Global Agricultural Value Chains and Structural Transformation*

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Abstract

How does participation in global agricultural value chains affect the structural transformation of modern economies? The rise of global value chains, wherein the different stages of the production process locate across different countries, has changed the nature of agricultural production around the world. Little is known, however, about how global value chains change the structure of participating economies. We first develop a theoretical model that shows how the exports of intermediate inputs for agricultural production change the structure of the economy in the exporting country under an open-economy scenario. We then empirically study the effect of participation in global agricultural value chains on structural transformation by using multi-region, input-output data on 183 countries for the period 1990-2013. Counter to conventional wisdom, our results indicate that as participation in global agricultural value chains increases, the average economy leapfrogs the manufacturing sector by going from being primarily agriculture-based to being primarily service-based.. Our findings thus show that trade liberalization through global agricultural value chains can help foster the structural transformation that has been considered a primary driver of economic development.

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. Historically, firms used to produce goods in one country, and trade finished goods with other countries. Nowadays, it is uncommon for international-trade transactions to be based on the exchange of finished goods. Rather, sales of individual components of products and value-added intermediate services dominate most of what is being traded, and over 70 percent of today's international trade involves GVCs wherein services, raw materials, parts, and components cross borders—often numerous times. Once those services, raw materials, parts, and components are incorporated into final products, those final products are shipped to consumers all over the world. The typical "Made in" labels have become symbols of a bygone era because the disintegration of production processes across borders has gradually spread in the modern economy (Antràs 2015).

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

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

Although the rise of GVCs have changed modern agricultural production systems, it is unclear whether and how agricultural GVCs affects the economic structure of participating countries. Since Kuznets (1966), the structural transformation—wherein a country reallocates its economic

[1] In a slight abuse of language, we use the term "agricultural GVC" to refer to all agricultural or food GVCs.

activities from the agricultural sector to the manufacturing then services sectors—has received a lot of attention in policy debates surrounding economic growth in both developed and developing countries.

We study how participation in agricultural GVCs affects the structural transformation of economies. To do so, we first develop a theoretical model that shows how the net exports of intermediate inputs (used for agricultural production in importing countries) change the structure of the economy in the exporting country under an open economy scenario. In the model, we introduce agricultural GVCs by allowing the trade of intermediate inputs between two countries and three sectors (i.e., agriculture, tradable manufacturing and services, non-tradable manufacturing and services), with both homothetic and non-homothetic preferences. We then develop a model of international trade based on the Ricardian motive by adapting Uy, Yi, and Zhang (2013). Based on this setup, we derive three propositions that provide the mechanisms whereby competitive advantages in tradable goods across countries affect those same countries' agricultural GVC participation, and explain the further reallocation of economic activities at the competitive equilibrium—that reallocation of economic activities being the so-called structural transformation.

In our empirical analysis, we look at whether participation in agricultural GVCs transforms the structure of economies by using data on 183 countries over the period 1990-2013. Specifically, we look at whether participation in agricultural GVCs changes the GDP shares of each of the agricultural, manufacturing, and services sectors. To do this, we begin by applying the bilateral gross exports decomposition method developed recently by Wang, Wei, and Zhu (2017) to the EORA multi-region input-output tables. We then rely on country and year fixed effects to look at whether agricultural GVC participation is associated with changes in GDP shares.

We find that participation in agricultural GVCs is associated on average with a significant decrease in the GDP share of the agricultural sector and an increase in the GDP share of the services sector. We find, however, that there is no statistically significant relationship between participation in agricultural GVCs and the GDP share of the manufacturing sector. This finding suggests that modern agrarian economies are leapfrogging the manufacturing sector to directly

develop their service sector as a consequence of greater participation in agricultural GVCs—a finding which runs counter to conventional wisdom about the structural transformation.

We assess the robustness of our result as follows. First, to ensure that our results are robust to changes in agricultural policy over time (Balié et al., 2018), we successively control for a country's (i) trade policy and (ii) domestic agricultural price policy. We then control for (iii) neighboring countries' average GVC participation, in an effort to ensure that our results are not driven by a violation of the stable unit treatment value assumption (SUTVA; see Pearl, 2009). Next, to ensure that our results are robust to different specifications, we include (iv) a linear time trend, and (v) country-specific linear time trends, and to ensure that our result are robust to the assumption of dynamic structural transformation (Carkovic and Levine, 2002; Vries et al, 2012), we estimate dynamic panel regressions using the Arellano-Bond GMM method. Lastly, to see whether our results are robust to different measures of structural transformation, we re-estimate everything using sectoral employment shares instead of GDP shares (Herrendorf, Rogerson, and Valentinyi, 2014). Throughout all of these efforts, our result that modern economies appear to transform their economies by leapfrogging the manufacturing sector remains.

The contribution of this study is threefold. First, we contribute to the literature on agricultural trade by providing evidence that trade liberalization via agricultural GVCs transforms the structure of economies. Since the late 1940s, world trade has rapidly liberalized along with successive rounds of trade negotiation by the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO). Unlike the progress made in the manufacturing or services sectors, the agricultural sector tends to be heavily protected by national agricultural policies (Reardon and Timmer, 2007; Sheldon, Chow, and McGuire, 2018).

Second, we contribute more directly to the literature on agricultural value chains by looking at the relationship between agricultural trade and agricultural value chains. In the literature, numerous studies have looked at the effects of participation in agricultural value chains by rural households, who stand at the very beginning of those value chains, on a myriad of economic outcomes such as income, food security, productivity, and so on (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 that literature has been abundant, there are few empirical studies looking at the effect of participation in

agricultural GVCs from the perspective of the other end of agricultural value chains, viz. international trade (Balié 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) and combining newly released multi-regional input-output (MRIO) data, we provide the first empirical evidence on the relationship between participation in agricultural value chains and the structure of economies from a global perspective.

Third, we contribute to the literature on the structural transformation by documenting that modern economies transform their economies by going directly from agriculture to services in response to increased participation in agricultural GVCs. In the early literature, the structural transformation was regarded as the key channel toward sustainable growth (Lewis, 1954; Kuznets, 1966; Chenery, 1986). As economies developed, poor countries would reallocate their economic activities from agriculture to manufacturing and then services to attain higher levels of productivity, and historically that is how rich countries saw their economies evolve (Rogerson, 2008). As a result, manufacturing was prioritized as a key driver of structural transformation in poor agrarian countries (e.g., East Asia in the 1980s).

More recent studies, however, provide evidence that the conventional structural transformation narrative has been less true for 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 to attempt to leapfrog manufacturing and go straight to services, which influences those countries' agricultural policies (Dasgupta and Singh 2007; Rodrik 2016). While many scholars have discussed this new paradigm of structural transformation, few studies empirically show what drives the leapfrogging. Our empirical findings illustrate that.

The remainder of this paper proceeds as follows. Section 2 discusses our theoretical framework. Section 3 and 4 respectively describe our data and empirical strategy. Our core findings and robustness checks are presented in Sections 5 and 6, and Section 7 considers extensions to our core findings. Section 8 concludes.

2. Theoretical Framework

2.1. Preferences

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

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

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. Parameter of $\bar{C}_{ia} \geq 0$ is a subsistence requirement for the consumption of the agricultural composite good in country i. For $\bar{C}_{ia}$, preferences are homothetic; otherwise, the preferences are non-homothetic which 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 maximization problem of the household consists in 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 sector k's (where $k \in \{a, t, n\}$) 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 in sector k, A_{ik} denotes exogenous technology in production of goods in sector k, and L_{ik} denotes labor inputs in production in sector k. The

variable $M_{ikm} > 0$ denotes the sector-m composite goods used as intermediate inputs in the production of sector-k good in country i. We 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 closed 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}) inputs 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 decomposed into

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

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

The profit optimization problem of the agricultural sector (a) in country i consists in 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 have an 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 (i.e., $p_{1a} = p_{2a} = p_a^w$, and $p_{1t} = p_{2t} = p_t^w$). 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}). By a similar reasoning, there is no single world wage rate (w_1, w_2).

