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Abstract

The evolution of agricultural value chains is influenced by numerous societal and economic dynamics, including trade and servicification of the economy. In this paper we analyze margins along agrifood value chains, proxied by the share of the Global Food Dollar accruing to farmers, controlling for differences in GDP and economic development levels. International trade and the increasingly diverse roles played by services in upstream and downstream activities shape the distribution of the value-added generated along the value chains. Trade regimes and services that favour domestic processing of agricultural products increase the farm share.

Keywords: Farm share; agri-food value chains; vertical linkages; structural transformation

JEL code: F14, O13, Q13, Q17, Q18

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1. Introduction

The transformations in the agricultural sector are often due to structural changes of the overall economy that characterize the so called "structural transformation". These changes entail the shift from agricultural to nonagricultural activities and from industries to services (Herrendorf et al., 2014). As the agricultural sector becomes more developed, the agricultural value chains (AVCs) also become more developed (Barrett et al., 2022). Furthermore, as economies develop, consumers demand greater services with food purchases. These transformations of the AVCs have been part of the so called "supermarket revolution" in Latin America, Central and Eastern Europe, and Asia (Rozelle and Swinnen, 2004), and of the "quite revolution" in African and Asian countries (Reardon, 2015). Moreover, as the agricultural sector develops, it becomes less labor intensive, requiring fewer individuals for production (Mellor, 2017). The dynamics of the structural transformation have been widely investigated through the lens of employment, value added, labor productivity, and consumption (*cfr*. Herrendorf et al., 2014 for a review; Barrett et al., 2022 on the agricultural value chain revolution). However, additional money spent on food seem to reward downstream activities (i.e. logistics, packaging, labeling) and not the farmers. For this reason, as alternative to the extant literature, we propose to use market margins, as proxied by the Global Food Dollar (GFD) that decomposes farmer and post farm-gate value-added shares. The evolution of the post-farmgate share of the AVC generally co-evolve with income levels and development status (Yi et al., 2021). Far from being an ideal proxy of structural transformation, the GFD adds a novel perspective to the debate and is likely to open a new strand of research.

Technology adoption is a key element of the transition from traditional to modern agricultural value chains (Swinnen and Kuijpers, 2019; Barrett et al., 2022; Neubauer et al., 2022). Trade and services are also important aspects of the transformation of the AVCs (Barrett et al., 2022). Production, trade distribution and marketing of agrifood products, post-farmgate value addition, and growth in the share of spending on food away from home also increase linkages with services sectors. We study the interconnections that farmers' food bill shares tend to have with the intensity and orientation of trade relationships, as well as the use of services as inputs.

Trade is an important element in the evolution of the AVCs. Barrett et al. (2022) point at very important characteristics of trade vis-à-vis the evolution of AVCs insofar. They argue that agricultural exports via global value chains are relevant for commodities such as cocoa, coffee, rubber, or tea, although they are quite concentrated in few countries[1]. The authors also note that in regions where the AVCs have evolved, the imports have increased as well. These elements point at the close connection between international trade and AVCs. he process of adding post-farmgate value, from the "hidden middle" to final consumer products, draws on a variety of domestic and imported inputs, including from outside the agri-food sector, to generate new products (Cattaneo and Miroudot, 2021; Barrett et al., 2022). Modern agri-food trade occurs at various points in the value chain, starting with primary products (e.g., bulk cereal grains), followed by middle and final processed goods with a range in addition of value from minimal (e.g., dried fruit or milled grain) to specialized higher-value branded products with associated speciality crops (e.g., fruit and vegetables), cheeses, wine, and spirits (Reardon, 2015; Tanrattanaphong et al., 2020).

Trade costs, associated with transport logistics, trade policy and product regulations and standards, are likely to affect the operation of the value chain. They may inhibit participation in GVCs, although this is not observed for agricultural inputs (Balie et al., 2019).

Services (i.e. logistics, information and communication technology (ICT), and financial services) are an important driver of transformation from traditional to modern value chains (Lagakos, 2016), improving the productivity and operational efficiency of the firms (Bloom and Van Reenen, 2010), as well as boosting knowledge capital and export intensity (Lodefalk, 2014). The lack of pre-harvest services is one of the major reasons for poorly functioning value chains in developing countries (Poulton and Macartney, 2012; Ola and Menapace, 2020). The increasing complexity and interconnectedness of agri-food systems is reflected in greater services intensity of production and consumption (Hsieh and Rossi-Hansberg, 2023).

The literature on margins along the AVCs has been more theoretical and model-based (e.g., computable partial or general equilibrium or network-based analysis), or micro-econometric (e.g., quasi-experimental and experimental trials controlling for heterogeneity) (Barrett et al., 2022).

[1] More specifically, Barrett et al. (2002) point at oranges and soy in Brazil, and at bananas and coffee in Colombia, among other emblematic cases.

There has been little comparative cross-country analyses of the transformations that occur during the development of more advanced agrifood systems, reflecting a lack of systematic data and measures on margins along the value chain. We use the *global* food dollar (GFD), a cross-countries indicator of the farmer's share of the final (domestic) food bill[2], to analyse how margins co-evolve with trade and services intensity. The GFD decomposes farmer and post farm-gate value-added shares for a set of 61 countries, representing 90% of global food consumption, The developments of the AVCs lead to declines in the farmer's share of the final food bill. In short, the goal of this paper is to document associations between AVCs, international trade and services,[3] with a view to motivating future research seeking to draw causal inferences regarding the relationships between trade, services, and proxies of structural transformation.

