed effect estimator. One might suggest applying the random effect estimator as robustness check. It is, however, inappropriate in this case where the variable of interest ─ GVC participation ─ (D_{it}) is not randomly assigned, which violates the random effect hypothesis (i.e., $E(D_{it}\varepsilon_{it}) = 0$).

I provide the identification strategy for β in Equation (1) by documenting four primary sources of endogeneity: (i) unobserved heterogeneity, (ii) measurement error, (iii) reverse causality, and (iv) violation of the stable unit treatment value assumption.

(i) Unobserved Heterogeneity

A specification model should include all potentially relevant variables in an estimated model to avoid a biased parameter estimate due to the unobserved heterogeneity. Although it is not feasible to completely include all omitted variables, in many cases, it is important to acknowledge and eliminate the possibility of omitted variables.

In my empirical framework, multiple econometric methods are employed to eliminate the unobserved heterogeneity. First, country fixed effects (α_i) used in the baseline model are expected to control for the time-invariant factors in each country. The time-invariant factors include country-specific geographical conditions and socio-cultural backgrounds, such as language or history, which have been considered as determinants to the volumes of trade or economic growth. Country fixed effects also control for the initial level of economic conditions (e.g., levels of GDP in the initial year in the panel data) in each country, which often determine the pattern of structural transformation of a country (Vries, Timmer, Vries, 2015; Hnatkovska and Lahiri, 2016; Bustos, Caprettini, and Ponticelli, 2016).

Secondly, year fixed effects (μ_t) in Equation (18) purge the error term of its correlation with the treatment variable due to factors that remain constant across all countries in a given year. For example, structural transformation might be deterred in 2007-2008 for the global financial crisis across countries. One might argue that year fixed effects cannot not capture time-varying unobserved confounding factors unique to a given region in a given year such as regional climate changes (e.g., the impacts of climate change on Sub-Saharan Africa) or political changes (e.g., Arab Spring in the Arab world in 2010). Thus, I include comparable alternative specifications to show regional time effects.

Third, the baseline model controls for an exhaustive set of time-varying confounders at the country-level. The vector of time-varying control variables (X_{it}) includes economic factors (e.g., GDP and arable land area of agriculture) and demographic structure (e.g., population, urban population growth, dependency ratio) by following previous empirical studies of structural transformation (Michaels et al., 2012; Bustos et al., 2016; Duarte and Restuccia, 2010, Alvarez-Cuadrado and Poschke, 2011).

One might concern that the extent of agricultural GVCs is endogenous due to changes in (i) trade policy within a country, (ii) trade competitiveness with other countries, or (iii) domestic agricultural price policy. To control for the time-varying trade policy and competitiveness, the vector of X_i also contains trade variables (e.g., regional trade agreement (RTA), free trade agreement (FTA), custom union (CU)) and the participation level of agricultural GVCs (D_{ot}) by neighboring countries of country i at year t. I control for domestic agricultural price policy by generating a time-varying variable adopting the method by Timmer and Akkus (2008).

Lastly, I control for time trends to eliminate the potential bias stemming from unobserved heterogeneity in my data that varies systematically across countries over time. The systematical pattern of structural transformation across country over years — increasing shares from the agriculture to manufacturing, and further service sector — is commonly observed in literature of economic growth. The dataset I used in this study also shows the pattern (See. Figure 3). Thus, I further estimate alternative specifications including (i) a linear time trend, (ii) a linear time trend squared, (iii) regional-specific time trends, and (iv) regional-specific time trend squared, respectively.

Although most of the unobserved heterogeneity can be captured by the econometric methods, the identification assumption in this study is that any left omitted variables do not significantly bias the estimate of β.

(ii) Measurement Error

Another source of endogeneity issue is measurement error. Measurement error might not be a serious concern if one uses a valid instrument variable. Otherwise, in fixed effects regression, one should avoid overly strong claims when interpreting fixed-effects estimates since the data might have systematic errors, such as under- or over- reporting (Angrist and Pischke, 2008).

In measuring the extent of GVCs, missing information on a division between intermediate and final goods is the major source of measurement error. This is because there are heterogenous custom product codes in cross-border supply chains. Although there are a few trials to measure the extent of GVSs in the literature, the existing measures are still not free from measurement error issue.[8]

In this study, the treatment variable of the extent of agricultural GVCs in each country (D_{it}) is measured using the recent measure developed by Wang, Wei, and Zhu (2017). Their measure eliminates the described missing information source by decomposing value-added production activities in cross-border production. Also, it provides the upstream and the downstream GVC participation index, which supply more detailed GVC involvement in countries compared to other measures (See. Antràs and Chor, 2018). Thus, this study relies on the proven validity of the measure of GVCs (Antràs and Gortari, 2017; Antràs and Chor, 2018; Balié et al., 2017) to reduce measurement error in measuring the treatment variable (D_{it}).

Another concern is on measurement error related to structural transformation. I use the GDP shares of three sectors each country over years as a primary measure of structural transformation. The panel data of GDP used in this study is the assembled collection from statistical offices in 183 countries which is uniquely available. Although the estimates of GDP are comparably reliable in most developed countries, they are likely to be associated with underestimation in many developing countries (Jerven, 2013; Vries et al., 2015). For example, various African countries are subject to large measurement error in estimating GDP due to low quality of statistical management ─ a weak capacity to collect data, inadequate funding of statistical offices, or fragmentation in surveys ─, so called "Africa's statistical tragedy" (Devarajan, 2013; Jerven and Johnston, 2015).

The possibility of underestimated GDP in developing countries might affect the identification of β in two ways. First, if GDP data are systematically underestimated for all three sectors ─ agriculture, manufacturing, and service ─, then the estimate of $\hat{\beta}$ is less likely to be biased because the shares of GDP by the sectors are still constant (i.e., the ratio of GDP by the sectors is constant as the total proportion of absolute GDP decreases by the sectors). Secondly, if GDP is relatively more underestimated in a specific sector, then the $\hat{\beta}$ is biased to β. Given that, in developing countries, GDP is seriously underestimated in the service sector (Jerven, 2013), it is likely to argue that the estimate of $\hat{\beta}$ would be $|\hat{\beta}| < |\beta|$ in the service sector. This implies that a rejection of the

[8] See Wang et al. (2017) for measurement error issue in the early-stage measures of GVCs, such as vertical specialization (VS) method by Hummels et al. (2001) or import to produce (I2P) and export (I2E) method by Baldwin and Lopez (2013).

null hypothesis test (i.e., $H_0 : \beta = 0$) provides a stronger evidence in the service sector because the coefficient of $\hat{\beta}$ is a lower bound of the true coefficient of β.

For the robustness check, I also use alternative measures of structural transformation — employment shares by the sectors. Moreover, in extension analysis, I provide separate estimation only for developed countries (i.e., OECD) whose data is more reliable, excluding developing worlds.

Despite all efforts to eliminate measurement error, there might be random sources due to unobserved quality issues with the data used in this study. Thus, the second identification assumption is that any other random measurement error does not significantly affect biasness of the estimate β.

(iii) Reverse Causality

The third concern of the endogeneity issue is reverse causality. If structural transformation leads to participation in agricultural GVCs at the country level (i.e., y_{it} and D_{it} is jointly determined), the estimate of β would obscure the reverse causality. The economic structural transformation is, however, unlikely to be the dominant influences on the participation in GVCs for two reasons.

First, in the literature of growth and trade theories, a country's structural transformation measured by GDP (or employment) shares by the sectors is proved as an outcome variable, which is determined by various economic activities and factors by countries (e.g., production function, land-augmenting technical change (Bustos, Caprettini, and Ponticelli, 2016), labor productivity (Vries et al., 2015), land allocation, population mobility (Michaels, Rauch, and Redding, 2012), or urbanization (AER, 2016). The more recent study by Teignier (2018) contributes to the literature by providing the theoretical model of how trade-related factors determine structural transformation in terms of the shares of economic activities by the sectors.

Secondly, in a year, trade activity is commonly performed before the GDP is calculated. The GDP is an aggregate measure of total economic production including personal consumption, government purchases, paid-in construction costs and the foreign trade balance within a country during the period. Therefore, the GDP in year t that should be calculated after year t can reflect economic production activities — including participation in GVCs — in a country in year t rather than vice versa.

One might concern that GVCs is influenced by structural transformation through dynamic mechanism. For example, the increased share of GPD (or employment shares) in agriculture might accelerate a country to be more involved in the agricultural value chains in the global trade since the country allocates more economic resources on the agricultural sectors. To explore the possibility of reverse causality due to the dynamic nature of structural transformation (Carkovic and Levine, 2002; Vries, Michaels, Rauch, Redding, 2012; Timmer, and Vries, 2015; Hnatkovska and Lahiri, 2016), I check the robustness of estimates β by using the dynamic panel linear regression method.

(iv) The Stable Unit Treatment Value Assumption (SUTVA)

The final endogeneity source is the Stable Unit Treatment Value Assumption (i.e., hereafter SUTVA). SUTVA requires that the dependent variable of a particular unit (y_i) depends only on the treatment to which it itself was treated (x_i), not the treatments of others around it (x_j) where $i \neq j$. In panel data analysis, a linear model is often assumed SUTVA without which the statistical theory does not hold (Heckman, 2008), and further violation of SUTVA obviously lead to endogeneity (Pearl, 2009).

In the model specification using Equation (18), SUTVA can be violated if and only if (i) the treatment of GVCs for country i affects the structural transformation for another country j or (ii) there is at least one more version of each treatment level (i.e., country). Especially for the first case, one might be concerned that SUTVA is violated because structural transformation in one country might be influenced by the trade strategies of his neighboring countries as spillover effects in trade. For example, the labor share in agriculture in a country might be increase (or decrease) through cross-border migration or the in-or-out flows of foreign investment as its bordered countries has been highly involved in agricultural GVCs.

In effort to eliminate the potential bias stemming from the violation of SUTVA, I control for the neighboring countries' GVCs for all countries. I define the neighboring countries' GVCs by taking the average value of GVCs indexes of neighboring countries. In this study, neighboring countries are defined as all bordered countries of each country. For isolated countries ─ both geographically (e.g., Australia or Japan) and politically isolated (e.g., South Korea)─, I use five geographically nearest countries as a proxy for bordered countries. The average GVCs index of neighboring countries can partially control for the within-year spillover effects, and thus the likelihood of violation to SUTVA decreases.

Although the identification strategy is expected to control for most possibility of the violation of SUTVA, it is only limited to contemporary SUTVA. Given that this use panel data, the possibility of violation of SUTVA is still remaining in cases that spillover effects occur within a country over years, or between countries over years is still remaining. Although my dynamic model estimation marginally check robustness for the former case, this study assumes that the violation of SUTVA between countries over years does not significantly bias the estimate of β.

