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Global Agricultural Value Chains and Structural Transformation

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Selected presentation for the International Agricultural Trade Research Consortium's (IATRC's) 2021 Annual Meeting: Trade and Environmental Policies: Synergies and Rivalries, December 12-14, 2021, San Diego, CA.

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Global Agricultural Value Chains and Structural Transformation

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Introduction

- 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 (GVC)**.
- Since the mid-1900s, agricultural GVCs (hereafter AGVCs) have grown rapidly.
- From the 1950s to the 1980s, agricultural industries went through pre-globalization, shifting from traditional small-scale, informal to larger-scale, formal industries.

- Since Kuznets (1966), **structural transformation** has received a lot of attention in policy debates surrounding economic growth.
- The *conventional structural transformation narrative* is this (Timmer 1988):

*A country starts out primarily agrarian. As the agricultural sector modernizes, labor is freed that is **reallocated from** the agricultural sector **to** the industrial sector. A similar process reallocates labor from the industrial sector **to** the services sector.*

- We study how a country's participation in AGVCs affects the structural transformation of economies.
- In our analysis, we look at whether participation in AGVCs transforms the structure of economies by using data on 155 countries over the period 1991-2015.
- Specifically, we look at whether participation in AGVCs 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 et al. \(2017\)](#) to the EORA multi-region input-output tables.
- We then rely on country and year fixed effects to look at whether AGVC participation is associated with changes in the GDP shares of agriculture, manufacturing, and services.
- To ensure that our results are robust to different measures of structural transformation, we re-estimate everything using sectoral employment shares instead of GDP shares ([Herrendorf et al. 2014](#)).

- We find that increased participation in AGVCs is associated in general with a significant **decrease** in the GDP share of the industrial sector and with a significant **increase** in the GDP share of the services sector.
- In some cases (e.g., increased upstream participation in AGVCs), increased participation in AGVCs is associated with a significant increase in the GDP share of the agricultural sector.
- These findings suggests that modern economies *leapfrog* the industrial sector to directly develop their services sector as a consequence of greater participation in agricultural GVCs—a finding which runs counter to conventional wisdom about the structural transformation.

We then unbundle our results as follows:

- ① By looking separately at agriculture and at the food industry
- ② By breaking up participation in AGVCs in upstream vs. downstream activities
- ③ By exploring treatment heterogeneity by income level

Throughout, our results show that by and large, modern economies appear to transform their economies by both intensifying their agricultural sector and **leapfrogging** the manufacturing sector to directly develop their services sector.

- In the paper, we also conduct a series of **robustness checks** by successively controlling for a country's
 - trade policy
 - domestic agricultural price policy
 - to ensure that our results are not driven by a SUTVA, neighboring countries' average GVC participation.
- We also assess robustness by including
 - a linear time trend
 - country-specific trends
 - dynamic panel regressions estimated by Arellano-Bond GMM.

Our **contribution** threefold:

- ① We provide evidence that trade liberalization via agricultural GVCs transforms the structure of economies.
- ② We look at the relationship between agricultural trade and agricultural value chains.
- ③ We document how modern economies transform their economies by going directly from agriculture to services in response to increased participation in agricultural GVCs.

Outline

- ① Introduction
- ② Data and Descriptive Statistics
- ③ Empirical Framework
- ④ Results and Discussion
- ⑤ Summary and Concluding Remarks

Measuring AGVC Participation

- We use UNCTAD-EORA Multi-Region Input-Output (MRIOs) tables to measure participation in agricultural GVCs following [Koopman et al. \(2010\)](#).

$$AGVC \text{ participation}_{it}^{Total} = \frac{DVX_{it}^{agr} + DVX_{it}^{food} + FVA_{it}^{agr} + FVA_{it}^{food}}{Gross \text{ Export}_{it}^{agr} + Gross \text{ Export}_{it}^{food}} \quad (1)$$