2. The Global Food Dollar

The food dollar approach allocates consumer expenditures across the AVC to different actors. A common metric is the average expenditure share of one U.S. dollar on food by a consumer that accrues to farmers. The remainder is allocated to primary inputs used in production, intermediary activities for value added processing, marketing, and associated costs of food delivery (e.g., transportation). This food dollar approach was first implemented for the U.S. agrifood sector, and subsequent applications have mostly focused on the U.S. context (Canning, 2011). The *global* food dollar (GFD) is an application of the food dollar approach. In its initial iteration, the GFD decomposes farmer and post farm-gate value-added shares for a set of 61 countries representing 90% of global food consumption (Yi et al., 2001).

The establishment of the GFD as an internationally comparable application of the U.S. Department of Agriculture Economic Research Service's food dollar has stimulated new research into international agrifood value chains (Canning, 2011; Canning et al., 2016; Barrett et al., 2022; Yi et al., 2021). The GFD and the more recently developed agri-food environmental economic

[2] We refer to the domestic food bill insofar the current version of the GFD considers only the expenditure on domestic food and does not consider imported and exported food.
[3] As pointed out by a reviewer, another interesting perspective would be to run cross-products analyses. These would provide different insights from those obtained from cross-country analysis. While a promising area of research, to the best of our knowledge this approach is currently unfeasible due to the lack of information.

data system (AgFEEDs) provide the framework and data for our exploration of how trade and services are associated with the evolution of AVCs.

Our analysis does not seek to identify causality. Instead, the aim is to elucidate plausible relationships between characteristics of agrifood value chains, trade, and services. The GFD is our cross-countries proxy for the farmer's share of the food bill. When the AVCs are developing the GFD tends to decline. Admittedly the opposite is not necessarily true. Nevertheless, the GFD informs on a very relevant characteristic of the AVC, the relative wealth (and value addition) that is captured by processors vis-à-vis farmers. Trade and services play an important role in this process. Hence, correlating the GFD with dynamics of international trade dynamics and services use is important to conclude on their role at different stage of the evolution of the AVCs.

We focus on how the distribution of margins and their evolution correlate with international movements and use of goods and services, using regression analysis to investigate associations between variables germane to agricultural value chains, considering both international trade and services. We complement the Ag-FEEDs and GFD data with information on agricultural production, trade flows and costs, and services intensity, integrating an index of agricultural total factor productivity with data on imports and exports. Trade costs are estimates that account for policies, regulations, geographical, cultural, and institutional factors. These costs are provided for both the upstream portion of the agricultural value chains (i.e., agriculture, hunting, forestry, and fishing sectors), and for downstream sectors (i.e., food, beverages, and tobacco). Services intensity is the ratio of services input to total input.

To ensure reproducibility of the analysis, we use publicly available country-specific secondary data from official sources.[4] We start with the principal 4-step data compilation for the Ag-FEEDs[5] and add crops and animal production, as well as productivity measures. We include a disaggregated measure of total value of agricultural output, split into crops and animal products, and a total factor productivity index (TFP) from the ERS international agricultural productivity

[4] The GFD data are also publicly available on the FAOSTAT website as "Value shares by industry and primary factors", under the section "Food Value Chain": https://www.fao.org/faostat/en/#data
[5] The four steps are described in the online GFD data repository: https://github.com/fedscornell/GlobalFoodDollar

(IAP) dataset.[6] Trade data are sourced from FAOSTAT and comprise import and export values for crops and livestock. Trade cost data are obtained from the WTO.[7] Information on services is sourced from the World Input-Output Database (WIOD), from which we calculate the proportion of the input set that are made up of services for both upstream and downstream activities. IAP and FAOSTAT data are merged with Ag-FEEDs by country and year and span the period 2005-2015.

The dataset includes three measures of food expenditure by consumers (*m*): (i) Food at Home (FAH), (ii) Food and Tobacco at Home (FTAH), and (iii) Food and Accommodation Away from Home (FAAFH). These food expenditure measures account for different portions of consumer agrifood expenditures. FAH refers to domestic expenditures of personal consumption for food consumed at home; FTAH adds tobacco expenditure to FAH; and FAAFH are domestic expenditures related to personal consumption of food away from home (e.g., restaurants).[8] All three measures are valued at purchaser prices. Farmer share of the GFD for nominal food expenditures for food at home (FAH) is about 0.27, with notable differences across income groups (Figure 1): FAH is about 0.24 for high income countries and 0.29 for upper middle-income countries (Table 1). Food and tobacco at home (FTAH) is about 0.23, with higher values for upper middle income (0.32) compared to high income countries (0.21). Similarly, the farmer shares of food away from home (FAAFH) is about 0.07, on average, with the lowest value by group for high income countries (0.04) and higher values (0.17) for lower middle-income countries. In short, higher GDP per capita is associated with lower farm share of consumer agrifood expenditure in cross-country comparisons.

The livestock industry is less relevant to our analysis as the country-level value of crops is larger than the value of animal products.[9] Analogously, trade in agricultural products (both export and import values) is larger than trade in live animals. Trade costs are greater in the upstream portion

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[6] Output data included in Ag-FEEDs and IAP are both derived from the United Nations Food and Agriculture Organization (FAOSTAT). While data have been appended, we have not investigated the role that the level of production may have on farmer shares as it is beyond the scope of our study to address the endogeneity issues that are likely to be associated with the inclusion of both trade and production data.