4.4. Data Sources for Control Variables

To address the endogeneity issues, I pool together data from a large number of sources for time-varying control variables (X_{it}) in Equation (18). First, to measure of domestic price policy variable, I generate the variable of the domestic policy agricultural terms of trade (Domestic policy AgToT) by adopting the method by Timmer (2009). I use FAO database and FAO price index to calculate the variable.[9] Secondly, CEPII database is used to have trade policy variables ─ regional trade agreements (RTA) sourced from WTO (2015), custom unions (CU), and free trade agreements (FTA) sourced from Baier and Bergstrand data. Third, I measure the neighbor countries' GVCs participation by averaging GVCs indexes of all bordered countries of each country. For island countries where bordering country does not exist, I use top five nearest countries as a proxy for bordering country. I use the geographical data from DistanceFromTo to identify the top five nearest countries from each island country. Lastly, I use the World Development Indicator database for the rest of control variables including agricultural land area, population, urbanization, GDP, and dependency ratio. Table 1 summarizes descriptive statistics.

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[9] By Timmer (2009), agricultural terms of trade (AgToT) ─ the ratio of GDP deflator in Agricultural value-added to GDP deflator in non-agricultural value-added ─ can be recognized as a proxy for agricultural price policy in trade, which is dominantly influenced by world food price. Domestic price policy is measured by $Domestic\ Policy\ AgToT = \frac{predicted\ AgToT}{actual\ AgToT} * 100$. See Timmer (2009) for more description of the calculation.

Table 1. Descriptive Statistics for 183 Countries for the Period 1990─2013

Variables	Obs.	Mean	Std.Dev.	Min.	Max.
Dependent Variable					
GDP share in Agriculture (%)	3,593	15.04	14.24	0.0354	93.98
GDP share in Manufacture (%)	3,608	29.67	11.86	1.882	84.80
GDP share in Service (%)	3,585	55.26	15.11	4.141	93.22
Employment share in Agriculture (%)	3,943	31.58	26.62	0.0110	92.84
Employment share in Manufacture (%)	3,943	20.23	9.459	1.741	54.10
Employment share in Service (%)	3,943	48.19	20.43	5.069	87.23
Global Value Chains (GVCs)					
Agriculture Industry					
GVC Participation	4,364	33.31	18.14	-515.7	282.2
GVC Participation by Neighboring countries	4,364	31.92	9.687	-111.7	116.6
Downstream Participation	4,364	21.68	9.747	-88.34	154.9
Downstream Participation	4,364	8.566	15.20	-535.1	249.0
Food Industry					
GVC Participation	4,392	32.23	15.597	-252.2	260.0
GVC Participation by Neighboring countries	3,480	31.80	10.098	-111.6	116.6
Upstream Participation	4,364	21.68	9.747	-88.34	154.9
Downstream Participation	4,364	8.566	15.20	-535.1	249.0
Control Variables					
Participation of RTA (Yes= 1)	4,364	0.871	0.335	0	1
Participation of CU (Yes= 1)	4,364	0.498	0.500	0	1
Participation of FTA (Yes= 1)	4,364	0.553	0.497	0	1
Numbers of RTA	4,364	29.24	24.91	0	110
Numbers of CU	4,364	7.418	9.416	0	31
Numbers of FTA	4,364	13.40	18.33	0	108
GDP (log)	3,905	24.79	2.056	19.44	30.42
Land share for Agriculture (%)	4,218	39.07	22.28	0.449	85.49
Rural Population (%)†	4,362	44.32	24.10	0	94.58
Urban Population Growth (%)	4,357	2.262	2.021	-7.115	17.63
Age Dependency Ratio (%)	4,167	65.27	19.93	16.45	119.1
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	4,301	100.0	0.556	95.32	112.0

† The zero values of rural population are associated with countries including Bermuda, Cayman Islands, Hong Kong, Macao, Monaco, and Singapore.

5. Estimation Results

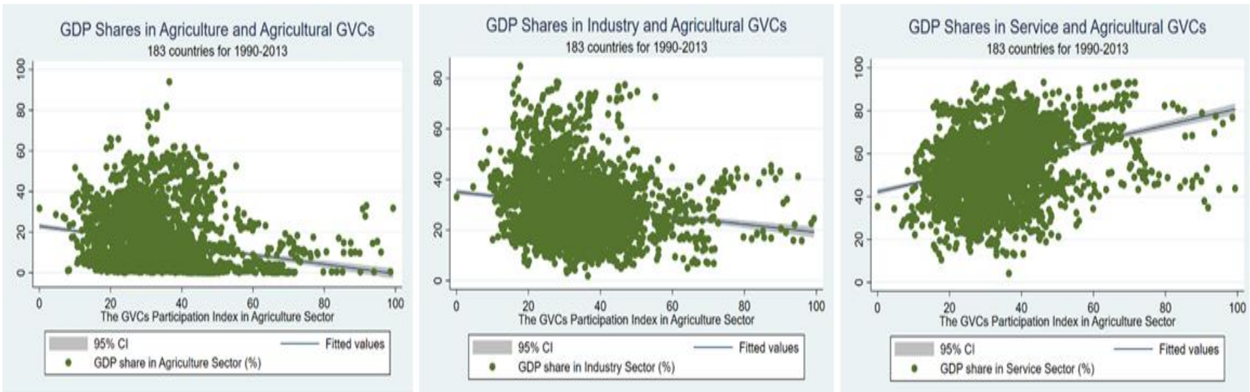
This section provides the empirical results. Before I discuss the parametric results, I begin by with nonparametric results that present unconditional relationships between structural transformation and participation in agricultural GVCs. After checking the instructive correlation, I then discuss parametric estimation results for the various linear specifications in Equation (18) along with comparable alternative specifications. In summary, both nonparametric and parametric results provide the robust evidence that as countries participate more in agricultural GVCs, the participating countries' GDP share in agriculture sector significantly decreases, GDP share in service sector significantly increases; GDP share in manufacturing is stable. In other words, in response to greater agricultural GVCs participation, countries transform their economies by reallocating their economic activities from the agricultural sector directly to the service sectors.

5.1 Nonparametric Results

Figure 4 shows scatter plots of the sectoral GDP shares and the index of agricultural GVCs participation for 183 countries from 1990 to 2013. Figure 4 respectively represent each sector agriculture, manufacturing, and service. The index of GVCs is shown on the X-axis and the GDP share by each sector is shown on the Y-axis. Each point in the scatter matches one country in a given year, and each figure include a linear regression of GDP shares on the index of GVSs along with 95% confidence interval.

One noteworthy interpretation from Figure 4 is that structural transformation seemingly occurs from agriculture to service. From the scatter plots in Figure 4.a, the negative relationship between the GDP share in agriculture and the participation in the agricultural GVCs. Similarly, the negative relationship is also observed in the manufacturing sector in Figure 4.b, along with nearly identical slope. It is, surprisingly, opposite in the service sector. In Figure 4.c, the relationship between the GDP share in the service sector, and the participation in GVCs is positive, along with almost twice higher slope in absolute value. The correlation is robust to an alternative measure of structural transformation—the employment shares—in the agriculture and service sectors, but the manufacturing sector (See Appendix Figure 2). This is, however, the results only looking at the unconditional correlation between structural transformation and agricultural GVCs. In the next subsection, I then provide the parametric results controlling for confounding factors with different specifications.

Figure 4. GDP Share and Agricultural GVCs Participation 1990 – 2013



5.2 Parametric Results

In this subsection, I begin by presenting the core results from most to least parsimonious specifications in terms of various set of control variables. First, I describe the initial estimation not controlling for confounding factors. Then, I successively discuss how the estimation results are robust by accounting for spillover effect by neighbor countries, trade policies, and a richer set of covariates, including domestic price policy, economic resources, and demographic transformation. By providing the estimation results in these steps, it is more clarified how stable the estimate of interest (β) is with or without controlling for different aspects of time-varying covariates, which are likely correlated with the treatment variable of D_{it}.

(i) Initial Estimates

Table 2 presents the initial estimation results from the linear regression estimation for Equation (18) without time-varying covariates, X_{it}. Panel 1—3 show the sectors of agriculture, manufacturing, and service respectively. For all panels, columns (1) through (5) show results on the full sample along with country fixed effects. Column (1) includes country-specific year fixed effects while column (2) to (5) contain (i) a time trend, (ii) time trend squared, (iii) region-specific time trends, and (iii) regional-specific time trends squared, respectively, all with country fixed effects.

Through Panel 1-3, my baseline specification results in column (1) provides two primary findings. First, the agricultural GVCs participation is negatively and significantly associated with the GDP share in the agricultural sector. On the other hand, the GVCs participation is positively and significantly associated with the GDP share in the service sector when controlling for country fixed effects and country-specific year fixed effects on average. The GDP share in service increases by 0.017 percent while the GDP share in agriculture decreases by 0.015 percent in response to the marginal increase in GVCs participation. No significant effects are found in the manufacturing sector. Secondly, the result is also robust to other specifications in columns (2)—(5). My initial estimation results overall imply that the agricultural GVCs participation leads to the GDP shares in a country directly from agriculture to service by leapfrogging manufacturing.

(ii) Does the neighboring countries GVCs matter?

The results in table 2 suggest how participation in GVCs by neighboring countries affects the structural transformation in a country. The motivation for controlling the GVCs by neighboring countries is that the economic structure in a country is likely exposed to trade competition or cooperation by its geographically near countries (Acemoglu, Autor, Dorn, Hanson, and Price, 2014). It might be possible that the structural change in economic growth labor shares across the sectors in a country is influenced not only by its GVCs involvement but also by the involvement of its neighboring countries in GVCs. To exam this issue, table 2 indicates the estimation results by controlling for the time-varying covariates of the GVCs by neighboring countries.

Table A1 yields similar results with table 1. In table A1, there are the statistically significant relationships between GVCs participation and each sector by addressing (i) negative effect in the agriculture sector, (ii) no effect in the manufacture sector, and (iii) positive effect in the service sector. Also, the estimated coefficients of our interest variable (β) is stable and more significant.

More importantly, in Panel 1, it appears that the GDP share in the agricultural sector has statistically significant association with its neighbor countries' GVCs participation in the same direction. Further, the effects of neighbor countries' GVCs participation is approximately six times larger than the effect of its own GVCs participation. This association additionally provides the new evidence of the spillover effects of GVCs by neighboring countries.