We model any incurred trade costs between country 1 and 2 as iceberg costs, denoted by φ_{ik}. We let $\varphi_{ik} = 1$ 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 unit—arrive in country 2. There are no trade costs within a country.

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

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

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

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

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

For non-tradable good, the following market clearing condition holds in each country $i \in \{1, 2\}$:

$$Y_{in} = C_{in} + M_{ian}. \quad (10)$$

Based on the discussion so far, we 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 structural parameters of total labor endowment (L_1, L_2), the subsistence requirement for agricultural consumption $(\bar{C}_{1a}, \bar{C}_{2a})$, and trade cost $(\varphi_{1k}, \varphi_{2k})$ with the exogenous technologies (A_{1k}, A_{2k}), where $k \in \{a, t, n\}$.

2.4. Structural Transformation in an Open Economy with GVCs

We now derive the partial effect of intermediate inputs sourcing across countries on the structural transformation. Since the structural transformation refers to a reallocation of a country's resource from the agricultural sector to manufacturing, and then to services (Timmer and Akkus, 2008), in our model, we define the structural transformation as a decreasing pattern of agricultural labor share in a sector, similar to the earlier literature (Timmer, 2009; Herrendorf, Rogerson, and Valentinyi, 2014). We denote the labor share in sector k as l_{ik} in country i, where $l_{ia} + l_{it} + l_{in} = 1$. Recall that we set the subsistence requirement for agricultural consumption $(\bar{C}_{1a}, \bar{C}_{2a})$ at zero for simplicity.

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

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

By dividing by $w_i L_i$ on both sides, this can be rewritten as

$$l_{in} = \frac{w_i L_{in}}{w_i L_i} = \frac{P_{in} Y_{in}}{w_i L_i} = X_{in}, \tag{12}$$

where X_{ik} denotes country i's expenditures on the sector-k good. Per 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:

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

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 as follows by dividing on both sides by $w_i L_i$:

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

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

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

To show the partial effect of cross-country intermediate inputs in agricultural production (i.e., agricultural GVCs) on the 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 leads to the two following propositions.

Proposition 1. *Suppose there exists a competitive equilibrium in an open economy with agricultural GVCs between two countries* i *and* j. *If country* i *increases its exports of agricultural the intermediate input to country* j*'s agricultural production, then country* i *reallocates its labor from the non-agricultural tradable sector* t *to the agricultural sector* a.

Proof. 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 derivatives of the labor shares of tradable sectors with respect to cross-country intermediate agricultural inputs are such that $\frac{dl_{ia}}{dM_{jiaa}} = \frac{\pi_{jia}P_a^W}{w_iL_i} > 0$ and $\frac{dl_{it}}{dM_{jiaa}} = -\frac{\pi_{jia}P_a^W}{w_iL_i} < 0$. ■

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 exists a competitive equilibrium in an open economy with agricultural GVCs between two countries* i *and* j. *If country* i *increases its exports of non-agricultural intermediate input to country* j*'s agricultural sector, then country* i *reallocates its labor from agricultural sector* a *to the non-agricultural sector* t.

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

Propositions 1 and 2 summarize the relationship between agricultural GVCs and structural transformation as follows: A country reallocates its endowment of resources more toward the tradable sector when it country increase its intermediate inputs for the sector in the other country's

agricultural production. Intuitively, a country has an incentive to concentrate on its resources on a specific tradable sector where the country has a competitive advantage against the other importing country in the case where the traded good is used as an intermediate input by the importing country. For example, if country j's demand for country i's tradable manufacturing or service goods increases, then country i allocates more resources toward the manufacturing or service sectors that leads to a structural transformation from the agricultural to non-agricultural sectors in country i. This is consistent with Uy, Yi, Zhang (2013) and Teignier (2018), which state that trade in agricultural goods can accelerate structural transformation.

In terms of size of marginal effects, there are three factors at play:

1. The marginal effect of 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 the labor share of the non-agricultural sector t proportionally increases.
2. The marginal effect is also positively related to the world price of the trade sector.
3. The marginal effect in country i has an inverse relationship with the size of the country's economy, $w_i L_i$.

By Proposition 1 and 2, we define the 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

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

Proposition 3. *Suppose country i has a comparative advantage in the non-agricultural sector relative to country j at the competitive equilibrium. If the world price of the non-agricultural good is higher than the world price of the agricultural good (i.e., $P_a^w < P_t^w$), then country i transforms*

its economy out of the agricultural sector as its overall global sourcing for agricultural production in country j increases.

Proof. Since $w_i L_i > 0$, 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 a competitive advantage in the non-agricultural sector t, $\pi_{jia} < \pi_{jit}$. 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 that has comparative advantage in the non-agricultural good transforms its economy from the agricultural sector to the non-agricultural sector such as manufacturing or services 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 the trade literature, there have been two barriers to mapping GVCs. First, unlike conventional trade data that account for the final product transaction, data for measuring GVCs essentially requires industry-level data, which enable one to track all value-added activities by industry or country involved in global production. National accounts data (e.g., gross import or export of final products) are not suitable for measuring GVCs because those data lack information on the value added of intermediate input transaction.[2] National input-output account data that describe value-chain linkages across industries can be considered as an alternative, but they 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 in time is required to provide a comprehensive map of international transactions of goods and services (Inomata, 2017).

Secondly, there is lack of agreement on a coherent measure of GVCs. Researchers have struggled to conceptually define what types of value-added activities should be taken into account

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

to measure GVCs (Hummels, Ishii, and Yi, 2001; Chen et al., 2004; Daudin, Rifflart, and Schweisguth, 2006; Johnson and Noguera, 2012; Bems and Johnson, 2012).[3] International trade in value-added goods or services has become more complicated to track because GVC flows are heterogeneous, varying by commodity and by industry. As a result, decomposition of gross exports into various sources of value-added is methodologically challenging.

To overcome these difficulties, we adopt a recent method developed by Wang et al. (2017) to measure participation in GVCs by using the 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 the Leontief inverse matrix. The primary advantages of Wang et al.'s measure of GVCs are twofold. First, the measure can capture all complicated sources of value-added activities across more than two countries, which are often missing in other measures of GVCs. Secondly, it provides 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.

Per Wang et al. (2017), gross exports can be decomposed into four broad value-added activities, which are themselves further disaggregated into 16 value-added activities. The four broad-value-added activities are (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 those 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 from GVC measurement because it represents conventional transactions of final products between two countries.[5] Second, DVX measures forward GVC participation (or downstream participation); it reflects producer perspectives by addressing the extent to which inputs used in a country have been involved in cross-country production. Third, FVA measures backward GVC participation (or upstream participation). FVA reflects consumer perspective by addressing the extent to which final products made by a country

[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] WE elaborate the difference between conventional trade of final goods and GVC production in trade account in Appendix A3.

are sourced from GVC activities. Lastly, PDC is an accounting component generated where value-added products cross borders multiple times and thus it needs to be included when measuring total GVCs. As a result, we measure GVC participation (D_{it}) for country i in year t using Wang et al.'s (2017) method by computing:

$$D_{it} = \frac{DVX_{it}+FVA_{it}+PDC_{it}}{Gross\ Export_{it}}. \quad (17)$$

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

Figure 1 shows an increasing trend in agricultural GVC participation between 1990 and 2013. Figure 2 shows average levels of agricultural GVC participation by country type.