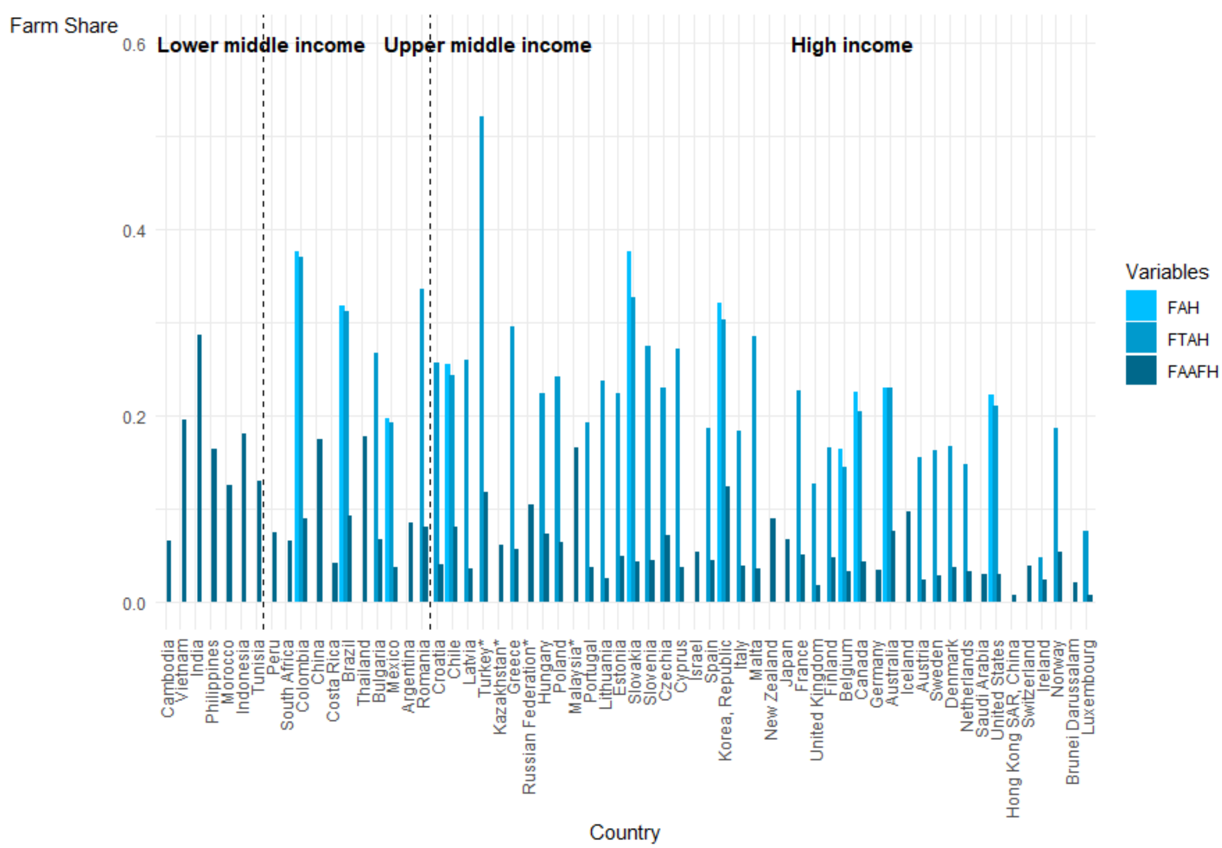
[7] We use the WTO trade cost index to capture international trade costs associated with a variety of factors such as, policies and regulations, geography, culture, or institutions. These are decomposed into bilateral variation in trade costs in each sector for five main components: transport and travel cost, information and transaction cost, ICT connectedness, trade policy and regulatory differences, and governance quality (additional details on the WTO trade index are included in the appendix).

[8] FAAFH includes expenditures for accommodations as this cannot be separated from food expenditures in the original data.

[9] The descriptive statistics are presented in the appendix.

of the value chain, possibly reflecting the heavier regulatory regimes influencing trade in raw produce. Services intensities are proportional to the level of economic development. Services intensities are larger for the upstream sector and differences in service intensities between the upstream and the downstream sector are inversely related to a country's level of economic development. Notably, a high level of economic development is associated with export orientation and servicification, i.e., an increasing share of services value-addition in manufacturing exports.

Figure 1: FAH, FTAH and FAAFH across sample countries (ordered by GDP per capita)



Countries are ordered by GDP per capita at PPP in 2015. The asterisk (*) indicates countries that are Upper middle (rather than High) income, according to the World Bank classification.

3. Empirical evidence

We investigate the association between farm share, trade and services. Farm share represents the proportion of consumer food expenditures that compensate on-farm activities (i.e., farm production, non-agricultural on-farm inputs, and agribusiness) versus the remainder that goes to the “downstream” activities of the agrifood value chain (e.g., processing, packaging, and marketing).

Our set of regressors includes the value of crops and animal products. Moreover, it includes the index of the Total Factor Productivity. These variables control for the magnitude of the agricultural sector and its productivity. As previously discussed, when the agricultural sector becomes more developed and more productive, the AVCs evolve. This is likely to be reflected in our proxy of the farmer’s share of the food bill.

We include the value of total imports and the total exports both of agricultural produce and live animals. These variables capture correlations between trade dynamics and the evolution of the AVCs. We expect imports to be positively correlated with the GFD and exports to be inversely correlated[10]. High values of the GFD are associated with less developed AVCs. Those are the value chains in needs of more imports of raw products while developing the processing industry. On the contrary, low values of the GFD are associated with more developed AVCs. The more developed value chains have relatively lower volumes of exports of raw products as compared to the exports of processed, high value added, downstream products.

We include the downstream and upstream import and export costs are included as indexes[11]. The larger the indexes, the higher the trade costs. We expect a positive correlation between the trade costs and the GFD. When economies and AVCs become more developed, the GFD tends to decline. Also, when economies and AVCs become more developed, the integration with international markets tends to be higher and the trade costs to be lower. Hence, higher value of the GFD is associated with higher international trade costs.