Table 2. Initial Estimation: Structural Transformation and Agricultural GVCs, 1990 -2013

Panel 1	**Dependent Variable: GDP Share in Agriculture (%)**				
	(1)	(2)	(3)	(4)	(5)
GVCs Participation	-0.015**	-0.015**	-0.019***	-0.013**	-0.018***
	(0.007)	(0.007)	(0.005)	(0.005)	(0.004)
Constant	18.870***	20.031***	18.365***	19.978***	18.353***
	(0.468)	(0.481)	(0.310)	(0.418)	(0.267)
Observations	3,593	3,593	3,593	3,593	3,593
R-squared	0.262	0.252	0.233	0.327	0.303
Number of country	175	175	175	175	175
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes

Panel 2	**Dependent Variable: GDP Share in Manufacture (%)**				
	(1)	(2)	(3)	(4)	(5)
GVCs Participation	-0.001	0.000	0.000	0.002	0.002
	(0.011)	(0.009)	(0.010)	(0.006)	(0.006)
Constant	31.158***	29.872***	29.792***	29.962***	29.742***
	(0.744)	(0.584)	(0.417)	(0.480)	(0.327)
Observations	3,608	3,608	3,608	3,608	3,608
R-squared	0.021	0.001	0.000	0.105	0.084
Number of country	175	175	175	175	175
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes

Panel 3	**Dependent Variable: GDP Share in Service (%)**				
	(1)	(2)	(3)	(4)	(5)
GVCs Participation	0.017***	0.015***	0.019***	0.011**	0.016***
	(0.006)	(0.005)	(0.006)	(0.004)	(0.005)
Constant	49.824***	50.065***	51.815***	50.034***	51.879***
	(0.742)	(0.610)	(0.402)	(0.503)	(0.328)
Observations	3,585	3,585	3,585	3,585	3,585
R-squared	0.200	0.193	0.178	0.292	0.253

Number of country	173	173	173	173	173
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

(iii) Controlling for Trade Agreements

One might argue that the effect of GVCs on structural transformation will disappear if trade policies by each country are accounted. Indeed, whether one country is more (or less) involved in GVCs is obviously related to its trade policy such as trade regulations or agreements. For example, trade liberalization in African countries has been dramatically expanding since 2000 through FTAs with major free trade countries or through Southern African Customs Union (SACU) between African countries (Goger et al., 2014). On the other hand, numerous politically unstable countries (e.g., Afghanistan, North Korea) or geographically isolated countries (e.g., Samoa, Solomon Islands) are limited to access to trade agreements with other countries, and thus their participation in GVCs are likely to be restricted.

To examine whether trade agreements are soaking up the effect of GVCs on structural transformation, table 3 provides the results of my baseline model in Equation (18) by controlling for three representative trade agreements ─ regional trade agreement, customs unions, and free trade agreement. I control for time-varying dummy variables of trade agreements in Columns (1)–(3) and control for the numbers of each trade agreement in Columns (4)–(6). The results are strongly robust to accounting for trade agreement covariates by addressing the fact that the GDP share in agriculture decreases and the GDP share is service increases while there is no effect on the manufacturing sector.

Table 3. Structural Transformation and Agricultural GVCs, 1990-2013: Controlling for Trade Policies

	Dependent Variable: GDP Share (%)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Variables	**Ag.**	**Manu.**	**Service**	**Ag.**	**Manu.**	**Service**	**Ag.**	**Manu.**	**Service**
GVCs Participation	-0.015**	-0.001	0.016***	-0.016**	-0.000	0.016***	-0.015**	-0.000	0.016***
	(0.007)	(0.010)	(0.006)	(0.006)	(0.010)	(0.006)	(0.007)	(0.010)	(0.006)
Participation of RTA (Yes= 1)	-0.760	0.520	0.241				-0.472	-0.039	0.515
	(1.156)	(1.166)	(1.294)				(1.191)	(1.166)	(1.291)
Participation of CU (Yes=1)	0.538	-1.246	0.697				-0.132	0.280	-0.183
	(0.662)	(0.864)	(0.902)				(1.143)	(1.558)	(1.623)
Participation of FTA (Yes=1)	-1.082	-0.831	1.916**				-1.558*	-0.036	1.600*
	(0.831)	(0.913)	(0.927)				(0.896)	(0.890)	(0.941)
Numbers of Regional Trade Agreements (RTA)				(0.035)	(0.036)	(0.044)	-0.007	0.035	-0.030
				0.033	-0.091	0.059	(0.035)	(0.040)	(0.045)
Numbers of Custom Unions (CU)				(0.044)	(0.061)	(0.065)	0.035	-0.105	0.073
				0.011	-0.099**	0.089*	(0.065)	(0.096)	(0.095)
Numbers of Free Trade Agreements (FTA)				(0.037)	(0.041)	(0.050)	0.049	-0.100**	0.051
				(0.035)	(0.036)	(0.044)	(0.037)	(0.043)	(0.052)
Constant	21.575***	30.966***	47.323***	20.885***	30.933***	48.061***	21.512***	30.883***	47.491***
	(1.485)	(1.368)	(2.009)	(1.314)	(1.127)	(1.809)	(1.457)	(1.283)	(1.948)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,593	3,608	3,585	3,593	3,608	3,585	3,593	3,608	3,585
R-squared	0.278	0.026	0.214	0.276	0.045	0.210	0.284	0.045	0.216
Number of country	175	175	173	175	175	173	175	175	173

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

(iv) Robustness to More Covariates

I finally assess the robustness of the core results in table (18) by controlling for a richer set of time-varying covariates in addition to the GVCs participation by neighbor countries and trade agreements. To alleviate concern about country-specific time-varying covariates, tables (4)–(6) explores whether the coefficient of interest variable is still statistically significant and stable by controlling for economic conditions (e.g., GDP, agricultural land), demographic changes (age dependency ratio), urbanization (rural population, urban population growth) and domestic agricultural policy (domestic policy agricultural terms of trade[10]). Finally, tables (4) – (6) present estimation results for the agriculture, manufacture, and service sectors, respectively. The results are similar with previous results. Conclusively, the results in tables (4)–(6) strengthen the evidence that participation in agricultural GVCs drives structural transformation directly from the agriculture to the service sector on average from 1990 to 2013. In all specifications, the estimates of our interest variable β are statistically significant following same directions found in tables (1)–(3).

[10] See Timmer (2008).

Table 4. Key Results ─ Structural Transformation and Agricultural GVCs, 1990 -2013: Agriculture, Controlling for all Covariates

	Dependent Variable: GDP Shares in Agriculture (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	-0.020***	-0.018***	-0.017***	-0.016***	-0.016***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
GVCs Participation by neighboring countries	-0.115***	-0.105**	-0.095**	-0.095**	-0.091**
	(0.044)	(0.043)	(0.045)	(0.040)	(0.042)
GDP (log)	-9.608***	-9.698***	-8.984***	-8.617***	-7.913***
	(1.872)	(1.875)	(1.828)	(1.694)	(1.706)
Land Share for Agriculture (%)	0.081	0.086	0.087	0.063	0.083
	(0.075)	(0.075)	(0.076)	(0.086)	(0.085)
Rural Population (%)	0.126	0.114	0.090	0.227**	0.176*
	(0.113)	(0.114)	(0.111)	(0.101)	(0.097)
Urbanization (urban population growth, %)	0.125	0.094	0.072	0.263	0.240
	(0.308)	(0.308)	(0.311)	(0.253)	(0.270)
Age Dependency Ratio (%)	0.056	0.059	0.047	0.025	0.020
	(0.052)	(0.051)	(0.051)	(0.060)	(0.054)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	1.976***	2.005***	1.934***	2.237***	2.094***
	(0.203)	(0.201)	(0.195)	(0.281)	(0.266)
Constant	45.371	44.716	36.648	-7.121	-7.694
	(53.691)	(52.840)	(53.026)	(56.524)	(56.517)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,386	3,386	3,386	3,386	3,386
R-squared	0.402	0.396	0.392	0.452	0.438
Number of country	166	166	166	166	166

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 5. Key Results ─ Structural Transformation and Agricultural GVCs, 1990 -2013: Manufacture, Controlling for all Covariates

	Dependent Variable: GDP Shares in Manufacture (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	0.006	0.006	0.002	0.006	0.002
	(0.005)	(0.004)	(0.005)	(0.004)	(0.005)
GVCs Participation by neighboring countries	0.058*	0.061**	0.034	0.060**	0.035
	(0.032)	(0.030)	(0.028)	(0.028)	(0.026)
GDP (log)	8.171***	8.717***	6.834***	8.466***	6.506***
	(1.781)	(1.726)	(1.717)	(1.816)	(1.757)
Land Share for Agriculture (%)	0.043	0.036	0.033	0.008	0.026
	(0.088)	(0.087)	(0.092)	(0.084)	(0.092)
Rural Population (%)	-0.224*	-0.220*	-0.157	-0.228*	-0.174
	(0.115)	(0.115)	(0.116)	(0.120)	(0.116)
Urbanization (urban population growth, %)	-0.317	-0.282	-0.223	-0.214	-0.151
	(0.278)	(0.286)	(0.294)	(0.262)	(0.280)
Age Dependency Ratio (%)	-0.158***	-0.163***	-0.130***	-0.205***	-0.147***
	(0.050)	(0.049)	(0.049)	(0.051)	(0.050)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	-1.748***	-1.744***	-1.550***	-1.430***	-1.332***
	(0.293)	(0.276)	(0.260)	(0.431)	(0.366)
Constant	26.398	13.024	33.721	-7.269	22.451
	(48.666)	(44.979)	(47.016)	(56.341)	(53.720)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,386	3,386	3,386	3,386	3,386
R-squared	0.175	0.161	0.134	0.208	0.169
Number of country	166	166	166	166	166

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6. Key Results ─ Structural Transformation and Agricultural GVCs, 1990 -2013: Service, Controlling for all Covariates

	Dependent Variable: GDP Shares in Service (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	0.015***	0.013***	0.015***	0.010**	0.014***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
GVCs Participation by neighboring countries	0.057	0.045	0.061	0.035	0.056
	(0.059)	(0.058)	(0.054)	(0.054)	(0.052)
GDP (log)	1.326	0.865	2.060	0.036	1.317
	(2.307)	(2.280)	(2.198)	(2.196)	(2.102)
Land Share for Agriculture (%)	-0.124	-0.121	-0.120	-0.070	-0.109
	(0.093)	(0.092)	(0.094)	(0.106)	(0.108)
Rural Population (%)	0.096	0.103	0.063	-0.001	-0.006
	(0.140)	(0.140)	(0.138)	(0.121)	(0.118)
Urbanization (urban population growth, %)	0.200	0.194	0.156	-0.042	-0.083
	(0.346)	(0.336)	(0.331)	(0.278)	(0.281)
Age Dependency Ratio (%)	0.101	0.103	0.082	0.177**	0.124*
	(0.065)	(0.065)	(0.065)	(0.071)	(0.068)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	-0.232	-0.263	-0.387	-0.793**	-0.755**
	(0.287)	(0.280)	(0.279)	(0.398)	(0.366)
Constant	31.371	45.467	32.479	116.042*	87.022
	(64.966)	(63.259)	(64.169)	(65.271)	(64.286)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,386	3,386	3,386	3,386	3,386
R-squared	0.210	0.200	0.192	0.294	0.264
Number of country	166	166	166	166	166

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

6. Robustness Checks

In this section, I conduct additional analyses to check the robustness of the results. The robustness is explored in three techniques: (i) an alternative estimation of dynamic model specification, (ii) an alternative measure of structural transformation, and (iii) an alternative measure of agricultural GVCs. The following results consistently show that the agricultural GVCs participation is negatively associated with the agricultural sector and positively associated with the service sector.