Figure 1. Trend of Agricultural GVCs, 1990 - 2013

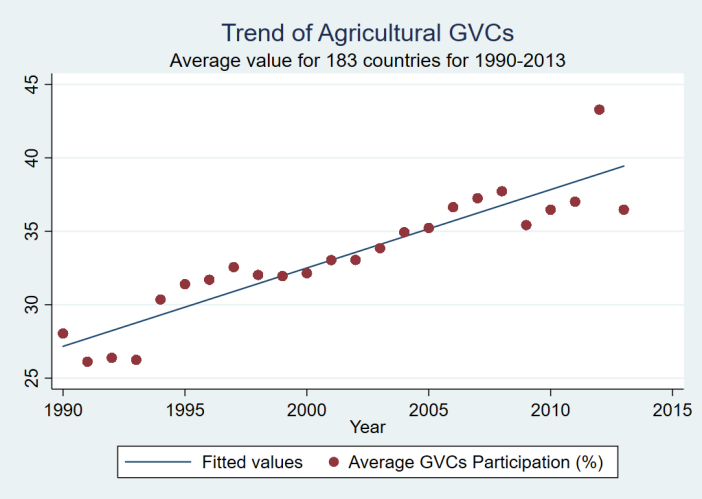


Figure 2. Trends of Agricultural GVC Participation by country groups, 1990-2013

Figure 2.a. OECD countries

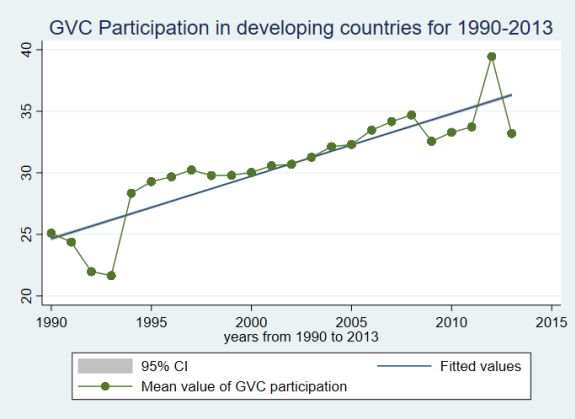


Figure 2.b. Developing countries†

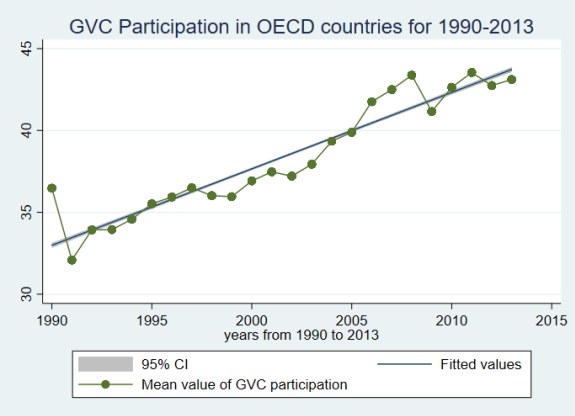


Figure 2.c. Sub-Saharan Africa countries

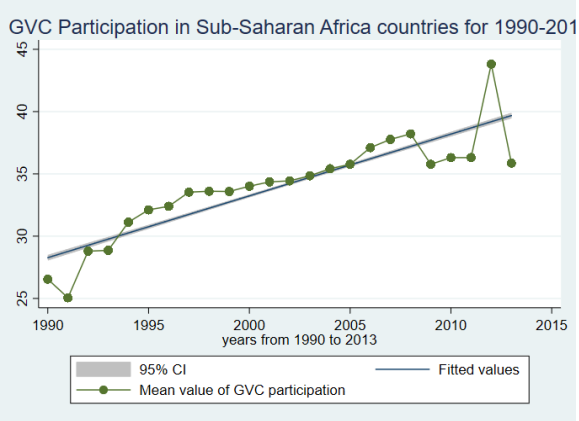


Figure 2.d. South Asia

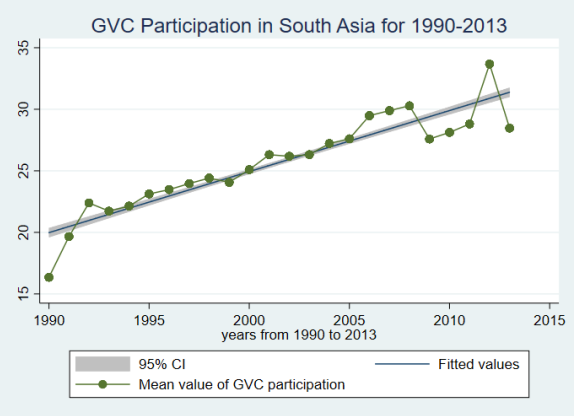


Figure 2.e. Latin American and the Caribbean countries

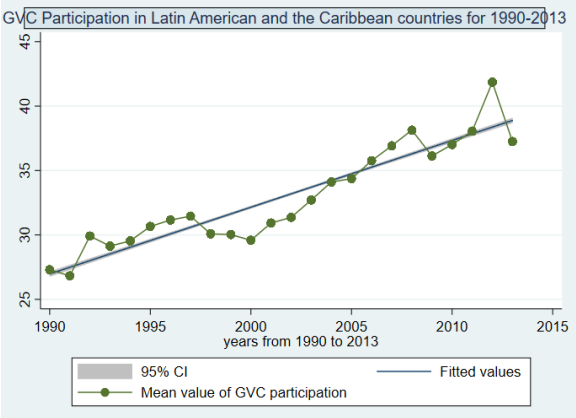
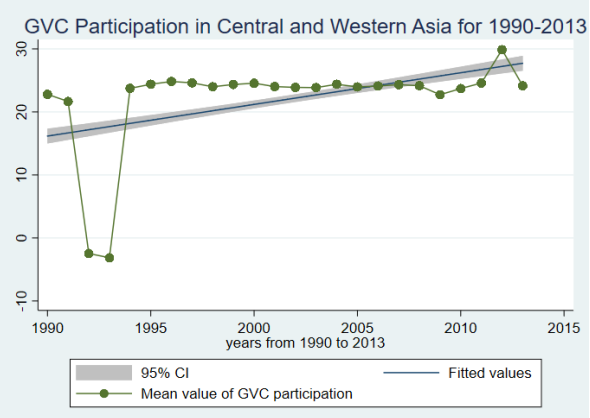


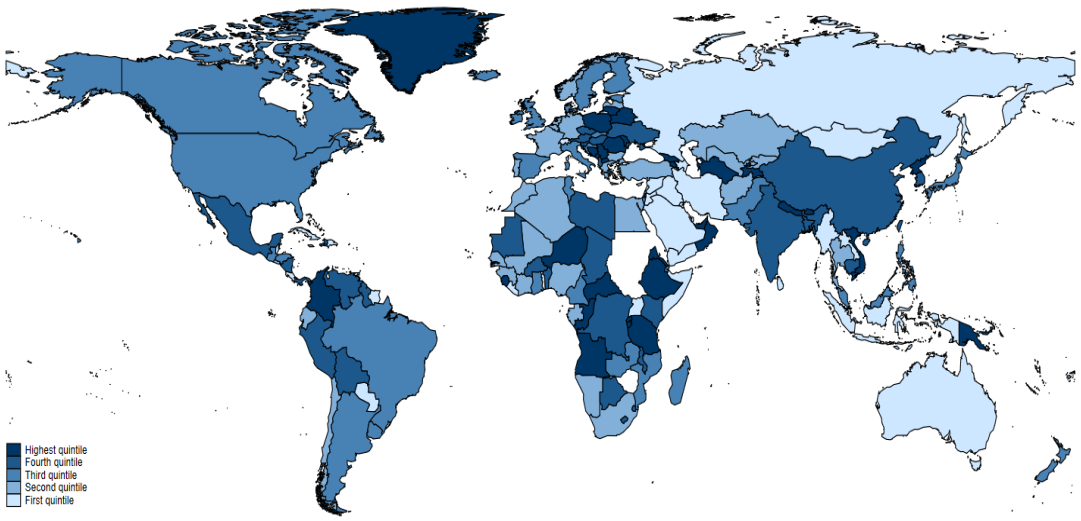
Figure 2.f. Central and Western Asia



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

In terms of the geographical distribution of GVC growth rates, Figure 3 provides prima facie evidence that developing countries have increasingly participated in agricultural GVCs.

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. Following Timmer (2009), the structural transformation is characterized within a country by the 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) migration from rural to urban areas, (iv) a demographic transition from high birth rates to low death rates, and (v) a rising female labor market participation from agriculture to service.

In the growth and development literature, three measures of national economic activity by sectors (agriculture, manufacturing, and services) have been widely used: (i) GDP shares, (ii) employment shares, and (iii) final consumption shares (Herrendorf, Rogerson, and Valentinyi, 2014). For instance, one can measure structural transformation in a country by looking at whether the share of agricultural activities decreases while the share of non-agricultural activities increases in over the years.