[10] To explain why we expect opposite signs for imports and exports of agricultural products, we introduce a simple conceptual framework. Assume for simplicity that the AVCs evolutions is a two stages process. In the first stage the processing industry is limited, so it is international trade. When countries and AVCs become more developed the imports of agricultural products is lower insofar the processing industry absorbs the domestic production of raw products to process them in downstream goods. This explains a positive association between imports and the farmer’s share of the food bill (i.e. the GFD). On the other hand, when countries and AVCs become more developed, the export capacity of the country increases as well and so it does its exports of agricultural products. This simple framework is admittedly one of the plausible explanations and points at the need to deepen into these dynamics.

[11] The trade costs have been derived from import and export costs indices and trade costs elasticity, as defined in the Appendix.

We regress the farm share of country *i* in year *t*, for each measure *m* (FAH, FTAH, and FAAFH)[12] on the logarithm of real GDP per capita and an index of agricultural total factor productivity (Ag. TFP):

$$Farm\_share_{i,t,m} = \beta_i + \beta_t + \beta_1 \ln(pc\ GDP) + \beta_2 AgTFP + \beta_3 GFD_{i,t,m} + \varepsilon_{i,t,m}$$

We include the three measures (*m*) for GFD[13] and follow Yi at al. (2021) by assuming that the difference across measures is constant over time, across countries, and with respect to the other regressors. We control for country and time fixed effects, respectively β_i and β_t, to account for unobserved heterogeneity across countries and years[14]. We run five specifications[15]: I) no fixed effects, no time trend; II) country fixed effects only (no year fixed effects nor time trend); III) time trend only (no fixed effects); IV) country and year fixed effects (no time trend); and, V) country fixed effects and time trend (no year fixed effects).

Results, reported in the appendix, are consistent with Yi et al. (2021), with a minimal modification to their analysis in the form of substituting yield as the measure of agricultural productivity for TFP. FTAH and FAH are similar in value (the difference is not statistically significant), while FAAFH differs from FAH by nineteen percentage points. This could be due to greater expenditure on food at restaurants under FAAFH, accounting for a large share of total consumer expenditures in AVCs.

[12]We include the 3 measures of the GFD to exploit the informative content of the indicator. The measures are indicative of the food shares for countries at different stages of development. They enter in our model as continuous variables and the dummies account for mean level differences. As in Yi et al. (2021), the individual observations are weighted by the inverse of the number of total observations by measure per county to account for sample size heterogeneity across countries. Moreover, we cluster standard errors at the country level.

[13] Using three measures is important to exploit the informative content of several methods to compute the GFD and should lead to more efficient estimates.

[14] Our dependent variable, proxying the share of food expenditures rewarding farmers, is associated with the dynamics of the structural transformation. Several proxies of the structural transformation show a r time trend. For instance, the contribution of the agricultural sector to the GDP and the share of workers employed in agriculture decline over time. Failure to control for the time trend may result in biased estimates due to the omission of an explanatory regressor.

[15] As astutely pointed by a reviewer, it may have been interesting diving into regional similarities to explore common dynamics of the AVCs evolution in Africa, Asia, or Latin America, in lieu of the big impacts originated by the "supermarket revolution" (*cfr.* Reardon et al., 2003; Rozelle and Swinnen, 2004; Reardon, 2015). Nonetheless, exploring geographical differences is beyond the scope of this paper and deserves deep investigations. This is left for future research.

We find no statistically significant relationship between the farm share of the GFD and productivity.[16] The farm share of domestic consumer food expenditures falls with GDP per capita. The addition of country fixed effects, to account for unobserved country-level heterogeneity, lowers the coefficients that are no longer statistically significant.[17]

Next, we include weighting and income alternatives into the pooled regressions. For brevity we report results in the appendix. The alternative to the weighting used in Yi et al. (2021) is to run the model without weights assigned to *m*, allowing Shapley decomposition of the regressors' explanatory power (reported in square brackets). For income, an indicator of development status is used instead of a continuous measure of GDP per capita. This is done to proxy the stage of AVC structural transformation, as described in Barrett et al. (2022), with low- and middle-income (LM), upper- middle- (UM), and high-income countries representing traditional, transitional, and modern AVCs, respectively. The Shapley decomposition of the pooled regressions is used to assess the extent to which economic development is associated with different farm share values.[18] GDP per capita explains about 19.9 percent of the entire variability of the model. Similarly, the dummies for lower-middle income and for the upper-middle income explain, respectively, 16.3 and 3.4 of the total variability.[19] The farm share time trend decreases in magnitude and is no longer statistically significant when income dummies are used instead of the continuous measure of GDP per capita. Assuming income categorization is a suitable proxy for country-level AVC transformation, this could help to explain the reduced significance of the time trend on the farm share of GFD.

Next, we estimate regressions that incorporate variables on trade exposure and costs, and services usage using the selected pooled model. While these models cannot be interpreted in a causal

[16] As suggested by a reviewer, this result could mean that TFP is not a factor in the final food share. For instance, the use of drought resistant varieties has affected TFP but does not imply that farmers should be getting a higher share of the supply chain. Indeed, the share may be smaller if final product prices remain constant and higher output puts downward pressure on prices.

[17] Contrarily to Yi et al. (2021) who found that the farmer share of the GFD is not correlated with the productivity of agricultural land, a differently built index (i.e., the ratio output of crops over the inputs), proxying for the productivity of the upstream sector, is positively associated with farm share of the GFD. These results, which are not the key focus of our analysis, are omitted for brevity.

[18] The Shapley decomposition has valuable properties, such as not being affected by variables that have zero contribution to the goodness of fit and, for correlated regressors, being affected by variables that help to explain the goodness of fit in sub-models.

[19] Results are robust to bootstrapping (up to 2000 iterations) and provides, for the GDP, 95 percent lower and upper bounds respectively equal to 15.2 and 25.7 percent.

framework, statistically significant estimates shed light on characteristics associated, either positively or inversely, with the farm share of the GFD.[20] The findings are useful in informing future research to deepen the analysis of the role of trade and services in AVCs and seek out plausible identification strategies.