6.1 Alternative Estimation: Dynamic Panel Regression

The alternative estimation considers a dynamic panel regression. Although the parametric results in tables (4)–(6) address that the baseline model of Eq. (1) is robust to four different specifications, one might concern that the effect of GVCs on structural transformation should be accounted for in dynamic model specification. In the literature of economic growth, a few studies often emphasize the dynamic nature of structural transformation (Carkovic and Levine, 2002; Vries, Michaels, Rauch, Redding, 2012; Timmer, and Vries, 2015; Hnatkovska and Lahiri, 2016).

To provide robustness under dynamic growth model, I estimate

$$y_{is,t} = \alpha + \theta y_{is,t-1} + \beta D_{it} + X_{it}\delta + \alpha_i + \epsilon_{it} \quad (19)$$

where y_{it-1} is the lagged dependent variable. Using the OLS estimator to estimate Eq. (18) might give rise to autocorrelation because of the presence of the lagged dependent variable (y_{it-1}). Also, the limited sample size in this study—the number of countries—cause inconsistent estimates by using a fixed effect estimator in dynamic panel regression where the strict exogeneity assumption is mostly violated. To avoid the potential shortcoming, I use the Generalized Method of Moments (GMM) panel estimator designed by Arellano and Bover (1995) and Blundell and Bond (1997). This dynamic panel estimator offers advantages to OLS estimator for three ways: (i) it eliminates the fixed effects as well as autocorrelation by instrumenting the lagged variables, (ii) it is developed for small T and large N (Mileva, 2007), and (iii) it extracts consistent and efficient estimates of the effect of GVCs participation on the outcome variables (Carkovic and Levine, 2002).[11]

The results shown in table 7 indicate that coefficient estimates of the interest variable (β) is highly significant both on the GDP shares in agriculture and service and the signs of coefficients are identical with the results found in table (1)—(6). Under the dynamic model, the negative effect on the GDP share in agriculture is stronger than the result by OLS estimator. The manufacturing sector is still not influenced by GVCs. In other words, the effect of agricultural GVCs on structural transformation is robust to the assumption of a dynamic feature of structural transformation.

Table 7. Dynamic Panel Regression: Structural Transformation and Agricultural GVCs, 1990-2013

	Dependent Variable: GDP Shares (%)		
Variables	**(1) Agriculture**	**(2) Manufacture**	**(3) Service**
GVCs Participation (%)	-0.027***	0.006	0.017***
	(0.004)	(0.006)	(0.006)
Lagged GDP Share (%)			
Agriculture	0.689***		
	(0.018)		
Manufacture		0.815***	
		(0.018)	
Service			0.810***
			(0.020)
Numbers of Regional Trade Agreements (RTA)	-0.015	0.125***	-0.077***
	(0.019)	(0.027)	(0.026)
Numbers of Custom Unions (CU)	-0.006	-0.105**	0.102**
	(0.035)	(0.047)	(0.045)
Numbers of Free Trade Agreements (FTA)	0.023	-0.137***	0.087***
	(0.021)	(0.029)	(0.028)
Participation of RTA (Yes= 1)	-1.133**	-1.329*	0.430
	(0.496)	(0.693)	(0.695)
Participation of CU (Yes=1)	-0.251	-0.528	0.256
	(0.571)	(0.788)	(0.810)
Participation of FTA (Yes=1)	0.796**	1.921***	-1.356***
	(0.385)	(0.503)	(0.510)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	1.867***	-1.044***	-0.692***
	(0.132)	(0.186)	(0.200)
GVCs Participation by neighboring countries (%)	-0.013	-0.056***	-0.038**
	(0.011)	(0.016)	(0.016)
GDP (log)	-0.993***	-0.599	-2.308***
	(0.316)	(0.532)	(0.542)
Land Share for Agriculture (%)	-0.156***	-0.024	0.011
	(0.023)	(0.029)	(0.030)
Rural Population (%)	0.153***	-0.092***	-0.076**
	(0.020)	(0.029)	(0.039)

[11] The moment conditions will be added (Carkovic and Levine, 2002)

Urbanization (urban population growth, %)	-0.161*	0.524***	-0.183
	(0.090)	(0.124)	(0.117)
Age Dependency Ratio (%)	0.115***	0.003	-0.107***
	(0.018)	(0.023)	(0.024)
Constant	-164.350***	128.965***	148.917***
	(14.877)	(21.860)	(25.241)
Country FE	YES	YES	YES
Country Year FE	YES	YES	YES
Observations	3,236	3,236	3,236
Number of country	165	165	165

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

6.2 Alternative Measure: Structural Transformation

As discussed in the section of empirical strategy, structural transformation can be measured in different ways due to the various features depending on its definitions. Table A2 shows results from an alternative measure of structural transformation – the employment shares by each sector (Timmer, 2008; Herrendorf, Rogerson, Valentinyi, 2013) – by estimating the baseline model Eq. (1) along with four different specifications similar tables (4)—(6). The main result from table A2 represents that the effects of GVCs on structural transformation is robust to an alternative measure of structural transformation which is measured in employment shares.

Table A3 provides an additional estimation result to check whether the main results are robust to the assumption of the dynamic panel model. By using the identical GMM method used in table A3, the results are strongly robust to the core results from table (4)—(6). Moreover, further distinct results are found: (i) the employment share of the manufacturing sector is significantly and positively associated with the agricultural GVCs, (ii) the effects of GVCs on each sector is approximately one-third smaller compared to the case using the GDP share measure.

Overall, the core results are robust to the alternative measure of structural transformation and the agricultural GVCs have smaller effects on structural transformation where it is measured in terms of the sectoral labor allocation.

6.3 Alternative GVCs: Food Industry

Lastly, one might argue that the overall results does not reflect the characteristics of the modern agricultural value chains because the treatment variable of GVCs in this study is measured by using only the agricultural industry but the food industry. Last two decades, the emergence of a supermarket revolution (See. Reardon, Timmer, and Minten, 2012) has enhanced developing countries to join multinational processed food production, which lies closer to the final consumer in downstream in value chains. A recent study by Balié et al. (2017) consistently showed that not only for rich countries (e.g., EU and North America) but also for many developing countries (e.g., India, Latin, and ASEAN countries), the extent of food GVCs participation exceeds the extent of agricultural GVCs participation.

To explore if structural transformation is also associated with food GVCs, the results shown in tables A4.a—A4.c provide the robustness check by using food GVCs instead of agricultural GVCs. In short, they tell a similar story that the food GVCs also has strongly significant relationship with structural transformation by passing over the manufacturing sector. The result is also robust to all different specifications in column (1)—(5).

One interesting additional finding is that the estimates of the interested variable (β) in table (A4.a)–(A4.c) is approximately 1.5 times bigger than the estimates in table (4)–(6). This finding can imply that, on average, the participation in food GVCs is more effective than the participation in agricultural GVCs for structural transformation.

7. Extension Analysis

Before concluding, I conduct two extension analyses. By slicing the data used in this study, this section explores (i) the comparison of the effects of GVCs between developed and developing countries, and (ii) the effects of the upstream and downstream GVCs participation on structural transformation by decomposing GVCs into two channels in global production.

7.1 Developed vs. Developing countries

First, table (8) presents the different effects agricultural GVCs on structural transformation between developed countries (i.e., OECD countries) and developing countries which includes (i) Sub-Saharan Africa, (ii) South Asia, (iii) Latin America and the Caribbean, and (iv) Central and Western Asia. The outcome variable is the GDP shares in each sector throughout Column (1) to (6). In Column (7)-(9), the outcome variable is replaced with the employment shares to check the robustness to an alternative measure of structural transformation. In Columns (1)-(3), the coefficients are estimated by the baseline specification of Equation (18). In Columns (4)-(6), the dynamic specification in Equation (19) is estimated by using the GMM estimator similar to table

(7). Throughout Column (1)-(9), I employ the country FEs and the country-specific year FEs by controlling for all time-varying covariates similar to table (4)-(6). Finally, Panels 1 to 6 present the results of estimation for each group, respectively.

The results in table (8) shows the agricultural GVCs play differently between developed and developing countries. In Panel 2, the results provide the similar pattern of structural transformation similar to the core results in developing countries. In Panel 1, the pattern is, however, opposite in OECD countries. Unlike developing countries, the employment shares in both agriculture and service significantly increases in developed countries while the share of employment in manufacture significantly decreases.

Not only for agricultural GVCs, this finding is also robust to the food GVCs. In table (A8), I use the food GVCs instead of agricultural GVCs. In short, the key results include the following: (i) the relationship between the employment share in agriculture and GVCs are positive in developed countries and negative in developing countries, (ii) the relationship in the manufacture sector is negative in developed countries and positive in developing countries, (iii) the relationships in the service sector are positive in both developed and developing countries.

7.2 Upstream and Downstream GVCs

Secondly, table 9 shows the effects of upstream and downstream GVCs participation on the GDP shares by three sectors, respectively. I use the method to decompose GVCs into up-and-downstream by using the method Balié et al. (2017). By estimating the coefficient of variable of our interest using identical specification with table (4)-(6), in short, the results provide two main finding: (i) the GDP share is significantly decreases in the agriculture sector and increase in the service sector as a country is more involved in upstream GVCs on average, and (ii) the GDP shares significantly increase in agriculture and decrease in the service sector.

The results marginally provide policy implications that participation in the upstream GVCs leads structural transformation from agriculture to the service sector than the participation in downstream GVCs.