We use GDP shares of agriculture, manufacturing, and services in each country as our main measure of structural transformation. To perform robustness checks, we use employment shares by sector. We exclude final consumption shares as an alternative measure of structural transformation, however, for two reasons: First, it is difficult to obtain credible expenditure estimates for numerous developing countries (Ravallion, 2001). Second, final consumption in the service sector has been proven to be perpetually challenging and underestimated, in both developing and developed countries (Landerfeld, Seskin, and Fraumeni, 2008). Thus, our measure of structural transformation is limited to production approach.

The source for the structural transformation indicators we use as dependent variables is the World Development Indicators (WDI) database. The cross-country data include value-added GDP shares by sector for 183 countries from 1990 to 2013.[6] Total GDP is measured at purchase prices. We dropped 28 observations whose sum of GDP shares by sector was larger than one to minimize measurement error issues.

4. Empirical Framework

We begin this section by presenting our preferred empirical specification, based on standard linear regression methods, and we then discuss alternative specifications. We next discuss our identification strategy by explaining how our empirical approach addresses the main sources of endogeneity.

4.1 Baseline

Our 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 GDP shares in a given sector (agriculture, manufacturing, or services) for country i in year t. This is a percentage outcome, taking on a value between 0 and 100, D_{it} is the treatment variable (i.e., the level of participation in agricultural GVCs of country i in year t), X_{it} denotes time-varying control variables, α_i denotes a vector of country fixed effects, μ_t denotes a vector of year fixed effects, and ε_{it} is an error term with mean zero.

We estimate Eq.(18) by the ordinary least squares. Country fixed effects (α_i) are included to control for time invariant unobserved heterogeneity within each country i. Year fixed effects (μ_t) control for all the country-invariant unobserved heterogeneity within each year. We cluster our standard errors at the country following the recommendations in Abadie et al. (2017).

Our goal is to estimate β to show the effect of participation in agricultural GVCs on structural transformation by testing the null hypothesis $H_0 : \beta = 0$ verus the alternative hypothesis $H_A : \beta \neq 0$.

4.2 Alternative specifications

Although our baseline specification controls for country and year fixed effects, time effects often differ by region or by country in cross-country analyses. For example, the effects of climate shocks or oil price shocks (Baumeister et al., 2010) in a year may be limited to specific regions or countries. To ensure that our findings are robust, we also estimate alternative specifications that control for (i) a linear time trend, (ii) a quadratic time trend, (iii) region-specific linear time trends, and (iv) region-specific quadratic time trends.

4.3 Identification Strategy

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

We discuss our identification strategy by addressing four broad sources of endogeneity: (i) unobserved heterogeneity, (ii) measurement error, (iii) reverse causality, and (iv) SUTVA violations.

Unobserved Heterogeneity

To properly identify the average treatment effect, a linear regression should include all potential confounders, i.e., all of the variables which cause both the outcome and the treatment. Although it is generally not feasible to account for all omitted variables, in many cases, it is important to identify and include potential unobserved confounders.

In our empirical framework, multiple tactics are deployed to minimize unobserved heterogeneity. First, the country fixed effects used in the baseline specification 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 deemed determinants of trade volumes or economic growth. Country fixed effects also control for initial 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).

Second, year fixed effects in purge the error term of its correlation with the treatment variable due to factors that are constant across all countries in a given year. For example, progress on the structural transformation might have been slowed in 2008-2009 because of the global financial crisis across countries. One might argue that year fixed effects do not capture time-varying, unobserved confounding factors unique to a given region in a given year, such as regional climate or political changes (e.g., the Arab Spring in 2010-2011). We thus 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 includes economic factors (e.g., GDP and arable land area) 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 be concerned that the extent of participation in agricultural GVCs is endogenous because of changes in (i) trade policy within a country, (ii) trade competitiveness with other countries, or (iii) domestic agricultural price policy. To control for time-varying trade policy and competitiveness conditions, vector X_i also contains trade variables (e.g., membership in regional trade agreements, free trade agreements, customs unions) and, to account for potential spillovers,

the participation level in agricultural GVCs of neighboring countries of country i in year t. We control for domestic agricultural price policy by generating a time-varying variable by adapting the method in Timmer and Akkus (2008).

Lastly, we also control in some specifications for time trends to account for the passage of time. The systematic pattern of structural transformation across countries over the years—shifts from agriculture to manufacturing, and then to the services sector—is a stylized fact of the literature on economic growth. The dataset we used in this study shows a similar pattern (see Figure 3). Thus, we estimate alternative specifications including (i) a linear time trend, (ii) a quadratic time trend, (iii) region-specific linear time trends, and (iv) region-specific quadratic time trends.

Although most of unobserved confounders that mar the identification of the causal effect of GVC participation on our measures of structural transformation can be captured by various means described above, the identifying assumption one needs to make in order to make a causal statement about the relationship between GVC participation and structural transformation is that whatever unobserved confounders are left do not significantly bias the estimate of β. This is an assumption that we are unwilling to make, and so for the remainder of this paper, we talk of the association between GVC participation and structural transformation, and interpret our estimates as only suggestive of a causal relationship.

Measurement Error

Another source of endogeneity is measurement error, especially in fixed-effects regressions such as ours, wherein one should avoid overly strong claims when interpreting estimates given that 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 the division between intermediate and final goods can be a source of measurement error. This is because there are heterogeneous 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.[7]

[7] 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).

Our treatment variable is the extent of agricultural GVC participation in each country (D_{it}), and it is measured using the recent measure developed by Wang, Wei, and Zhu (2017). Their measure eliminates the aforementioned missing information source by decomposing value-added production activities in cross-border production. Also, it provides measures of upstream and downstream GVC participation, which show a much more detailed GVC involvement compared to other measures (see Antràs and Chor, 2018). Thus, we rely on the proven validity of the measure of GVCs (Antràs and Gortari, 2017; Antràs and Chor, 2018; Balié et al., 2017) to obviate concerns about measurement error in the treatment variable (D_{it}).

Another concern is measurement error related to our measures of structural transformation. Recall that we use the GDP shares of each of the three sector of the economy (i.e., agriculture, manufacturing, services) for each country over the years as a primary measure of structural transformation. The longitudinal data we use for this was assembled collection from statistical offices from 183 countries. Although the estimates of GDP shares are reliable in most developed countries, they are likely to be measured with error 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—phenomenon that has been referred to as "Africa's statistical tragedy" (Devarajan, 2013; Jerven and Johnston, 2015).

There is no evidence, however, that GDP shares are systematically over- or under-estimated, and so the measurement error we face in this case is classical measurement error, and so our estimate of β may suffer from attenuation bias. This implies that a rejection of the null hypothesis (i.e., $H_0 : \beta = 0$) provides stronger evidence than in the absence of measurement error and that our estimate $\hat{\beta}$ is an estimate of the lower bound (in absolute value) of the true coefficient of β.

As a robustness check, we use an alternative measures of structural transformation, viz. employment shares by sector. Moreover, we provide separate estimation results only for developed countries (i.e., OECD), whose data is more reliable.

Reverse Causality

The third endogeneity concern stems fro reverse causality. If structural transformation leads to changes in participation in agricultural GVCs and y_{it} and D_{it} are thus jointly determined, our estimate of β would thus be biased. Structural transformation is, however, unlikely to be a

dominant influences on GVC participation. Indeed, for a given country in a given year, trade activity occurs before GDP is calculated, and so reverse causality wherein GDP shares drive participation in agricultural GVCs is not a concern.

More seriously, one might be concern that participation in agricultural GVCs is influenced by the structural transformation through some dynamic mechanism. For example, the increased share of GPD (or employment shares) in agriculture might accelerate a country's involvement in agricultural GVCs since the country allocates more economic resources on the agricultural sectors. To explore this possibility, we check the robustness of our results by using dynamic panel data method (Carkovic and Levine, 2002; Vries, Michaels, Rauch, Redding, 2012; Timmer, and Vries, 2015; Hnatkovska and Lahiri, 2016).