3.1 Trade and margins along the value chain

Although the farm share does not account for foreign expenditures (e.g., revenues from exports), the literature on structural transformation has established many of the implications for openness to trade on AVC development and evolution (Cattaneo et al., 2013; Barrett et al., 2022). We run a series of regressions (Table 1) that include trade flows (i.e., export and import values of agricultural products and live animals) and costs (i.e., export and import trade costs associated with policies, regulations, geographical, cultural, and institutional factors). We retain the control variables used in the base pooled specification (i.e., GDP, time trend, and indicators, *m*) in the trade estimations.

Coefficient estimates for each of these control variables are observed to be consistent in sign, magnitude, and statistical significance with prior base regressions. Inclusion of trade variables in the pooled regression model reveals that trade matters to agrifood value chains (AVC). The relationship reflects the role of trade and associated policies (standards) in the structural transformation of AVCs. Processing and capacity to add value across agrifood systems generates demand for raw materials from the global market, as well as demand for a suite of services associated with import and domestic production requirements. Agricultural exports are inversely related to the farm share of the GFD. In other terms, increases in exports of agricultural products tend to shrink the farm share of the GFD. Plausibly, the larger the value of exports, the lower the (relative) margins of the farmers. In developed economies large productions correlates with higher productivity and advances technology, which is relatively more rewarding for the downstream sector.

The statistical relationships hold when controlling for time trend, GDP, indicators *m*, import volume, and trade costs. We use import costs (ICI_1) and export costs indexes (ECI_1) for

[20] These results do not rule out the possibility of underlying causal relationships, but such assessment requires additional data and methods that are outside the scope of this study. Arguably, this would be best achieved in specific instances (e.g., at the country-level), where richer data and observable exogenous shocks can be exploited to identify causal relationships.

agriculture, hunting, forestry, and fishing sectors, and the same indexes for food, beverages, and tobacco sectors (ICI_3 and ECI_1). Farmers in countries with greater agricultural exports receive a smaller proportion of the value of domestic agri-food sectoral activity, i.e., export values are inversely correlated with the share of food expenditure that remunerates upstream activities. As this is a relative (i.e., proportional) measure, farmers are not necessarily worse off, since the total return to farms from export activities also depends upon the magnitude and composition of exports.

The relative size of a country's economy places downward pressure on farm shares but on average farms in wealthier countries receive higher returns (see Appendix). Export composition is an important consideration as well, since this could imply that a greater share of the large exporters' value chain is allocated to downstream activities (i.e., value addition) through processing of domestic or imported raw materials, requiring sufficient capital, labor, and services inputs. Taken together this could reflect a later stage structural transformation more commonly occurring in countries that have greater values of agri-food exports.

Imports of agricultural products and live animals are observed to be increasing with the farm share of the GFD. Using the same set of controls, coefficient estimates are statistically significant. Larger volumes of agricultural goods are imported by countries where farmers' margins are larger, i.e., importing more raw products is associated with farms receiving a larger share of domestic expenditures on food.[21] Higher imports signal that the domestic price is higher than the international price. Higher prices of raw commodities may easily explain the relatively higher farmer's share of the food bill, a characteristics of less advanced value chains (e.g., traditional and transitional of lower income economies).

Taken together, overall trade activity, including both imports and exports, appear to feed into (value-adding) processing of primary goods and various services inputs, and ultimately, result in (higher-value) food reaching consumers domestically and abroad as exports. International trade is a key element for the transformation of the AVCs. For instance, measures devoted to facilitating exports of raw products, by improving access to foreign markets and increasing the export capacity though investments in infrastructures (e.g. bigger ports, larger cargoes, etc.) would facilitate the transition from traditional to more advanced AVCs.

[21] As mentioned previously, we cannot assess the direction of causality.