Table 8. Regional Structural Transformation and Agricultural GVCs, 1990-2013

Dependent Variable:	GDP Shares (%)						Employment Shares (%)		
	Linear Model (FE)			Dynamic Model (GMM)			Linear Model (FE)		
Panel	(1) Agriculture	(2) Manufacture	(3) Service	(4) Agriculture	(5) Manufacture	(6) Service	(7) Agriculture	(8) Manufacture	(9) Service
1. OECD									
GVCs Participation	0.006	0.000	-0.007	0.003	-0.125***	0.125***	0.091	-0.301***	0.210***
	(0.005)	(0.009)	(0.010)	(0.009)	(0.025)	(0.032)	(0.076)	(0.097)	(0.066)
Observations	726	726	726	693	693	693	767	767	767
R-squared	0.748	0.512	0.637				0.735	0.750	0.889
2. Developing Countries †									
GVCs Participation	-0.024***	0.011**	0.014***	-0.029***	0.014*	0.013	-0.000	-0.005	0.005*
	(0.004)	(0.005)	(0.005)	(0.006)	(0.008)	(0.008)	(0.004)	(0.003)	(0.003)
Observations	1,955	1,955	1,955	1,868	1,868	1,868	2,065	2,065	2,065
R-squared	0.399	0.149	0.153				0.368	0.129	0.368
3. Sub-Saharan Africa									
GVCs Participation	-0.049	0.108	-0.053	-0.092	-0.114**	0.098*	-0.045	0.099**	-0.053
	(0.120)	(0.154)	(0.135)	(0.060)	(0.055)	(0.058)	(0.081)	(0.048)	(0.050)
Observations	853	853	853	810	810	810	928	928	928
R-squared	0.365	0.217	0.166				0.305	0.129	0.402
4. South Asia									
GVCs Participation	-0.047	0.106	-0.058	-0.051	0.093*	-0.062	-0.356*	0.132	0.224
	(0.052)	(0.080)	(0.049)	(0.051)	(0.056)	(0.054)	(0.164)	(0.107)	(0.190)
Observations	193	193	193	185	185	185	186	186	186
R-squared	0.910	0.649	0.780				0.837	0.567	0.779
5. Latin America and the Caribbean									
GVCs Participation	0.009	0.093	-0.102	-0.000	0.032	-0.066**	0.078	0.047	-0.125
	(0.065)	(0.123)	(0.108)	(0.024)	(0.039)	(0.033)	(0.098)	(0.060)	(0.098)
Observations	557	557	557	533	533	533	547	547	547
R-squared	0.516	0.245	0.373				0.418	0.366	0.581
6. Central and Western Asia									
GVCs Participation	-0.016***	0.012**	0.005	-0.035***	0.014	0.018*	-0.003	0.004	-0.001
	(0.005)	(0.005)	(0.007)	(0.005)	(0.010)	(0.010)	(0.005)	(0.005)	(0.006)
Observations	352	352	352	340	340	340	404	404	404
R-squared	0.681	0.430	0.513				0.566	0.358	0.373
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

† Developing countries include Sub-Saharan Africa, South Asia, Latin America and the Caribbean, and Central and Western Asia.
Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 9. Upstream and Downstream GVCs and Structural Transformation, 1990-2013

Panel 1. Agriculture Sector

	Dependent Variable: GDP Shares in Agriculture									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Upstream Participation	0.091***	0.090***	0.093***	0.072***	0.079***					
	(0.027)	(0.027)	(0.029)	(0.023)	(0.024)					
Downstream Participation						-0.026***	-0.025***	-0.024***	-0.021***	-0.021***
						(0.006)	(0.005)	(0.005)	(0.005)	(0.004)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Time trend	No	Yes	No	No	No	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes	No	No	No	No	Yes
Observations	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386
R-squared	0.407	0.402	0.399	0.455	0.443	0.404	0.398	0.394	0.454	0.440
Number of country	166	166	166	166	166	166	166	166	166	166

Panel 2. Manufacture Sector

	Dependent Variable: GDP Shares in Manufacture									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Upstream Participation	-0.027	-0.018	-0.026	-0.020	-0.026					
	(0.027)	(0.026)	(0.028)	(0.020)	(0.023)					
Downstream Participation						0.009**	0.008**	0.005	0.008*	0.005
						(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No	Yes	No	No	No	No
Time trend	No	Yes	No	No	No	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes	No	No	No	No	Yes
Observations	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386
R-squared	0.176	0.161	0.134	0.208	0.170	0.175	0.161	0.134	0.208	0.169
Number of country	166	166	166	166	166	166	166	166	166	166

Panel 3. Service Sector

	Dependent Variable: GDP Shares in Service									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Upstream Participation	-0.063**	-0.072**	-0.067**	-0.053**	-0.053**					
	(0.030)	(0.030)	(0.030)	(0.022)	(0.022)					
Downstream Participation						0.017***	0.017***	0.019***	0.013***	0.016***
						(0.006)	(0.006)	(0.006)	(0.005)	(0.005)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trade Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No	Yes	No	No	No	No
Time trend	No	Yes	No	No	No	No	Yes	No	No	No
Time^2 trend	No	No	Yes	No	No	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No	No	No	No	Yes	No
Regional-specific time^2 trend	No	No	No	No	Yes	No	No	No	No	Yes
Observations	2,880	2,880	2,880	2,880	2,880	2,880	2,880	2,880	2,880	2,880
R-squared	0.193	0.394	0.193	0.608	0.287	0.185	0.392	0.185	0.608	0.286
Number of country	138	138	138	138	138	138	138	138	138	138

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

8. Conclusion

This paper is the first to investigate the relationship between agricultural GVCs and structural transformation of economies. In theory, I develop an international trade model to demonstrate how the net exports of intermediate inputs change the structure of the economy in the exporting country. Under an open economy scenario by allowing intermediate inputs trade across two countries and three sectors, I show how net exports of intermediate inputs in agricultural GVCs changes the reallocation of the exporting countries' economic activities and further structural of their economies. In the empirical analysis, I show the effect of agricultural GVC participation on the reallocation of economic activities in terms of the share of GDP in each agricultural, manufacturing, and service sectors. By using cross country data that cover 183 countries from 1990 to 2013, the key finding in this study addresses that modern-day developing economies leapfrog manufacturing sector to directly to the service sector as they are participating in GVCs in agriculture industries on average. This result is strongly and significantly robust to various model specifications. The results are more clear in developed countries than in developing countries.

This finding can inform agricultural trade policy in two ways. First, policymakers need to focus on participating in global agricultural production to transform their economies in the ways they want to reallocate their economic resources. In debates about the UK's exit from the European Union, the re-design of the North American Free Trade Agreement, and the recent Trade War between U.S., and China, trade policies aimed at protecting domestic agriculture sector from being dominated by imported agricultural goods and further enhancing economic growth. This perspective seems to reflect a tacit expectation that GVC linkages alter the conventional calculus of trade protection (Blanchard et al., 2017). In the era of GVCs, for example, tariffs might need to be decreasing in final goods produced in importing countries wherein domestically-produced intermediate inputs were used in the foreign final production. The results in this study suggest that trade liberalization through agricultural GVCs is significantly associated with structural transformation in the way that a country can reallocate its economic resources into non-agricultural sector—that has been seen as the main driver of sustainable economic growth.

Second, although it may be tempting to participating in GVCs for structural transformation, policymakers should be very cautious when trying to opening their agricultural markets. My results suggest that a country transforms its economy out of agriculture when the country participates in GVCs by producing intermediate inputs related to manufacturing or service sectors but the agriculture sector. Given that many poor developing countries have a competitive advantage in agriculture rather than manufacturing or service, it is tempting to participating in agricultural GVCs by allocating more agricultural resources into intermediate production to export. Although this might result in higher overall GDP or employment, the economy is unlikely to be transformed into an economy primarily based on manufacturing and service. Thus, trade policies should be considered in the way to improve manufacturing or service related domestic activities in agricultural intermediate production.

Appendix

Figure A1.a World Map of Agricultural GVC Participation in 2013

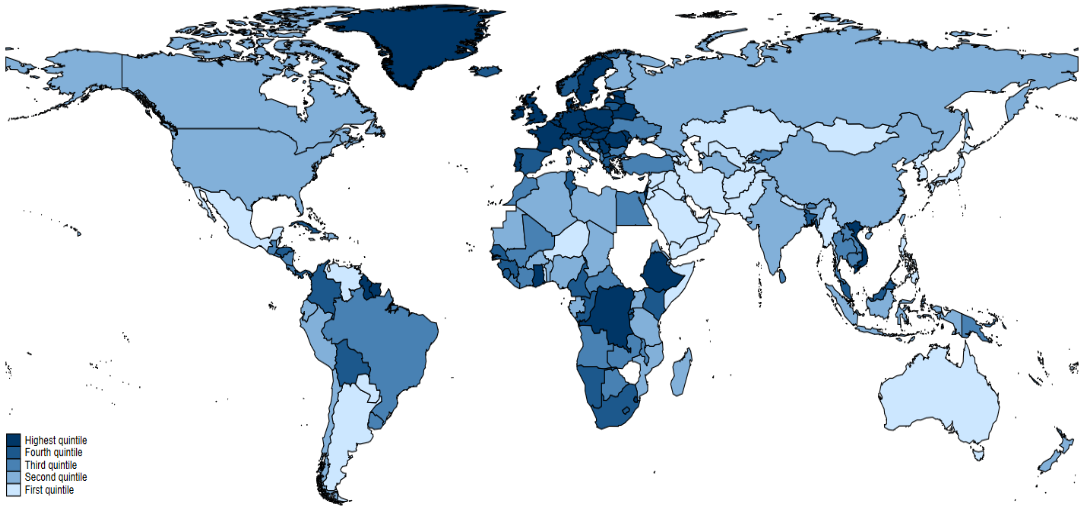


Figure A1.b World Map of Food Global Value Chains Participation in 2013

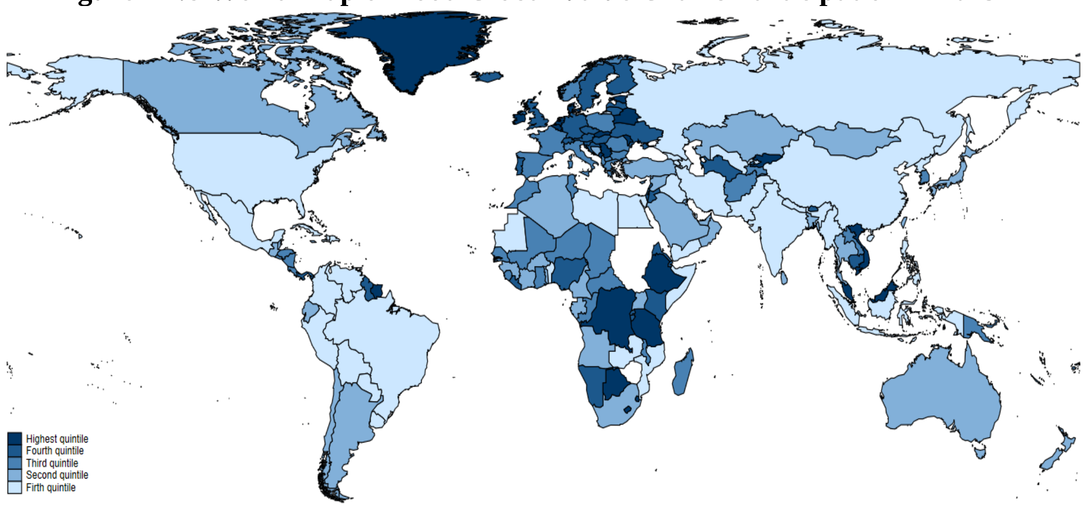


Figure A1.c World Map of Food Global Value Chains Growth Rate, between 1990 – 2013