Violations of the Stable Unit Treatment Value Assumption

One final endogeneity concern stems from violations of the stable unit treatment value assumptions (SUTVA), which requires that there be no spillovers (i) within a country across years, (ii) across countries within a given year, and (iii) across countries and across years. In analyses of longitudinal data, SUTVA is often assumed to hold (Heckman, 2008), and violations of SUTVA obviously lead to bias in the coefficient estimate of interest (Pearl, 2009).

In effort to reduce—although not eliminate—the potential bias stemming from SUTVA violations, we control for the neighboring countries' average level of GVC participation in a given year. We thus create a control variable that averages out GVCs participation indices in neighboring countries. "Neighboring countries" are defined as countries with which a country shares a border. For isolated countries, both geographically (e.g., Japan) or politically (e.g., South Korea), we use the five nearest countries to serve as "border" countries. The average agricultural GVC participation index in neighboring countries partially control for within-year cross-country spillover effects, and thus lessen the issue of SUTVA violations. Our identification strategy thus controls only for cross-border, contemporary SUTVA violations.

4.4. Data Sources for Control Variables

To account for potential confounders, we control for a number of time-varying control variables in Equation (18). First, to measure domestic price policy, we use a measure of domestic policy

agricultural terms of trade by adopting the method in Timmer (2009). We use FAO data and FAO price indices to compute that variable.[8] Secondly, we rely on CEPII data for our trade policy variables, i.e., regional trade agreements (RTAs) sourced from WTO (2015), customs unions (CUs), and free trade agreements (FTAs) sourced from Baier and Bergstrand. Third, as discussed, we measure neighboring countries' GVCs participation by averaging GVCs indexes in all bordering countries for each country. For island countries, which have no bordering countries, we use the five nearest countries as a proxy for bordering countries. Lastly, we rely on the World Development Indicators data for the rest of our control variables, including agricultural land area, population, urbanization, GDP, and dependency ratio. Table 1 summarizes descriptive statistics.

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

Variables	Obs.	Mean	Std.Dev.
Dependent Variable			
GDP share in Agriculture (%)	3,593	15.04	14.24
GDP share in Manufacture (%)	3,608	29.67	11.86
GDP share in Service (%)	3,585	55.26	15.11
Employment share in Agriculture (%)	3,943	31.58	26.62
Employment share in Manufacture (%)	3,943	20.23	9.459
Employment share in Service (%)	3,943	48.19	20.43
Global Value Chains (GVCs)			
Agriculture Industry			
GVC Participation	4,364	33.31	18.14
GVC Participation by Neighboring countries	4,364	31.92	9.687
Downstream Participation	4,364	21.68	9.747
Downstream Participation	4,364	8.566	15.20
Food Industry			
GVC Participation	4,392	32.23	15.597
GVC Participation by Neighboring countries	3,480	31.80	10.098
Upstream Participation	4,364	21.68	9.747
Downstream Participation	4,364	8.566	15.20
Control Variables			

[8] By Timmer (2009), agricultural terms of trade--he ratio of GDP deflator in agricultural value added to GDP deflator in non-agricultural value added—is used as a proxy for agricultural price policy in trade, which is predominantly influenced by the world price of food price. Domestic price policy is measured. See Timmer (2009) for more description of the calculation.

Participation of RTA (Yes= 1)	4,364	0.871	0.335
Participation of CU (Yes= 1)	4,364	0.498	0.500
Participation of FTA (Yes= 1)	4,364	0.553	0.497
Numbers of RTA	4,364	29.24	24.91
Numbers of CU	4,364	7.418	9.416
Numbers of FTA	4,364	13.40	18.33
GDP (log)	3,905	24.79	2.056
Land share for Agriculture (%)	4,218	39.07	22.28
Rural Population (%)†	4,362	44.32	24.10
Urban Population Growth (%)	4,357	2.262	2.021
Age Dependency Ratio (%)	4,167	65.27	19.93
Domestic Policy Agricultural Terms of Trade	4,301	100.0	0.556

† Some countries (e.g., Bermuda, Cayman Islands, Hong Kong, Macao, Monaco, and Singapore) have zero percentages of their population that is rural.

5. Estimation Results

Before we discuss parametric results, we begin with nonparametric results that present unconditional relationships between our measures of structural transformation and participation in agricultural GVCs. Both our nonparametric and parametric results provide robust evidence that, as participation in agricultural GVCs increases, a participating country's GDP share of agriculture sector decreases significantly, its GDP share of services significantly increases, and its GDP share in manufacturing is stable. In other words, in response to greater participation in agricultural GVCs, modern countries seemingly transform their economies by reallocating economic activity from the agricultural sector directly to the service sectors, thereby leapfrogging the manufacturing sector.

5.1 Nonparametric Results

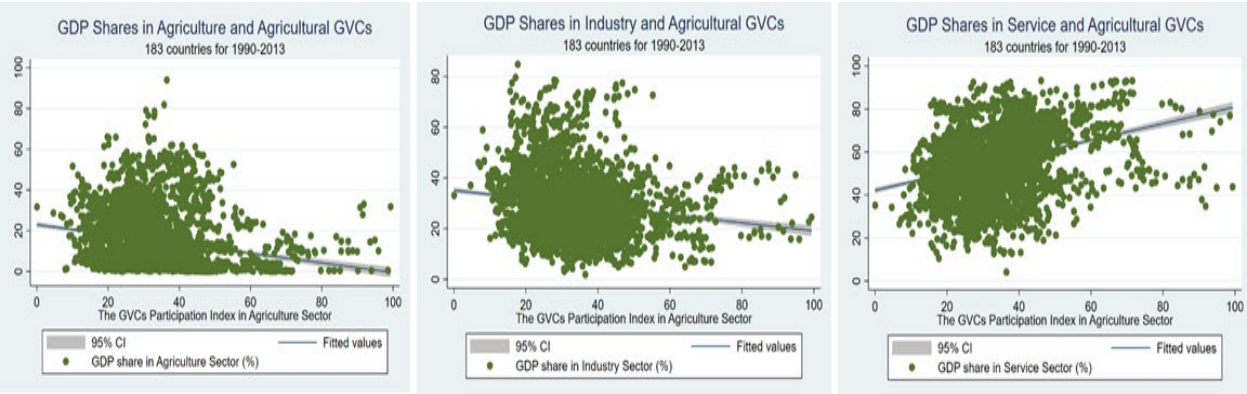
Figure 4 shows scatter plots of sectoral GDP shares and our index of agricultural GVCs participation for 183 countries from 1990 to 2013. The three panels in Figure 4 respectively show results for each sector. The index of GVCs participation is on the X-axis, and sectoral GDP share is on the Y-axis. Each figure includes a linear regression of GDP share on GVC participation along with a 95% confidence interval.

From Figure 4, it appears that the structural transformation seemingly shifts economic activity from agriculture to services. From the scatter plots in the first panel of Figure 4, there is a negative (unconditional) relationship between the share of GDP in agriculture and participation in agricultural GVCs. A similar negative can be seen for the share of GDP in manufacturing in the

second panel of Figure 4. The share of GDP in the services sector, however, is positively associated with the index of participation in GVCs.

These correlations are robust to an alternative measure of structural transformation—i.e., employment shares—in the agriculture and service sectors.

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



5.2 Parametric Results

We now come to the crux of our results. We begin by presenting our core results, from the most to least parsimonious specification. Table 2 presents estimation results for a linear regression of Equation (18) without any time-varying covariates (i.e., X_{it}). Panels 1 to 3 respectively have GDP shares in agriculture, manufacturing, and services as their dependent variables. For all panels, columns (1) through (5) show results for the full sample with country fixed effects. Column (1) includes country-specific year fixed effects while column (2) to (5) includes (i) a linear time trend, (ii) a quadratic time trend, (iii) region-specific time trends, and (iii) regional-specific quadratic time trends.