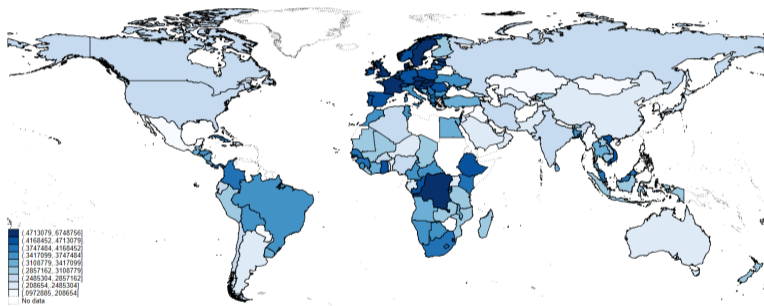
- We use the “agriculture” industry classification to measure ag. GVCs and the “food & beverage” industry classification to measure food GVCs.
- To address different effects of GVC participation by stream, we further measure **upstream** participation, $\frac{FVA_{it}^j}{Gross \text{ Export}_{it}^j}$, and **downstream** participation, $\frac{DVX_{it}^j}{Gross \text{ Export}_{it}^j}$, where $j \in \{agr, food\}$.

Table: Agri-Food GVC Participation (1991-2015, N=155 countries)

	N	Mean	S.D.	Min	Max	p25	Median	p75
Total								
AGVC Part. (%)	3200	31.763	9.912	9.088	85.507	25.015	30.534	37.428
Downstream Part. (FVA, %)	3200	15.671	10.132	.082	76.929	7.959	12.886	21.819
Upstream Part. (DVX, %)	3200	16.091	7.47	3.578	53.649	11.06	14.79	19.894
Agriculture								
AGVC Part. (%)	3200	33.208	10.687	8.506	74.923	25.456	32.526	39.844
Downstream Part. (FVA, %)	3200	10.913	7.51	.078	63.581	5.492	8.755	14.639
Upstream Part. (DVX, %)	3200	22.296	8.303	4.149	67.814	16.602	22.388	27.178
Food Industry								
AGVC participation (%)	3200	30.91	10.273	9.693	87.333	23.474	29.544	36.639
Downstream participation (FVA, %)	3200	19.288	10.508	.133	80.974	11.458	16.827	25.16
Upstream participation (DVX, %)	3200	11.621	5.894	2.394	41.82	7.588	10.465	14.395

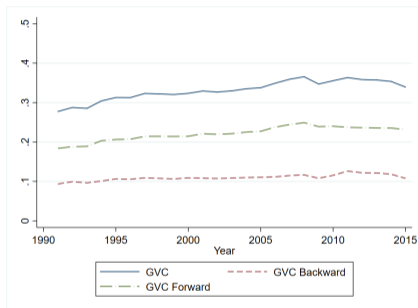
Notes: Data from UNCTAD-Eora Global Value Chain (GVC) database. GVC is measured by a GVC share of a country's gross exports following Koopman et al. (2014). Downstream participation is measured by the foreign value added (FVA). Upstream participation is measured by the domestic value added (DVX). Total is the sum of upstream and downstream participation across both industries

Figure: Agricultural GVC Participation across Countries

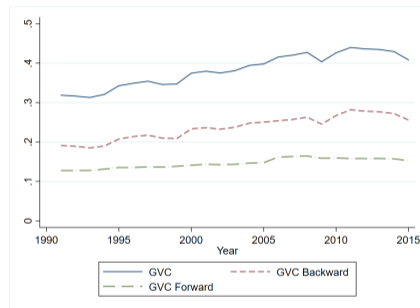


Notes: The figure displays AGVC participation rates in agriculture for 155 countries in 2015. White color areas reports countries without GVC data.

Figure: AGVC Participation Trends in Selected Regions



(a) Africa



(b) Europe

Measuring Structural Transformation

- Following [Timmer et al. \(2009\)](#), 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.
- We use the World Development Indicators (WDI) database in order to measure GDP and employment shares by sector for 155 countries in the period of 1991-2015.