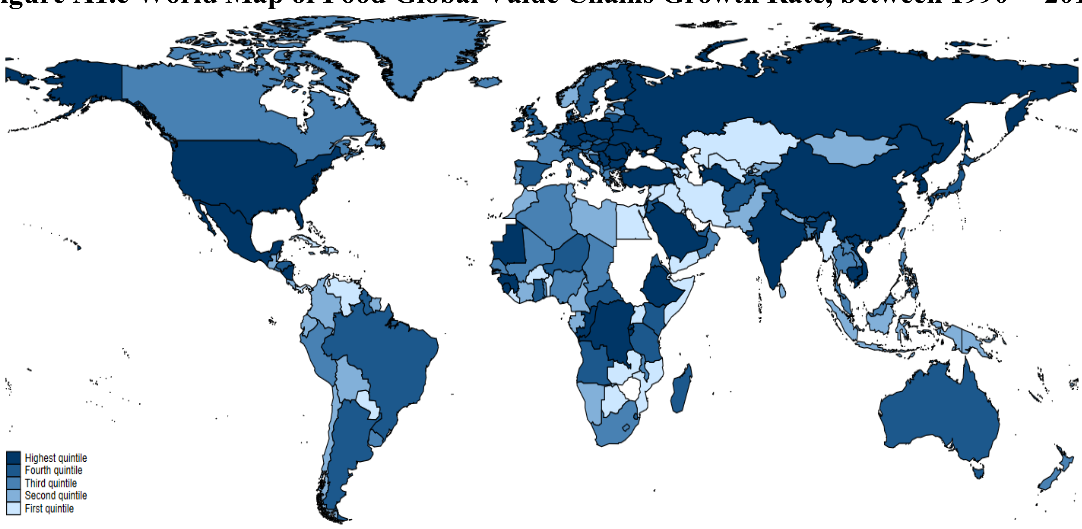


Figure A2. Structural Transformation and Agricultural GVCs, 1990 – 2013

Figure 3a. GDP Shares in Agriculture and Agricultural GVCs Participation

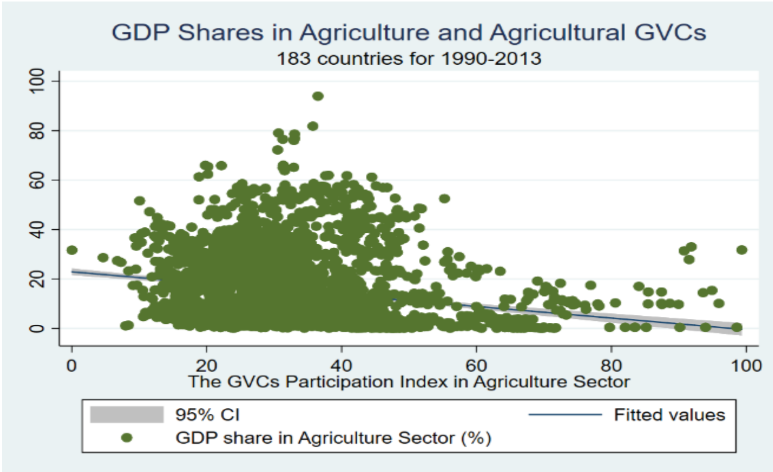


Figure 3b. GDP Shares in Manufacturing and Agricultural GVCs Participation

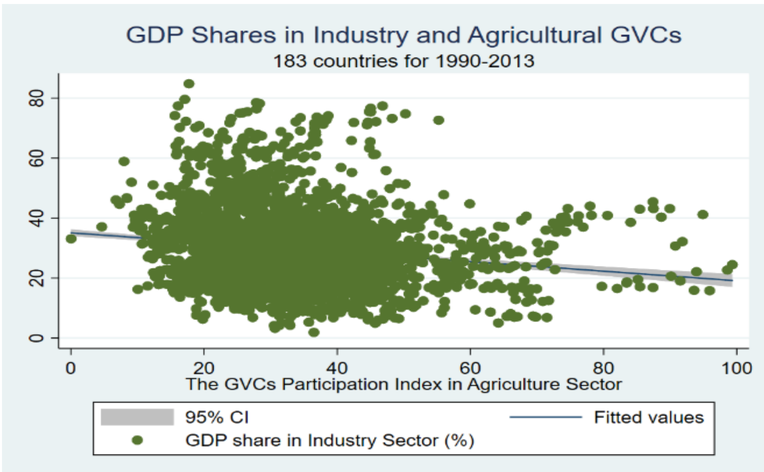


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Figure 3c. GDP Shares in Service and Agricultural GVCs Participation

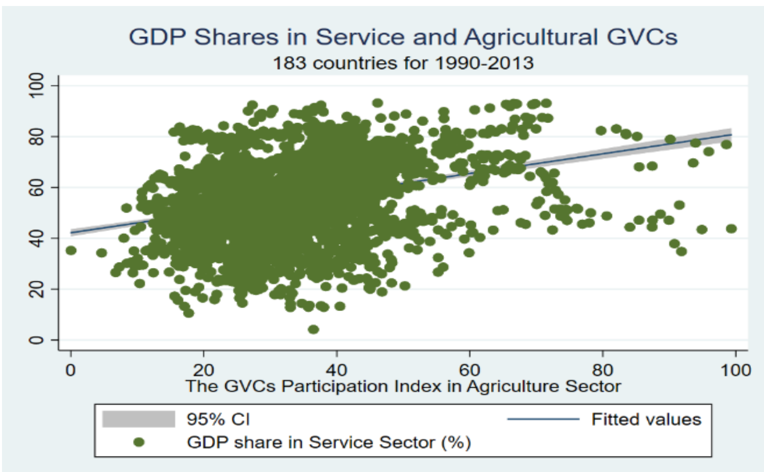
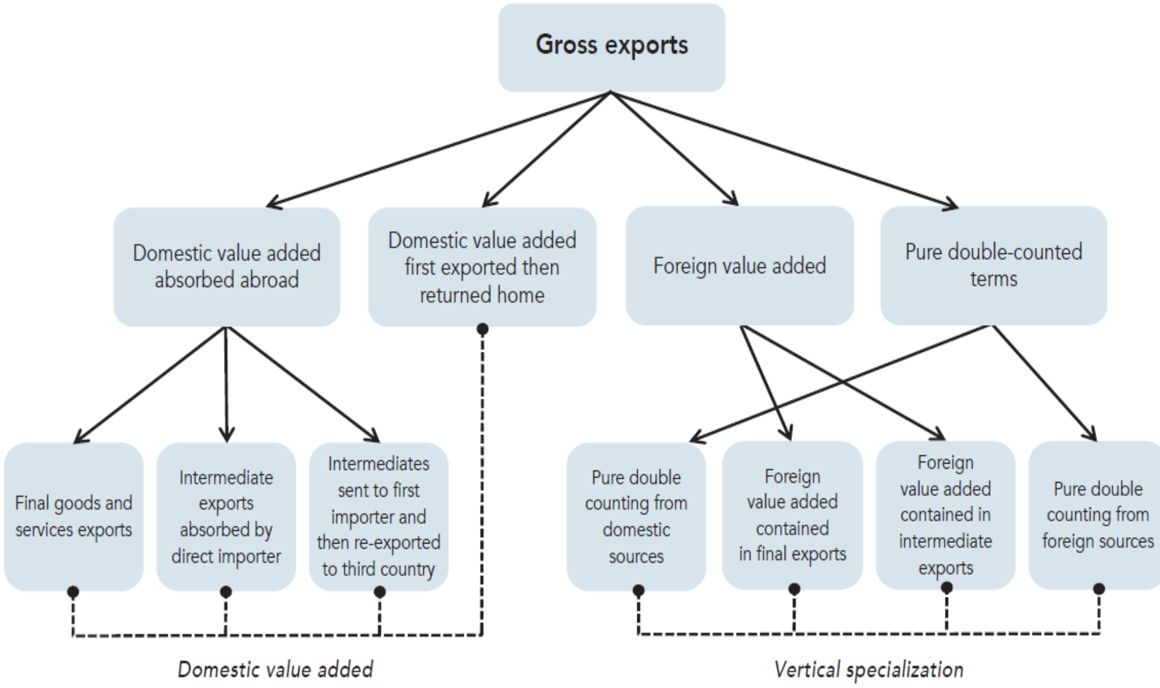


Figure A3. Decomposition of Gross Exports to measure GVCs



Source: This figure is a revised version by Inomata (2017) based on Wang et al. (2017).

Figure A4. An Example of Computational Difference between Conventional Bilateral Trade and GVCs Trade in Trade Account

Case 1. Conventional Bilateral Trade (without GVCs)

Variables	Country A	Country B
Domestic Consumption	0	10
Gross Import	0	10
DVA	10	0
FVA	0	0
DVX	0	0
PDC	0	0
Gross Export	10	0
GVC	0	0

Case 2. GVCs for three countries

Variables	Country A	Country B	Country C
Domestic Consumption	0	5	25
Gross Import	0	20	25
DVA	20	10	0
FVA	0	15	0
DVX	0	0	0
PDC	0	0	0
Gross Export	20	25	0
GVC	0	0.6	0

Table A1. Top 30 Highest and Lowest GVC participation countries, 1990─2013†

Top 30 Highest GVC Participation Countries			Top 30 Lowest GVC Participation Countries		
Rank	**Country Name**	**GVC Participation**	**Rank**	**Country Name**	**GVC Participation**
1	Greenland	42.99	1	Armenia	-21.81
2	Germany	43.06	2	Kazakhstan	11.45
3	British Virgin Islands	43.18	3	Tajikistan	12.57
4	Austria	43.38	4	North Korea	13.24
5	France	43.41	5	Nepal	14.35
6	Israel	44.13	6	Uzbekistan	14.53
7	Denmark	44.21	7	Mexico	16.10
8	Czech Republic	44.8	8	Korea, Rep.	16.62
9	Sweden	44.94	9	Oman	17.57
10	United Kingdom	45.29	10	Belize	17.82
11	Singapore	45.37	11	Paraguay	18.19
12	Hungary	46.76	12	Mongolia	18.35
13	Switzerland	48.19	13	Haiti	18.80
14	Swaziland	48.28	14	Yemen, Rep.	18.94
15	Belgium	51.98	15	Afghanistan	19.55
16	Congo, Dem. Rep.	52.50	16	Iraq	19.87
17	Malta	53.10	17	Trinidad and Tobago	20.22
18	Hong Kong SAR, China	56.70	18	Philippines	20.71
19	Latvia	60.58	19	Fiji	20.83
20	Luxembourg	61.58	20	Bahamas, The	20.94
21	Estonia	62.06	21	Pakistan	20.94
22	Suriname	71.64	22	Somalia	21.08
23	Belarus	79.54	23	Iran, Islamic Rep.	21.53
24	Aruba	82.73	24	Japan	21.80
25	Moldova	100.65	25	Georgia	22.27
26	Niger	22.25	26	China	22.29
27	Turkmenistan	27.77	27	Argentina	22.34
28	Angola	35.51	28	Jamaica	22.60
29	Qatar	23.80	29	United Arab Emirates	22.72
30	Seychelles	38.87	30	Venezuela, RB	22.75

† GVC participation is a mean value from 1990─2013. Shaded rows represent OCDE countries.