Through panels 1 to 3, or baseline specification results in column (1) contains two primary findings. First, agricultural GVC participation is negatively and significantly associated with GDP share in the agricultural sector. On the other hand, the GVCs participation is positively and significantly associated with the GDP share in the services sector. 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. For the manufacturing sector, there is no

such significant effect, either statistically or economically as the estimate coefficients seem to be true zeros. Secondly, results are robust to the specifications in columns (2) to (5). Our initial estimation results thus imply that participation in agricultural GVCs is associated with a pattern of economic activity being reallocated from agriculture to services, and thus with a leapfrogging of manufacturing.

The results in table 2 suggest that 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
Year FE	Yes	No	No	No	No
Linear time trend	No	Yes	No	No	No
Quadratic trend	No	No	Yes	No	No
Region-specific linear time trend	No	No	No	Yes	No
Regional-specific quadratic time 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
Year FE	Yes	No	No	No	No
Linear time trend	No	Yes	No	No	No
Quadratic trend	No	No	Yes	No	No
Region-specific linear time trend	No	No	No	Yes	No
Regional-specific quadratic time 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
Year FE	Yes	No	No	No	No
Linear time trend	No	Yes	No	No	No
Quadratic trend	No	No	Yes	No	No
Region-specific linear time trend	No	No	No	Yes	No
Regional-specific quadratic time 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

One might argue that the hitherto statistically significant relationship between participation in agricultural GVCs and structural transformation might disappear if we account for trade policies. Whether one country is more or less involved in GVCs is obviously related to its trade policy, such as trade regulations or agreements. To examine whether trade agreements soak up the relationship between participation in agricultural GVCs and structural transformation, Table 3 provides results for a version of Equation (18) that controls for the presence of three types of trade agreements: RTAs, CUs, and FTAs. This is done with dummy variables to account for the presence of any such trade agreements in columns (1) to (3) and with counts of the number each type of trade agreement in columns (4) to (6). Results are robust to accounting for trade agreement.

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				(0.044)	(0.061)	(0.065)	0.035	-0.105	0.073

(CU)				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

We finally assess the robustness of the results in Equation (18) by controlling for a richer set of time-varying covariates in addition to the participation in GVCs in neighboring countries and trade agreements. To alleviate concern about country-specific time-varying covariates, tables (4) to (6) explore whether our estimate of the coefficient of interest is robust 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).[9] The results in Tables (4) to (6) are similar to our previous results, and they strengthen the evidence that participation in agricultural GVCs is associated with a structural transformation of the kind that sees an economy reallocate its activity from the agriculture to the services sector from 1990 to 2013. This runs counter to the usual structural transformation narrative, wherein economies reallocate activity from agriculture to manufacturing first, and then from manufacturing to services.

[9] 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, we conduct additional analyses to further ensure that our results are robust. Here, robustness is explored in three ways: (i) by estimating dynamic models, (ii) by using alternative measures of structural transformation, and (iii) by using an alternative measure of participation in agricultural GVCs. Our results consistently show that participation in agricultural GVCs is negatively associated with the size of the agricultural sector, and positively associated with the size of the service sector.

6.1. Dynamic Models

We first consider a dynamic panel regression. Although the results in tables (4) to (6) address that our baseline specification is robust to different specifications, one might be concerned that the relationship between participation in agricultural GVCs and structural transformation should be estimated in the context of a dynamic model. In the literature of economic growth, 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). Thus, to check whether our results are robust to introducing dynamics in the dependent variable, we estimate the following regression:

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

where y_{it-1} is the dependent variable in the previous year. To avoid the shortcoming of OLS in the presence of the lagged dependent variable, we use the generalized method of moments panel estimator developed by Arellano and Bover (1995) and Blundell and Bond (1997). This dynamic panel estimator offers the following advantages relative to OLS: (i) it eliminates the need for fixed effects and obviates concerns over autocorrelation in the dependent variable by instrumenting the lagged variable, (ii) it is ideal for data sets that have a small T and a large N such as ours (Mileva, 2007), and (iii) it generates consistent and efficient estimates of the effect of participation in GVCs participation on our outcome variables (Carkovic and Levine, 2002).

Estimation results for the dynamic model in Equation (19) are in table 7. These results are qualitatively similar to our earlier results.

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

Variables	Dependent Variable: GDP Shares (%) (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	1.867***	-1.044***	-0.692***
	(0.132)	(0.186)	(0.200)
Terms of Trade (DPAgTOT)	-0.013	-0.056***	-0.038**
GVCs Participation by neighboring countries (%)	(0.011)	(0.016)	(0.016)
	-0.993***	-0.599	-2.308***
GDP (log)	(0.316)	(0.532)	(0.542)
	-0.156***	-0.024	0.011
Land Share for Agriculture (%)	(0.023)	(0.029)	(0.030)
	0.153***	-0.092***	-0.076**
Rural Population (%)	(0.020)	(0.029)	(0.039)
	-0.161*	0.524***	-0.183
Urbanization (urban population growth, %)	(0.090)	(0.124)	(0.117)
	0.115***	0.003	-0.107***
Age Dependency Ratio (%)	(0.018)	(0.023)	(0.024)
	-164.350***	128.965***	148.917***
Constant	(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 of Structural Transformation

As discussed in our empirical strategy section, "structural transformation" can be measured in different ways depending on how one defines it Table A2 shows results for an alternative measure of structural transformation—i.e., employment share in each sector (Timmer, 2008; Herrendorf, Rogerson, Valentinyi, 2013). Tables A2a to A2c show that the relationship between participation in agricultural GVCs and structural transformation is robust to this alternative measure of structural transformation.

Table A3 provides an additional robustness check to ensure that our main result is robust to estimating dynamic models as well as using employment shares instead of GDP shares as dependent variables. Again, results for the agricultural and services sectors are robust, although in this case the employment share of the manufacturing sector is significantly and positively associated with participation in agricultural GVCs. Overall, our core results are robust to alternative measures of structural transformation GVCs. We now turn to alternative measures of participation in agricultural GVCs.

6.3 Alternative Measure of Participation in Agricultural GVCs

Lastly, one might argue that the overall results do not reflect the characteristics of modern agricultural value chains because the treatment variable in this study—that is, participation in agricultural GVCs—is measured using only the agricultural sector, without the food industry. Over last few decades, a supermarket revolution (See Reardon, Timmer, and Minten, 2012) has allowed developing countries to get involved in the multinational production of processed food production, which is closer downstream to the final consumer in value chains. A recent study by Balié et al. (2017) showed that in many developing countries, the extent of participation in food GVCs exceeds the extent of participation in agricultural GVCs.

To explore whether structural transformation is also associated with participation in food GVCs, we show the results in tables A4a to A4c, which use participation in food instead of agricultural GVCs as a treatment variable. These results tell a similar story to the one told by our core results, and participation in food GVCs also seems to suggest a leapfrogging of the manufacturing sector.

7. Extensions

Before concluding, we conduct two additional analyses by comparing developed and developing countries, and by looking at the relationship between upstream of downstream participation in agricultural GVCs on the one hand and structural transformation on the other hand, thereby decomposing GVC participation into two global production channels.

7.1 Developed vs. Developing countries

First, table (8) presents results for developed countries (i.e., OECD countries) and developing countries, which includes countries in (i) Sub-Saharan Africa, (ii) South Asia, (iii) Latin America and the Caribbean, and (iv) Central and Western Asia. The outcome variables are the GDP shares of each sector in columns Column (1) to (6). In Columns (7) to (9), the outcome variable is replaced by employment shares to ensure robustness to an alternative measure of structural transformation. In Columns (1) to (3), the coefficients are estimated using the baseline specification in Equation (18). In Columns (4) to (6), the dynamic specification in Equation (19) is estimated by GMM. In Columns (1)-(9), we use country FEs and year FEs. Finally, Panels 1 to 6 present estimation results estimation for each group, respectively.

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)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Agriculture	**Manufacture**	**Service**	**Agriculture**	**Manufacture**	**Service**	**Agriculture**	**Manufacture**	**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
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

The results in table (8) shows the agricultural GVCs play differently between developed and developing countries. The results in Panel 1 show that OECD economies seem to respond to greater participation in agricultural GVCs by respectively decreasing and increasing their involvement in the manufacturing and services sector. The results in Panel 2, for their part, are a mixed bag: Going by GDP shares, it seems like participation in agricultural GVCs is associated with an increase in both GDP shares of manufacturing and services, but those results are not robust to using employment shares as an alternative measure of the dependent variable.