Table 1. Farm share of global food dollar and trade

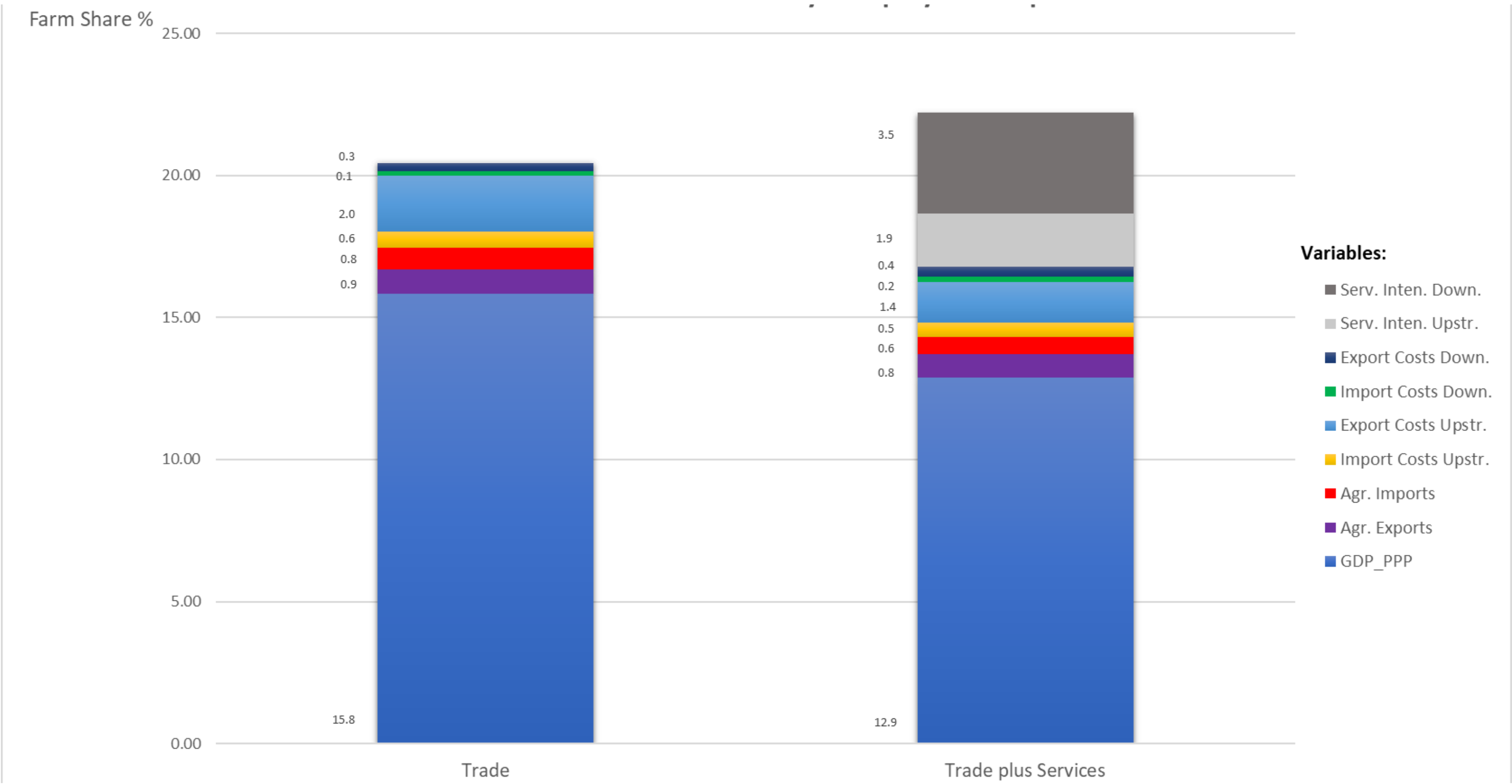
	I[a]	I[b]	II[a]	II[b]
GDP_PPP (log)	-0.0614***	-0.0710***	-0.0861***	-0.0986***
	(0.0039)	(0.0043)	(0.0052)	(0.0044)
	[20.2060]		[15.8213]	
Agr. Exports(log)	-0.0017***	-0.0017***	-0.0074***	-0.0084***
	(0.0015)	(0.0017)	(0.0028)	(0.0031)
	[1.4581]		[0.8770]	
Agr. Imports(log)	0.0072***	0.0108***	0.0156***	0.0190***
	(0.0019)	(0.0020)	(0.0019)	(0.0017)
	[0.9164]		[0.7687]	
ICI_1 (Agr. Sec.)			0.0016	0.0032
			(0.0035)	(0.0043)
			[0.5537]	
ECI_1 (Agr. Sec.)			0.0125***	0.0116***
			(0.0044)	(0.0044)
			[1.9718]	
ICI_3 (Food&Tob. Sec.)			-0.0016	-0.0048**
			(0.0023)	(0.0024)
			[0.1498]	
ECI_3 (Food&Tob. Sec.)			-0.0079***	-0.0055
			(0.0028)	(0.0031)
			[0.3074]	
Year	0.0010***	0.0018***	0.0004	0.0008**
	(0.0004)	(0.0005)	(0.0004)	(0.0005)
	[1.5895]		[1.6301]	
Type of estimate (baseline = FAH)				
FTAH (dummy)	-0.0296***	0.0000***	-0.0268***	-0.0205***
	(0.0091)	(.)	(0.0090)	(0.0097)
	[26.9089]		[27.7282]	
FAAFH (dummy)	-0.1969***	-0.0214***	-0.2021***	-0.2042***
	(0.0085)	(0.0096)	(0.0086)	(0.0088)
	[48.9212]		[50.1920]	
Constant	0.7937***	-0.0214***	0.9909***	1.0786***
	(0.0427)	(0.0096)	(0.1007)	(0.1053)
N. of Observations	892	892	656	656
R-squared	0.7663	0.735	0.8534	0.8616

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. a Regression models without weights, but with Shapley decomposition in square brackets. b Regression models with individual observations weighted by the inverse of the number of total observations. Sample spans 61 countries.

Trade costs may influence the upstream and downstream segments of AVCs. Indeed, we find that the import cost indexes are not correlated with the farm share of the GFD. On the other hand, farm share of the GFD has a statistically significant relationship with the export cost indexes. The correlation is positive for upstream costs, suggesting that higher transaction costs result in larger rewards for raw inputs at the farm-gate. High export costs of downstream products decrease the farm share. These results suggest that higher export costs of raw products, coupled with low export costs for processed goods, benefit farmers, likely due to the more strategic position of domestic production would have within the domestic value chain if imported inputs were restricted. How much trade costs matter vis-à-vis the level of economic development and trade intensity can be assessed using the Shapley decomposition (Table 1 and Figure 2). GDP per capita matters the most (about 15.8 percent), while trade flows account for about 1.6 percent. Trade costs explain nearly 3 percent of global variability. The results suggest that lowering export costs may shrink margins for raw input vendors, and facilitating access to international markets may be associated with lower margins for suppliers of the exported goods. Taken together, the results on trade costs point at the benefit associated with efforts devoted to lower export costs of processed goods, while favouring the domestic use of agricultural products. Lowering trade barriers is key for developing more advanced AVCs[22].

[22] As pointed by Barrett et al. (2022), the AVCs of developing economies evolve in response to changes in economic policy such as the reduction of trade barriers.

Figure 2: Shapley decomposition for Trade and Trade plus Services models



The contribution of each variable to the R^2 of the models presented in Table 1 (trade) and Table 2 (trade and services) are reported on the left edge of each bar.