Table A2.a. Robustness Checks: Alternative Measure of Structural Transformation

Employment Share in Agriculture Sector, 1991 -2013

	Dependent Variable: Employment Shares in Agriculture (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	-0.004	-0.003	-0.001	-0.002	0.000
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
GVCs Participation by neighboring countries	0.006	0.010	0.020	0.012	0.023*
	(0.013)	(0.013)	(0.012)	(0.012)	(0.012)
GDP (log)	-9.324***	-9.466***	-8.650***	-9.916***	-8.925***
	(0.491)	(0.484)	(0.469)	(0.486)	(0.469)
Land Share for Agriculture (%)	0.037	0.038	0.036	-0.036	-0.024
	(0.026)	(0.026)	(0.026)	(0.028)	(0.028)
Rural Population (%)	0.218***	0.221***	0.194***	0.280***	0.249***
	(0.032)	(0.032)	(0.031)	(0.033)	(0.033)
Urbanization (urban population growth, %)	0.070	0.057	0.047	0.007	0.014
	(0.073)	(0.073)	(0.073)	(0.070)	(0.070)
Age Dependency Ratio (%)	0.125***	0.124***	0.114***	0.097***	0.077***
	(0.016)	(0.015)	(0.015)	(0.018)	(0.017)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	0.329***	0.304***	0.249**	0.652***	0.562***
	(0.113)	(0.112)	(0.111)	(0.112)	(0.110)
Constant	208.981***	214.751***	202.487***	193.398***	180.630***
	(16.018)	(15.720)	(15.909)	(15.589)	(15.675)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,589	3,589	3,589	3,589	3,589
R-squared	0.423	0.421	0.418	0.483	0.482
Number of country	164	164	164	164	164

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2.b. Robustness Checks: Alternative Measure of Structural Transformation

Employment Share in Manufacture Sector, 1991 -2013

	Dependent Variable: Employment Shares in Manufacture (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	-0.005	-0.005*	-0.009***	-0.005*	-0.008**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
GVCs Participation by neighboring countries	-0.001	-0.001	-0.021***	-0.003	-0.019**
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
GDP (log)	3.400***	3.688***	2.225***	3.220***	1.586***
	(0.316)	(0.313)	(0.310)	(0.319)	(0.314)
Land Share for Agriculture (%)	0.107***	0.108***	0.112***	0.072***	0.082***
	(0.017)	(0.017)	(0.017)	(0.018)	(0.019)
Rural Population (%)	-0.081***	-0.093***	-0.043**	-0.110***	-0.071***
	(0.020)	(0.020)	(0.021)	(0.022)	(0.022)
Urbanization (urban population growth, %)	0.190***	0.204***	0.225***	0.262***	0.273***
	(0.047)	(0.047)	(0.048)	(0.046)	(0.047)
Age Dependency Ratio (%)	-0.184***	-0.181***	-0.162***	-0.146***	-0.108***
	(0.010)	(0.010)	(0.010)	(0.012)	(0.012)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	-0.712***	-0.651***	-0.536***	-0.582***	-0.484***
	(0.073)	(0.072)	(0.074)	(0.073)	(0.074)
Constant	21.522**	9.288	29.271***	13.345	37.960***
	(10.292)	(10.178)	(10.530)	(10.220)	(10.507)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,589	3,589	3,589	3,589	3,589
R-squared	0.245	0.230	0.191	0.296	0.262
Number of country	164	164	164	164	164

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A2.c. Robustness Checks: Alternative Measure of Structural Transformation

Employment Share in Service Sector, 1991 -2013

	Dependent Variable: Employment Shares in Service (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	0.009**	0.008**	0.010**	0.007*	0.008*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
GVCs Participation by neighboring countries	-0.006	-0.009	0.001	-0.009	-0.004
	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
GDP (log)	5.924***	5.778***	6.425***	6.696***	7.339***
	(0.429)	(0.423)	(0.410)	(0.411)	(0.397)
Land Share for Agriculture (%)	-0.144***	-0.146***	-0.148***	-0.036	-0.058**
	(0.023)	(0.023)	(0.023)	(0.024)	(0.024)
Rural Population (%)	-0.137***	-0.129***	-0.150***	-0.170***	-0.178***
	(0.028)	(0.028)	(0.028)	(0.028)	(0.028)
Urbanization (urban population growth, %)	-0.259***	-0.261***	-0.272***	-0.269***	-0.287***
	(0.064)	(0.063)	(0.064)	(0.060)	(0.060)
Age Dependency Ratio (%)	0.058***	0.058***	0.048***	0.049***	0.030**
	(0.014)	(0.013)	(0.013)	(0.015)	(0.015)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	0.384***	0.347***	0.287***	-0.070	-0.078
	(0.099)	(0.098)	(0.097)	(0.094)	(0.093)
Constant	-130.503***	-124.039***	-131.759***	-106.743***	-118.591***
	(13.987)	(13.738)	(13.914)	(13.167)	(13.277)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	3,589	3,589	3,589	3,589	3,589
R-squared	0.485	0.482	0.479	0.568	0.565
Number of country	164	164	164	164	164

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A3. Robustness Checks: Alternative Measure of Structural Transformation using Dynamic Panel Regression (GMM), 1990-2013

	Dependent Variable: Employment Shares (%)		
	(1)	**(2)**	**(3)**
	Agriculture	**Manufacture**	**Service**
GVCs Participation (%)	-0.010***	0.008***	0.006*
	(0.003)	(0.002)	(0.003)
Lagged Employment Share (%)	0.857***		
Agriculture	(0.013)		
		0.946***	
Manufacture		(0.016)	
			0.946***
Service			(0.016)
	-0.414	0.694***	-0.130
Numbers of Regional Trade Agreements (RTA)	0.044***	-0.014	-0.019
	(0.013)	(0.010)	(0.014)
Numbers of Custom Unions (CU)	0.025	-0.020	0.021
	(0.022)	(0.016)	(0.023)
Numbers of Free Trade Agreements (FTA)	-0.040***	0.007	0.027*
	(0.014)	(0.010)	(0.015)
Participation of RTA (Yes= 1)	-0.414	0.694***	-0.130
	(0.286)	(0.239)	(0.291)
Participation of CU (Yes=1)	-1.114***	0.505*	0.009
	(0.339)	(0.270)	(0.350)
Participation of FTA (Yes=1)	0.100	-0.164	-0.242
	(0.226)	(0.181)	(0.232)
Domestic Policy Agricultural	0.489***	-0.271***	-0.084
Terms of Trade (DPAgTOT)	(0.091)	(0.074)	(0.094)
GVCs Participation by neighboring countries (%)	-0.004	-0.010*	0.016**
	(0.007)	(0.006)	(0.007)
GDP (log)	-1.502***	0.137	0.918***
	(0.157)	(0.125)	(0.144)
Land Share for Agriculture (%)	-0.050***	0.026***	0.013
	(0.012)	(0.009)	(0.012)
Rural Population (%)	-0.032***	0.052***	0.049***
	(0.010)	(0.009)	(0.015)
Urbanization (urban population growth, %)	-0.301***	-0.105***	0.278***
	(0.052)	(0.039)	(0.049)
Age Dependency Ratio (%)	0.054***	-0.040***	-0.049***
	(0.012)	(0.010)	(0.010)
Constant	-6.871	24.746***	-12.340
	(10.137)	(8.229)	(10.518)
Country FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	3,457	3,457	3,457
Number of country	164	164	164

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4.a. Robustness Checks: Alternative GVCs (Food Industry)

Agriculture Sector, 1990 -2013

	Dependent Variable: GDP Shares in Agriculture (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	-0.036***	-0.030**	-0.029**	-0.027**	-0.026**
	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
GVCs Participation by neighboring countries	-0.117**	-0.108**	-0.100**	-0.100**	-0.094**
	(0.045)	(0.045)	(0.047)	(0.040)	(0.044)
GDP (log)	-9.228***	-9.232***	-8.806***	-8.512***	-7.734***
	(2.063)	(2.057)	(2.056)	(1.827)	(1.843)
Land Share for Agriculture (%)	0.104	0.112	0.118	0.091	0.118
	(0.094)	(0.094)	(0.094)	(0.101)	(0.100)
Rural Population (%)	0.132	0.116	0.094	0.312**	0.244**
	(0.138)	(0.139)	(0.133)	(0.120)	(0.115)
Urbanization (urban population growth, %)	0.222	0.193	0.182	0.376*	0.351
	(0.289)	(0.288)	(0.292)	(0.221)	(0.240)
Age Dependency Ratio (%)	0.064	0.068	0.058	0.057	0.045
	(0.058)	(0.056)	(0.056)	(0.066)	(0.057)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	1.889***	1.954***	1.841***	2.110***	1.889***
	(0.631)	(0.607)	(0.591)	(0.617)	(0.604)
Constant	45.603	39.318	41.835	-1.784	4.559
	(90.473)	(85.575)	(88.122)	(78.312)	(81.057)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	2,880	2,880	2,880	2,880	2,880
R-squared	0.374	0.367	0.364	0.437	0.425
Number of country	138	138	138	138	138

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4.b. Robustness Checks: Alternative GVCs (Food Industry)

Manufacture Sector, 1990 -2013

Variables	Dependent Variable: GDP Shares in Manufacture (%) (1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	0.011	0.009	0.008	0.012	0.011
	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
GVCs Participation by neighboring countries	0.054	0.058	0.048	0.059	0.048
	(0.038)	(0.037)	(0.034)	(0.037)	(0.035)
GDP (log)	4.637	4.691	4.473	3.992	3.505
	(3.997)	(4.198)	(3.362)	(4.569)	(3.699)
Land Share for Agriculture (%)	0.014	0.004	-0.006	-0.068	-0.057
	(0.105)	(0.100)	(0.106)	(0.098)	(0.106)
Rural Population (%)	-0.233	-0.217	-0.190	-0.264*	-0.220
	(0.141)	(0.143)	(0.136)	(0.154)	(0.144)
Urbanization (urban population growth, %)	-1.048	-0.996	-0.978	-0.983	-0.930
	(0.769)	(0.748)	(0.759)	(0.748)	(0.751)
Age Dependency Ratio (%)	-0.099	-0.112	-0.099	-0.169*	-0.130*
	(0.083)	(0.078)	(0.067)	(0.090)	(0.070)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	-0.078	-0.270	-0.038	-0.162	0.023
	(1.919)	(1.751)	(1.645)	(1.830)	(1.695)
Constant	-54.166	-36.306	-56.740	-20.424	-33.356
	(140.955)	(117.971)	(129.157)	(121.472)	(131.699)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	2,880	2,880	2,880	2,880	2,880
R-squared	0.078	0.063	0.062	0.102	0.092
Number of country	138	138	138	138	138

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4.c. Robustness Checks: Alternative GVCs (Food Industry)