In table (A8), we use participation in food GVCs instead participation in agricultural GVCs as our treatment variable. What we find in that case is that (i) the relationship between employment share in agriculture and GVCs is positive in developed countries and negative in developing countries, (ii) for the manufacturing, that relationship is negative in developed countries and positive in developing countries, and (iii) for the services sector, the relationship is positive in both developed and developing countries.

7.2 Upstream and Downstream GVCs

Finally, table 9 shows the effects of upstream and downstream participation in agricultural GVCs on sectoral GDP shares. To obtain upstream and downstream participation, we use the in Balié et al. (2017).

The following findings emerge: (i) participation upstream or downstream in agricultural GVCs is associated with a greater share of GDP in agriculture, but this effect is more pronounced for upstream participation, (ii) there does not seem to be a robust pattern between upstream participation in agricultural GVCs and the share of GDP in the manufacturing sector, (iii) the relationship between downstream participation in agricultural GVCs and the share of GDP in the manufacturing sector is positive, but not very robust, (iv) the relationship between upstream participation in agricultural GVCs and the share of GDP in the services sector is negative, and (v) the relationship between downstream participation in agricultural GVCs and the share of GDP in the services sector is positive.

Put differently, upstream participation in agricultural GVCs—economic closer to the farm—is associated with more agriculture and less services, but downstream participation in agricultural GVCs—economic activity further away from the farm and closer to the consumer—is associated with more agriculture, but also more services in an economy.

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. Summary and Concluding Remarks

This paper is the first to investigate the relationship between the extent of a country's participation in agricultural GVCs and the structural transformation of its economy. To do so, we first developed an international trade model to show how the net exports of intermediate inputs can change the structure of the economy in the exporting country. Under an open economy scenario, and allowing the trade of intermediate inputs across two countries and three sectors, we have shown how net exports of intermediate inputs in agricultural GVCs can lead to a reallocation of the exporting countries' economic activities. In our empirical analysis, we have looked at the relationship between agricultural GVC participation on the one hand and the reallocation of economic activities in terms of the share of GDP in the agricultural, manufacturing, and services sectors on the other hand. Using cross0country data that cover 183 countries for the period 1990-2013, our core finding is that modern economies leapfrog the manufacturing sector to reallocate economic activity from their agricultural to their services sector as their participation in agricultural GVCs becomes more extensive. This result is robust, and our results seem driven by developing countries rather than developed countries. This suggests that the usual structural transformation narrative no longer applies to developing countries.

Our findings can help inform agricultural trade policy in two ways. First, policy makers may wish to focus on participation in global agricultural production if they wish to transform their economies by reallocating resources across sectors. In debates about Brexit, the re-design of the North American Free Trade Agreement, and the recent trade war between the US and China, trade policies aimed at protecting domestic agriculture from agricultural imports have featured prominently. This perspective seems to reflect a tacit expectation that GVC linkages alter the conventional calculus of trade protection (Blanchard et al., 2017). Our results suggest that trade liberalization through agricultural GVCs can lead to structural transformation in the way that a country can reallocate its economic resources into non-agricultural sectors, which has been seen as a main driver of economic growth.

Second, although it may be tempting to foster participation in GVCs with an eye toward structural transformation, policy makers should be cautious when trying to open up their agricultural markets. Our 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.

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Appendix

Figure A1a World Map of Agricultural GVC Participation in 2013

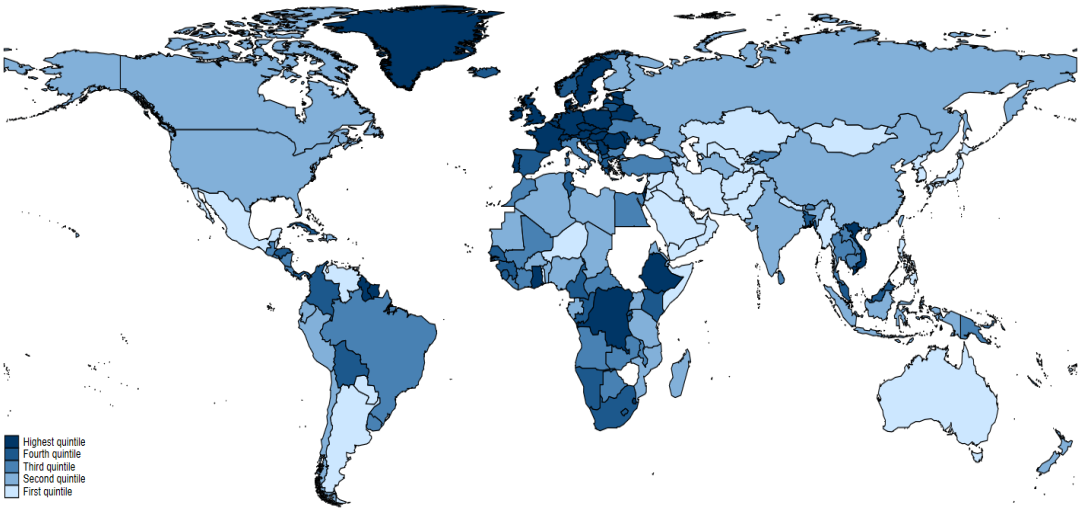

Figure A1b World Map of Food Global Value Chains Participation in 2013

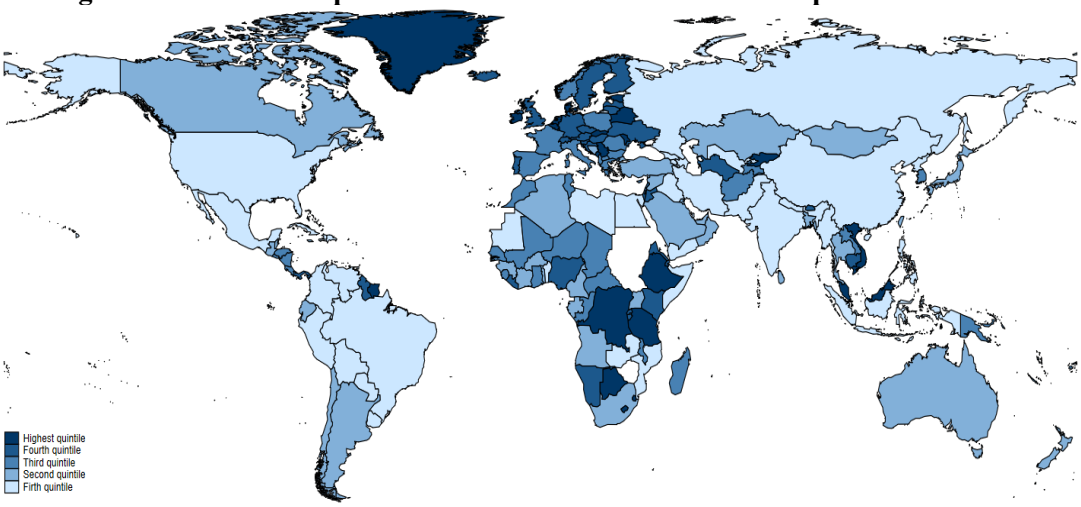

Figure A1c World Map of Food Global Value Chains Growth Rate, between 1990 ─ 2013