Table: Employment and GDP Share by Sector (N=155 countries)

	Obs.	Employment Share (%)				GDP Share (%)			
		Mean	S.D.	Min	Max	Mean	S.D.	Min	Max
Low Income									
Agriculture sector (%)	1674	64.73	16.93	29.31	92.37	31.92	10.55	14.06	79.04
Manufacturing sector (%)	1674	9.37	5.72	1.86	31.55	20.22	6.75	3.24	45.98
Service sector (%)	1674	25.9	12.96	5.34	62.41	42	8.76	12.44	67.59
Lower-Middle Income									
Agriculture sector (%)	2565	39.92	15.22	8.66	86.82	16.93	8.21	3.76	51.85
Manufacturing sector (%)	2565	18.22	6.25	2.8	38.3	30.28	11.2	14.16	84.8
Service sector (%)	2565	41.86	11.39	10.39	66.5	46.56	9.69	10.57	72.59
Upper-Middle Income									
Agriculture sector (%)	2685	21.3	12.04	.26	59.7	7.89	4.62	1.83	36.41
Manufacturing sector (%)	2685	23.33	6.17	9.44	40.29	31.16	9.78	8.41	66.16
Service sector (%)	2685	55.38	11.18	18.9	78.8	53.24	9.34	21.76	75.41
High Income									
Agriculture sector (%)	2676	5.23	3.92	.18	22.88	2.3	1.45	.05	7.98
Manufacturing sector (%)	2676	25.9	6.73	9.19	54.14	28.11	12.64	6.72	74.81
Service sector (%)	2676	68.87	8.72	43.99	87.91	60.94	10.47	25.25	91.92

Notes: World Bank defines four income categories based on GNI per capita in US\$ at year 2010: low income ($\leq 1,005$); lower middle income (1,006 – 3,975); upper middle income (3,976 – 12,275); high income ($> 12,275$). GDP and employment shares data sourced from the World Development Indicator database.

Empirical Framework

- We analyze whether AGVC participation is associated with structural transformation (i.e., changes in GDP or employment share across sectors).
- Our core equation of interest is such that:

$$y_{it} = \alpha + \beta AGVC_{it} + X_{it}\delta + \gamma_i + \mu_t + \varepsilon_{it} \quad (2)$$

- y_{it} : sector share (%) of agriculture, manufacturing, or services.
 - D_{it} : level of AGVC participation (%)
 - X_{it} : time-varying control variables
 - γ_i : country fixed effects
 - μ_t : year fixed effects
- In some specifications, γ_i is replaced with country-specific trends.

AGVC Participation and Structural Transformation: Total

Dependent variable: GDP or Employment share by sector (%)									
	Agriculture			Industry			Service		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A. GDP share									
AGVC	0.11*** (0.013)	0.039*** (0.014)	0.018** (0.008)	-0.179*** (0.02)	-0.338*** (0.023)	-0.052*** (0.016)	0.003 (0.022)	0.112*** (0.025)	-0.048*** (0.017)
R ²	0.958	0.97	0.987	0.95	0.966	0.976	0.959	0.971	0.981
Panel B. Employment share									
AGVC	0.206*** (0.022)	0.006 (0.016)	-0.006 (0.008)	-0.365*** (0.021)	-0.151*** (0.019)	-0.088*** (0.01)	0.159*** (0.017)	0.144*** (0.019)	0.094*** (0.011)
R ²	0.983	0.995	0.998	0.895	0.95	0.983	0.99	0.993	0.997
Obs.	3200	3200	3200	3200	3200	3200	3200	3200	3200
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes		yes	yes		yes	yes	
Time trends			yes			yes			yes
Controls		yes	yes		yes	yes		yes	yes

Notes: Standard errors clustered at country level in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$. All regression specifications include country fixed effects and year fixed effects. Country-level characteristics include population bins (by age, by gender, rural and urban population ratio), agricultural production conditions (arable land, agricultural land, total land area, food production index, livestock production index, land under cereal production, total cereal production, total fisheries production), and economic characteristics (GDP, GDP growth, inflation GDP deflator, trade proportion (%), exports of goods and services, self-employment totla). Trade policy controls include the number of 5 types of trade agreements and a binary variable for each trade agreement (RTA, CU, FTA, PSA, EIA).

- On average, as a country's participation in AGVCs increases, that country tends to become more agrarian.
- By the same token, however, that country will also tend to become less industrial, and more services-based.
- This points both to a hollowing out of the middle of the economic structure (i.e., the industrial sector).
- More importantly, it points to a leapfrogging by the average economy of the industrial sector to directly develop the services sector.
- This last finding bucks conventional structural transformation narratives.

The next slide offers support for these findings by unbundling AGVCs into agriculture and the food industry.