3.2 Services and farm share

Structural transformation of value chains is closely associated with growth in services activities. Using input-output data sourced from WIOD, we compute services input intensities, defined as the proportion of total expenditure on inputs that is accounted for by different types of services, for both sectors that are upstream and those that are downstream in AVCs. We include services such as electricity, transport, telecommunications, information and financial services, i.e., the major services sectors for which data are reported in WIOD.

We find differences in the association between upstream and downstream services and farm share of the GFD (Table 2). For upstream service intensities ('Service Intensity U'), the share of services in total inputs used to produce upstream goods, the estimates suggest no relationship. The services intensity in downstream sectors ('Service Intensity D'), defined as share of services in all inputs used to produce downstream goods, is negatively associated with farm share. Thus, the greater the intensity of use of services in downstream activities (e.g. marketing, packaging, labelling of the final produce) the smaller the margins captured by farms. Plausibly, the servicification process of the post-farm gate activities and the subsequent addition of value to final products, tends to remunerate processors and retailers relatively more than the farms that provide the primary produce and are not involved in the downstream segments of the value chain. Overall, the level of services intensity explains nearly 5.3 percent of the total variation, as compared to 12.9 percent for GDP per capita, and 3.8 percent for trade (flows and costs) variables.

Investigating the relationship between services and AVC margins further, we find that the World Bank Logistics Performance Index (LPI) is positively correlated with farm share of the GFD (cfr. appendix Table B). The composite LPI index includes six variables: i) the efficiency of customs and border management clearance; ii) the quality of trade and transport infrastructure; iii) the ease of arranging competitively priced shipments; iv) the quality of logistics services; v) the ability at country level to track and trace consignments; and, vi) the frequency with which shipments reach consignees within scheduled delivery times. The LPI is positively associated with farm share (explaining 1.5% of the variability, driven by the infrastructure score, which is the only component that is significantly correlated with the farm share). *Ceteris paribus*, the better the quality of logistics, trade and transport infrastructure the higher the share of food expenditures accruing to farm-gate activities.

Taken together, the results on services point at their relevance for the evolution of the AVCs and suggest directions for policy interventions. Improving logistics, trade and transport infrastructure is relevant for the downstream sectors, whereas enhancing services provision to the agrifood sector could increase the relative returns in the upstream segments of AVCs.

Table 2. GFD farmer share of the global food dollar and services

	I[a]	I[b]	II[a]	II[b]
GDP_PPP (log)	-0.0748***	-0.0853***	-0.0795***	-0.0932***
	(0.0050)	(0.0049)	(0.0058)	(0.0055)
	[14.9472]		[12.8838]	
Service Intensity U	0.0112	0.0831***	0.0089	0.0503
	(0.0283)	(0.0222)	(0.0315)	(0.0311)
	[1.7540]		[1.8809]	
Service Intensity D	-0.2868***	-0.3532***	-0.2079***	-0.2069***
	(0.0365)	(0.0480)	(0.0425)	(0.0477)
	[4.2497]		[3.5331]	
Agr. Exports(log)			-0.0041	-0.0063**
			(0.0029)	(0.0030)
			[0.8304]	
Agr. Imports(log)			0.0117***	0.0156***
			(0.0019)	(0.0017)
			[0.5819]	
ICI _1 (Agr. Sec.)			0.0049	0.0045
			(0.0039)	(0.0046)
			[0.5128]	
ECI_1 (Agr. Sec.)			0.0141***	0.0108**
			(0.0046)	(0.0043)
			[1.4278]	
ICI_3 (Food&Tob. Sec.)			-0.0023	-0.0040
			(0.0024)	(0.0027)
			[0.1926]	
ECI_3(Food&Tob. Sec).			-0.0090***	-0.0049*
			(0.0029)	(0.0029)
			[0.3544]	
Year	0.0015***	0.0026***	0.0008*	0.0011**
	(0.0004)	(0.0005)	(0.0005)	(0.0005)
	[1.7771]		[1.6700]	
Type of estimate (baseline = FAH)				
FTAH (dummy)	-0.0310***	-0.0253***	-0.0266***	-0.0196*
	(0.0095)	(0.0100)	(0.0096)	(0.0103)
	[28.1536]		[27.9653]	
FAAFH (dummy)	-0.1994***	-0.1978***	-0.2005***	-0.2031***
	(0.0092)	(0.0092)	(0.0093)	(0.0097)
	[49.1184]		[48.1671]	
Constant	1.0559***	1.1566***	0.9447***	1.0545***
	(0.0530)	(0.0495)	(0.1053)	(0.1067)
N. of Observations	654	654	639	639
R-squared	0.8454	0.8468	0.859	0.8687

Note: U: upstream; D: downstream. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. a Regression models without weights, but with Shapley decomposition in square brackets. b Regression models with individual observations weighted by the inverse of the number of total observations. The sample spans 61 countries.

Concluding remarks and policy reflections

Following the seminal study on the Global Food Dollar (GFD) by Yi et al. (2021) our analysis reaffirms that the farm share of GFD is inversely associated with per capita GDP. We extend and decompose this finding by examining results conditional on the income level of countries, which serves as a proxy for the stylized categories of agrifood value chains (AVC) described by Barrett et al. (2022), i.e., traditional, transitional, and modern. The farm share of the GFD is relative to the size of the gross 'agrifood' domestic product. Therefore, the size of the agrifood economy, as well as the expansion and outgrowth of the value chain can offer greater prospective returns to growers despite a reduction in their share of the (larger) sectoral economy.

The farm share of the GFD is not correlated with agricultural productivity but is associated with trade and services intensity of upstream and downstream activities along the value chain. Imports are positively associated with the farm share, while a negative relationship is found for exports. Put differently, net importer countries of upstream products have higher farm margin levels. Moreover, the margins are relatively higher when trade is relatively more costly for raw products than for processed goods. Increases in service intensity may enhance AVC transformation through different channels, such as more intensive value chain participation (Manghnani et al., 2021), technology adoption (e.g. Swinnen and Kuijpers, 2019) and consolidation of midstream segments of AVCs (e.g. Reardon, 2015). We find that the farm share is negatively associated with the intensity of services used in downstream activities.