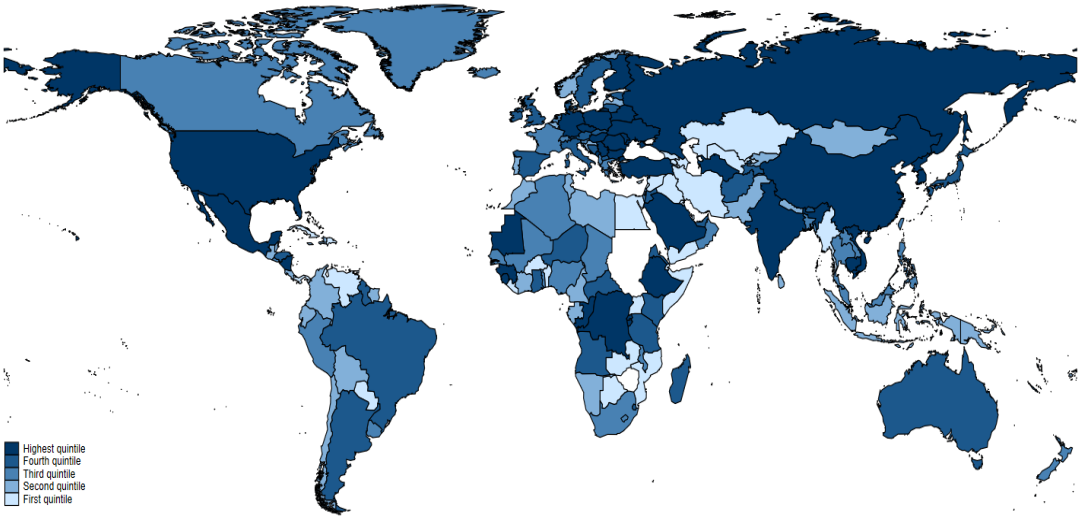

Figure A2. Structural Transformation and Agricultural GVCs, 1990 – 2013

Figure A2a. GDP Shares in Agriculture and Agricultural GVCs Participation

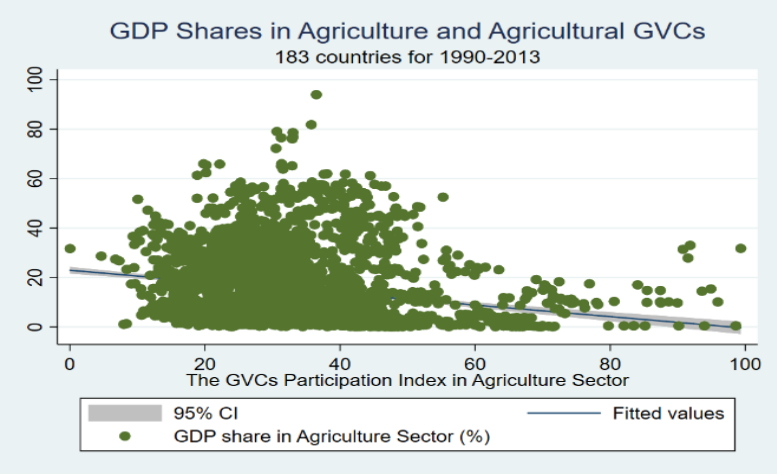

Figure A2b. GDP Shares in Manufacturing and Agricultural GVCs Participation

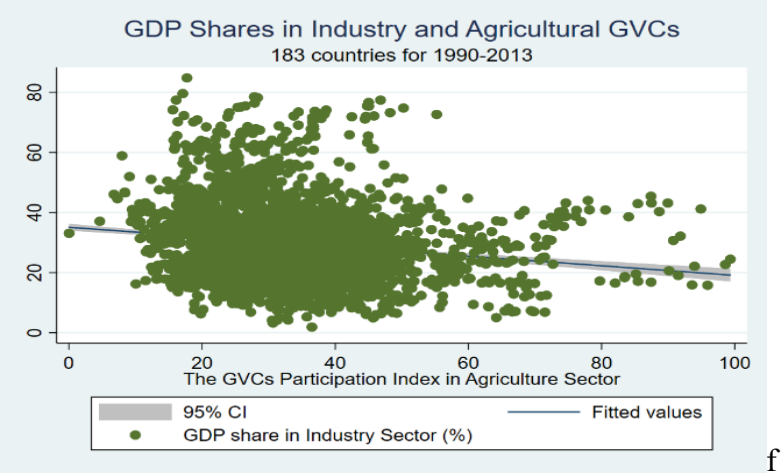

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Figure A2c. GDP Shares in Service and Agricultural GVCs Participation

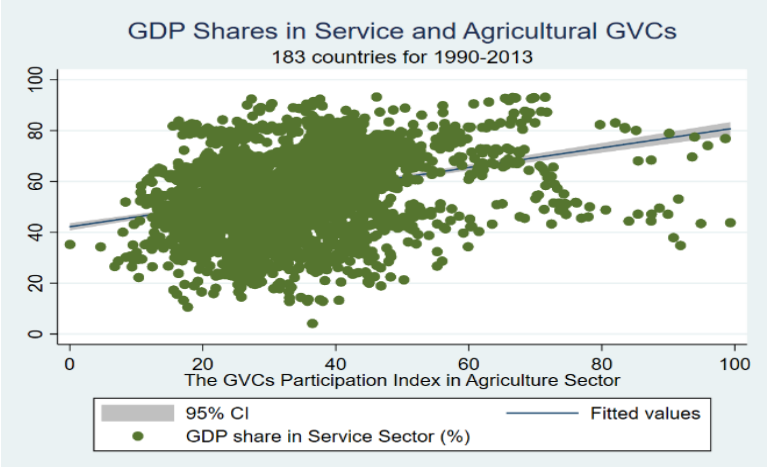
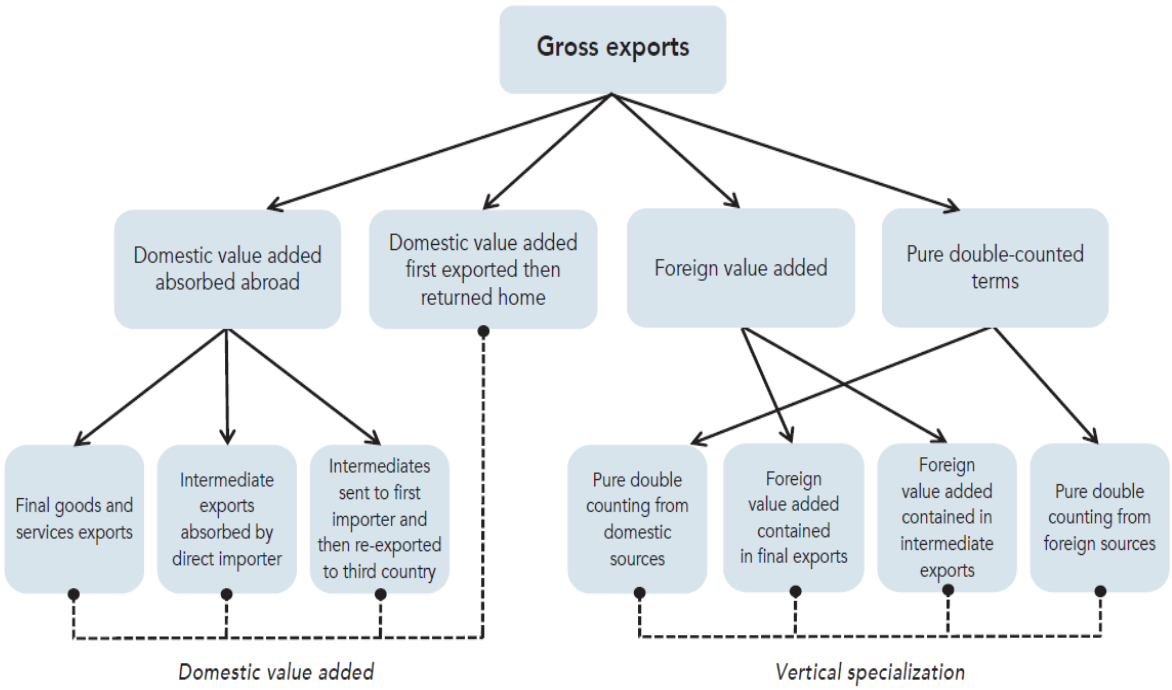


Figure A3. Decomposition of Gross Exports to measure GVCs



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

Figure A4. An Example of 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 OECD countries.

Table A2a. 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 A2b. 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 A2c. 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 A4a. 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 A4b. Robustness Checks: Alternative GVCs (Food Industry)

Manufacture Sector, 1990 -2013

	Dependent Variable: GDP Shares in Manufacture (%)				
Variables	(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 A4c. 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. 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
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. 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
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 A7. 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
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.