Agriculture vs. Food Industry

Dependent variable: GDP or Employment share by sector (%)									
	Agriculture			Industry			Service		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>A.1 Agriculture GDP share</i>									
AGVC Part.	0.115*** (0.018)	0.055*** (0.019)	0.011 (0.011)	-0.255*** (0.023)	-0.315*** (0.025)	-0.016 (0.019)	0.046* (0.025)	0.095*** (0.027)	-0.087*** (0.019)
R ²	0.954	0.966	0.987	0.948	0.962	0.975	0.961	0.972	0.982
<i>A.2 Agriculture Employment share</i>									
AGVC Part.	0.164*** (0.027)	0.033* (0.018)	-0.022** (0.01)	-0.402*** (0.025)	-0.198*** (0.02)	-0.065*** (0.011)	0.238*** (0.019)	0.165*** (0.019)	0.087*** (0.012)
R ²	0.984	0.995	0.998	0.886	0.951	0.984	0.992	0.994	0.997
<i>B.1 Food Industry GDP share</i>									
AGVC Part.	0.067*** (0.009)	0.012 (0.01)	0.017** (0.007)	-0.103*** (0.018)	-0.247*** (0.02)	-0.048*** (0.015)	-0.002 (0.019)	0.084*** (0.022)	-0.039** (0.015)
R ²	0.96	0.974	0.986	0.951	0.967	0.977	0.957	0.97	0.981
<i>B.2 Food Industry Employment share</i>									
AGVC Part.	0.16*** (0.018)	-0.006 (0.014)	-0.005 (0.008)	-0.265*** (0.018)	-0.083*** (0.017)	-0.087*** (0.009)	0.105*** (0.015)	0.089*** (0.017)	0.093*** (0.01)
R ²	0.981	0.995	0.998	0.899	0.949	0.982	0.989	0.992	0.996
Obs.	3200	3200	3200	3200	3200	3200	3200	3200	3200
Country FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year FE	yes	yes		yes	yes		yes	yes	
Time trends			yes			yes			yes
Controls		yes	yes		yes	yes		yes	yes

When separating out total AGVC participation in agriculture *per se* and the food industry, we note:

- When looking at GDP shares, AGVC participation via agriculture is associated with declining a declining services sector when accounting for country-specific trends, but the opposite result when looking at employment shares.
- In all cases, increased participation in AGVCs (measured by either GDP shares or employment shares, and looking at either agriculture or the food industry) is associated with a hollowing out of the middle (i.e., industrial) sector of the economy.

Does Positioning in AGVCs Matter on Structural Transformation?

- We can further decompose AGVC participation into upstream participation and downstream participation.
- This allows us to analyze whether the type of GVC participation (or positioning) matters for structural transformation:

$$y_{it} = \alpha + \beta_1 GVC_{it}^{up} + \beta_2 GVC_{it}^{down} + X_{it}\delta + \gamma_i + \mu_t + \varepsilon_{it}, \quad (3)$$

where

- GVC_{it}^{up} is upstream participation, as measured by DVX (%)
- GVC_{it}^{down} is downstream participation, as measured by FVA (%)

Positioning in AGVCs and Structural Transformation

	Dependent variable: Structural Transformation (share by sector)					
	GDP share (%)			Employment share (%)		
	Agr	Ind	Srv	Agr	Ind	Srv
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Total						
Upstream (%)	3.915*** (1.437)	-33.869*** (2.272)	11.63*** (2.526)	1.093 (1.597)	-15.568*** (1.939)	14.464*** (1.89)
Downstream (%)	2.927 (3.361)	-34.649*** (5.313)	30.36*** (5.908)	19.656*** (3.734)	-36.294*** (4.534)	16.629*** (4.42)
R ²	0.97	0.966	0.971	0.995	0.95	0.993
Panel B: Agriculture Industry						
Upstream (%)	6.103*** (2.01)	-33.897*** (2.636)	4.87* (2.878)	-0.041 (1.935)	-14.995*** (2.134)	15.033*** (2.068)
Downstream (%)	3.858 (2.765)	-24.618*** (3.626)	22.425*** (3.959)	12.584*** (2.662)	-33.206*** (2.935)	20.624*** (2.845)
R ²	0.966	0.962	0.972	0.995	0.952	0.994
Panel C: Food Industry						
Upstream (%)	1.784* (1.053)	-25.181*** (2.031)	9.336*** (2.251)	0.567 (1.368)	-9.891*** (1.767)	9.307*** (1.729)
Downstream (%)	10.418*** (3.179)	-31.975*** (6.129)	23.236*** (6.792)	18.767*** (4.128)	-33.959*** (5.332)	15.172*** (5.218)
R ²	0.974	0.967	0.97	0.995	0.95	0.992
Country FE	yes	yes	yes	yes	yes	yes
Year FE	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes

- One thing that immediately jumps out is that both upstream and downstream participation in AGVCs are associated with a leapfrogging of the industrial sector to directly develop the services sector.
- When considering GDP shares as outcomes, upstream participation in AGVCs is associated with a more agrarian economy.
- When considering employment shares as outcomes instead, it is downstream participation in AGVCs that is associated with a more agrarian economy.
- This suggests upstream (downstream) participation leads to more (labor-) capital-intensive agriculture.

Treatment Heterogeneity: Income Level

- We further look at the heterogeneous effects of AGVC participation by income level.
- Following World Bank income categories, four income levels are defined based on GNI per capita in US\$ at year 2010:
 - low income ($\leq 1,005$)
 - lower middle income (1,006 – 3,975)
 - upper middle income (3,976 – 12,275)
 - high income ($> 12,275$).

Treatment Heterogeneity: Income Level

	Dependent variable: Structural Transformation (share by sector)					
	GDP share (%)			Employment share (%)		
	Agr	Ind	Srv	Agr	Ind	Srv
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Low Income countries						
AGVC Participation (%)	15.428 (11.43)	-28.038*** (6.707)	28.357*** (10.065)	-20.004*** (6.147)	10.133*** (3.454)	9.861*** (3.359)
R^2	.829	.873	.753	.976	.958	.986
Panel B: Low-middle Income countries						
AGVC Participation (%)	4.499 (3.558)	-46.479*** (4.106)	16.537*** (4.302)	-7.38** (3.112)	1.62 (1.732)	5.744** (2.523)
R^2	.9	.933	.903	.983	.962	.986
Panel C: Middle-high Income countries						
AGVC Participation (%)	15.446*** (3.693)	-31.863*** (5.522)	-20.097*** (6.231)	17.949*** (4.805)	-28.387*** (3.722)	10.457** (4.319)
R^2	.926	.974	.944	.992	.946	.994
Panel D: High Income countries						
AGVC Participation (%)	5.351*** (.996)	-37.379*** (3.871)	24.74*** (4.066)	8.286*** (1.66)	-33.785*** (3.824)	25.47*** (3.896)
R^2	.949	.964	.969	.974	.968	.978

Notes: All regression specifications include country fixed effects, year fixed effects, and all control variables. Observations: Low=558; Low-middle=855; Middle-high=895; High=892.

- Here, we see that our average findings mask some heterogeneity.
- Our core story appears driven by high-income countries.
- Outside of that high-income category, findings seem to be highly dependent on the type of country considered.
- Low-income and low middle-income countries, in particular, seem to follow the conventional structural transformation narrative when it comes to employment shares.

Summary

- Using trade data on 155 countries for the period 1991-2015, we have looked at the relationship between a country's degree of participation in AGVCs and the structure of that country's economic activity.
- We document a pattern whereby modern economies **leapfrog the industrial sector to directly develop their services sector** in response to increase participation in AGVCs.
- These findings, which are robust to different specifications of our core equations, point to the need for studies exploring the precise within-country mechanisms whereby increased participation in AGVCs is now associated with services rather than industry or manufacturing.

Policy Implications

- First, policymakers may wish to focus on participation in global agricultural production if their goal is to transform their economies by reallocating resources across sectors.
- Second, although it may be tempting for governments to foster participation in GVCs with an eye toward structural transformation, policymakers should be cautious when trying to open up their agricultural markets.

For More Information

- Lim (2021). *Global Agricultural Value Chains and Structural Transformation*. [NBER Book: Risks in Agricultural Supply Chains](#).
- Lim (2021). *Structural transformation in the era of global agricultural value chains*. [VoxEU](#).
- Lim and Kim (2021). *Global Agricultural Value Chains and Employment Growth*. [SSRN](#).