Service Sector, 1990 -2013

	Dependent Variable: GDP Shares in Service (%)				
Variables	(1)	(2)	(3)	(4)	(5)
GVCs Participation (%)	0.025**	0.017	0.021*	0.013	0.016
	(0.012)	(0.012)	(0.012)	(0.013)	(0.013)
GVCs Participation by neighboring countries	0.055	0.041	0.058	0.039	0.057
	(0.060)	(0.060)	(0.057)	(0.055)	(0.054)
GDP (log)	0.789	0.402	1.356	-0.050	0.912
	(2.567)	(2.528)	(2.480)	(2.383)	(2.293)
Land Share for Agriculture (%)	-0.073	-0.075	-0.061	0.018	-0.015
	(0.105)	(0.104)	(0.107)	(0.119)	(0.121)
Rural Population (%)	0.165	0.176	0.125	0.043	0.025
	(0.163)	(0.163)	(0.159)	(0.143)	(0.139)
Urbanization (urban population growth, %)	-0.075	-0.070	-0.095	-0.288	-0.315
	(0.303)	(0.299)	(0.296)	(0.248)	(0.251)
Age Dependency Ratio (%)	0.107	0.109	0.087	0.188**	0.126*
	(0.073)	(0.072)	(0.071)	(0.078)	(0.072)
Domestic Policy Agricultural Terms of Trade (DPAgTOT)	0.358	0.280	0.028	0.141	0.016
	(0.985)	(0.928)	(0.944)	(0.941)	(0.991)
Constant	-21.778	-4.918	0.733	16.160	12.524
	(125.369)	(116.547)	(122.345)	(114.240)	(122.607)
Trade Controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	No	No	No	No
Time trend	No	Yes	No	No	No
$Time^2$ trend	No	No	Yes	No	No
Region-specific time trend	No	No	No	Yes	No
Regional-specific $time^2$ trend	No	No	No	No	Yes
Observations	2,880	2,880	2,880	2,880	2,880
R-squared	0.184	0.172	0.163	0.275	0.250
Number of country	138	138	138	138	138

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A5. Extension Analysis: Regional Structural Transformation and Food GVCs, 1990-2013

Dependent Variable:	GDP Shares (%)						Employment Shares (%)		
	Linear Model (FE)			Dynamic Model (GMM)			Linear Model (FE)		
Panel	(1) Agriculture	(2) Manufacture	(3) Service	(4) Agriculture	(5) Manufacture	(6) Service	(7) Agriculture	(8) Manufacture	(9) Service
1. OECD									
GVCs Participation	0.049	0.006	-0.055	0.004	-0.098***	0.084***	0.072	-0.155**	0.083
	(0.030)	(0.104)	(0.111)	(0.008)	(0.024)	(0.026)	(0.070)	(0.057)	(0.061)
Observations	641	641	641	612	612	612	675	675	675
R-squared	0.782	0.504	0.650				0.738	0.728	0.887
2. Developing Countries †									
GVCs Participation	-0.058	0.091	-0.027	0.004	0.010	0.018	-0.146	0.107	0.039
	(0.057)	(0.055)	(0.065)	(0.023)	(0.027)	(0.026)	(0.108)	(0.065)	(0.051)
Observations	1,996	1,996	1,996	1,906	1,906	1,906	2,104	2,104	2,104
R-squared	0.297	0.116	0.193				0.385	0.268	0.555
3. Sub-Saharan Africa									
GVCs Participation	-0.081	0.044	0.044	0.005	0.037	0.057	-0.222	0.137	0.086
	(0.053)	(0.068)	(0.068)	(0.040)	(0.041)	(0.040)	(0.155)	(0.090)	(0.072)
Observations	760	760	760	725	725	725	824	824	824
R-squared	0.295	0.186	0.163				0.319	0.158	0.377
4. South Asia									
GVCs Participation	-0.046	0.150**	-0.104	-0.057	0.142**	-0.050	0.130	-0.018	-0.112**
	(0.081)	(0.058)	(0.127)	(0.054)	(0.070)	(0.052)	(0.114)	(0.110)	(0.044)
Observations	156	156	156	149	149	149	150	150	150
R-squared	0.927	0.788	0.778				0.867	0.717	0.814
5. Latin America and the Caribbean									
GVCs Participation	0.096	0.301	-0.397**	0.036	0.020	-0.088	-0.092	0.173**	-0.081
	(0.108)	(0.214)	(0.162)	(0.043)	(0.061)	(0.063)	(0.187)	(0.073)	(0.137)
Observations	439	439	439	420	420	420	455	455	455
R-squared	0.557	0.207	0.389				0.412	0.450	0.597
6. Central and Western Asia									
GVCs Participation	-0.031**	-0.019	0.015	-0.058***	0.033	0.010	-0.008	0.004	0.004
	(0.011)	(0.036)	(0.019)	(0.009)	(0.025)	(0.020)	(0.011)	(0.007)	(0.009)
Observations	335	335	335	325	325	325	369	369	369
R-squared	0.701	0.224	0.532				0.598	0.381	0.424
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

† Developing countries include Sub-Saharan Africa, South Asia, Latin America and the Caribbean, and Central and Western Asia.

Table A6.a Extension Analysis: Regional Structural Transformation and Upstream Participation, 1990-2013

Dependent Variable:	**GDP Shares (%)**						**Employment Shares (%)**		
	Linear Model (FE)			**Dynamic Model (GMM)**			**Linear Model (FE)**		
Panel	(1) Agriculture	(2) Manufacture	(3) Service	(4) Agriculture	(5) Manufacture	(6) Service	(7) Agriculture	(8) Manufacture	(9) Service
1. OECD									
Upstream Participation	-0.225***	-0.259	0.484*	-0.007	-0.129*	0.124	-0.141	-0.168	0.309
	(0.076)	(0.236)	(0.263)	(0.024)	(0.070)	(0.077)	(0.289)	(0.268)	(0.235)
Observations	641	641	641	612	612	612	675	675	675
R-squared	0.787	0.508	0.658				0.737	0.719	0.887
2. Developing Countries †									
Upstream Participation	0.263*	-0.094	-0.158	0.142***	-0.162***	-0.049	0.041	0.083	-0.124
	(0.138)	(0.121)	(0.140)	(0.031)	(0.040)	(0.037)	(0.181)	(0.089)	(0.107)
Observations	1,996	1,996	1,996	1,906	1,906	1,906	2,104	2,104	2,104
R-squared	0.312	0.113	0.197				0.375	0.253	0.558
3. Sub-Saharan Africa									
Upstream Participation	0.250	-0.038	-0.200	0.240***	-0.135**	-0.061	0.032	0.039	-0.071
	(0.166)	(0.166)	(0.184)	(0.058)	(0.063)	(0.060)	(0.228)	(0.106)	(0.131)
Observations	760	760	760	725	725	725	824	824	824
R-squared	0.305	0.186	0.169				0.294	0.110	0.372
4. South Asia									
Upstream Participation	0.017	0.075	-0.092	0.025	0.097	-0.082	0.025	0.018	-0.043
	(0.072)	(0.133)	(0.188)	(0.062)	(0.087)	(0.069)	(0.106)	(0.053)	(0.089)
Observations	156	156	156	149	149	149	150	150	150
R-squared	0.927	0.783	0.777				0.866	0.717	0.812
5. Latin America and the Caribbean									
Upstream Participation	-0.086	-0.054	0.140	0.099*	-0.089	-0.072	0.031	0.317*	-0.348
	(0.173)	(0.415)	(0.346)	(0.052)	(0.076)	(0.069)	(0.219)	(0.180)	(0.238)
Observations	439	439	439	420	420	420	455	455	455
R-squared	0.556	0.196	0.373				0.411	0.447	0.601
6. Central and Western Asia									
Upstream Participation	0.293**	-0.183	-0.247	0.370***	-0.255	-0.084	0.005	-0.044	0.039
	(0.124)	(0.315)	(0.244)	(0.080)	(0.186)	(0.163)	(0.109)	(0.143)	(0.194)
Observations	335	335	335	325	325	325	369	369	369
R-squared	0.702	0.224	0.535				0.597	0.381	0.424
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1
† Developing countries include Sub-Saharan Africa, South Asia, Latin America and the Caribbean, and Central and Western Asia.

Table A6.b Extension Analysis: Regional Structural Transformation and Downstream Participation, 1990-2013

Dependent Variable:	GDP Shares (%)						Employment Shares (%)		
	Linear Model (FE)			Dynamic Model (GMM)			Linear Model (FE)		
Panel	(1) Agriculture	(2) Manufacture	(3) Service	(4) Agriculture	(5) Manufacture	(6) Service	(7) Agriculture	(8) Manufacture	(9) Service
1. OECD									
Downstream Participation	0.058*	0.064	-0.122	0.002	-0.068**	0.055*	0.014	-0.074	0.060
	(0.031)	(0.094)	(0.103)	(0.009)	(0.028)	(0.030)	(0.067)	(0.051)	(0.065)
Observations	641	641	641	612	612	612	675	675	675
R-squared	0.783	0.506	0.654				0.736	0.720	0.886
2. Developing Countries †									
Downstream Participation	-0.174***	0.145	0.032	-0.132***	0.148***	0.101***	-0.181**	0.063*	0.119
	(0.054)	(0.089)	(0.075)	(0.032)	(0.037)	(0.038)	(0.083)	(0.035)	(0.072)
Observations	1,996	1,996	1,996	1,906	1,906	1,906	2,104	2,104	2,104
R-squared	0.309	0.120	0.194				0.385	0.253	0.560
3. Sub-Saharan Africa									
Downstream Participation	-0.176**	0.054	0.126	-0.163***	0.128**	0.142***	-0.225*	0.100**	0.124
	(0.067)	(0.120)	(0.099)	(0.050)	(0.052)	(0.053)	(0.117)	(0.043)	(0.084)
Observations	760	760	760	725	725	725	824	824	824
R-squared	0.305	0.186	0.168				0.312	0.128	0.381
4. South Asia									
Downstream Participation	-0.245	0.258	-0.013	-0.281**	0.137	0.069	0.345	-0.127	-0.218
	(0.192)	(0.263)	(0.326)	(0.111)	(0.133)	(0.122)	(0.397)	(0.359)	(0.249)
Observations	156	156	156	149	149	149	150	150	150
R-squared	0.929	0.786	0.775				0.868	0.719	0.814
5. Latin America and the Caribbean									
Downstream Participation	0.100	0.324	-0.423**	-0.081	0.142	0.009	-0.177	0.109	0.068
	(0.109)	(0.239)	(0.193)	(0.057)	(0.089)	(0.077)	(0.262)	(0.115)	(0.179)
Observations	439	439	439	420	420	420	455	455	455
R-squared	0.557	0.204	0.385				0.413	0.438	0.597
6. Central and Western Asia									
Downstream Participation	-0.031***	-0.015	0.016	-0.057***	0.035	0.009	-0.006	0.004	0.002
	(0.010)	(0.033)	(0.019)	(0.009)	(0.024)	(0.020)	(0.010)	(0.007)	(0.009)
Observations	335	335	335	325	325	325	369	369	369
R-squared	0.701	0.224	0.532				0.598	0.381	0.424
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors clustered at the country level in parentheses *** p<0.01, ** p<0.05, * p<0.1

† Developing countries include Sub-Saharan Africa, South Asia, Latin America and the Caribbean, and Central and Western Asia.

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(Note: References will be revised in the final version of draft)

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