The absence of a significant association between agricultural productivity and the evolution and cross-country differences in the farm share of the GFD suggests that increases in productivity may be captured by other segments in the AVC, not the farm's. Alternatively, productivity may not be a defining factor for the allocation of margins along the value chain. Structural transformation forces and movement of productive resources out of agriculture could place downward pressure on upstream (farm) productivity, especially in cases where technological progress is insufficient to make up for the losses (Suri and Udry,2022; Udry, 2024). More generally, our findings suggest a focus on trade and trade costs may have greater prospects for improving margins for farms. Farmers benefit from relatively higher export costs at the upstream level, and lower export costs for downstream produce. Put differently, when it is relatively cheaper to process than trade raw products, and to export rather than import processed goods, the farm share of consumer food expenditures is higher.

From a policy perspective, balancing support for services activities at the upstream and downstream level could lead to greater returns to farmers that participate in AVCs. For example, improving logistics for downstream sectors, without supporting trade in processed products could shrink margins received by farms and exacerbate the mismatch in distribution of returns along the AVCs. In other terms, lowering export costs in processed products could increase the margins received by farms, whereas the opposite is true for policies devoted to shrink the export costs of agricultural products.

A greater focus on enhancing services provision to the agrifood sector could also increase the relative returns to AVC actors, e.g., interventions devoted to logistics infrastructure could serve to benefit stakeholders in the upstream segments of AVCs. More specific policy implications call for research on the exact dynamics and mechanisms associated with trade, services, and structural transformation of AVCs. Future research should further examine the role of international trade costs, and the implications of the servicification of food supply chains for domestic and trade markets for the distribution of returns along the value chains.

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Appendix

Table A - FAH, FTAH and FAAFH by country

Country	FAH	FTAH	FAAFH		FAH	FTAH	FAAFH
Argentina			0.085	Korea, Republic	0.320	0.303	0.124
Australia	0.229	0.229	0.076	Latvia		0.260	0.035
Austria		0.155	0.023	Lithuania		0.237	0.025
Belgium	0.164	0.144	0.033	Luxembourg		0.076	0.008
Brazil	0.317	0.312	0.092	Malaysia			0.166
Brunei Darussalam			0.020	Malta		0.285	0.035
Bulgaria		0.267	0.067	Mexico	0.197	0.193	0.037
Cambodia			0.066	Morocco			0.125
Canada	0.225	0.205	0.043	Netherlands		0.148	0.032
Chile	0.255	0.243	0.080	New Zealand			0.090
China			0.175	Norway		0.187	0.053
Colombia	0.376	0.370	0.089	Peru			0.075
Costa Rica			0.042	Philippines			0.164
Croatia		0.257	0.040	Poland		0.241	0.064
Cyprus		0.272	0.037	Portugal		0.192	0.037
Czechia		0.230	0.071	Romania		0.336	0.080
Denmark		0.167	0.037	Russian Federation			0.105
Estonia		0.224	0.049	Saudi Arabia			0.029
Finland		0.166	0.047	Singapore			0.000
France		0.227	0.050	Slovakia	0.376	0.326	0.043
Germany			0.034	Slovenia		0.275	0.045
Greece		0.296	0.057	South Africa			0.066
Hong Kong SAR, China			0.008	Spain		0.187	0.044
Hungary		0.224	0.073	Sweden		0.162	0.028
Iceland			0.097	Switzerland			0.038
India			0.287	Taiwan			0.033
Indonesia			0.181	Thailand			0.178
Ireland		0.047	0.024	Tunisia			0.130
Israel			0.053	Turkey		0.520	0.117
Italy		0.184	0.038	United Kingdom		0.126	0.018
Japan			0.067	United States	0.222	0.211	0.029
Kazakhstan			0.061	Vietnam			0.196

Table B. Income groups and farmer share of GFD for FAH, FTAH and FAAFH

	FAH	FTAH	FAAFH
High income	0.247	0.208	0.045
Upper middle income	0.293	0.326	0.098
Lower middle income			0.171

Source: AgFEEDs data (Yi et al. 2021).

Table C. Descriptive statistics

Variable	Unit	Obs. (n)	Mean	Mean: Income group		
		Full sample		High	Upper Middle	Lower Middle
Output: crops	mln USD	888	3.20	1.69	6.73	6.53
Output: animal products	mln USD	888	1.98	1.47	3.69	2.00
Ag. TFP (2015=100)	Index	888	94.7	95.4	94.8	89.7
Export of agricultural products	mln USD	910	1.93	2.06	1.82	1.16
Import of agricultural products	mln USD	910	2.62	2.06	1.72	0.79
Export of live animals	mln USD	909	0.52	0.38	0.18	0.01
Import of live animals	mln USD	908	0.57	0.37	0.15	0.10
Trade cost index upstream	Index	471	3.65	3.67	3.56	3.68
Import cost index upstream	Index	471	3.72	3.80	3.48	3.07
Export cost index upstream	Index	471	3.57	3.51	3.67	4.36
Trade cost index downstream	Index	471	3.41	3.42	3.48	3.00
Export cost index downstream	Index	471	3.42	3.49	3.26	2.63
Import cost index downstream	Index	471	3.45	3.39	3.76	3.48

Source: Authors'elaborations from FAO, USDA, WTO.

Table D. Share of services in upstream and downstream sectors, by income group

	Upstream	Downstream	Overall
High income	0.147	0.145	0.322
Upper middle income	0.119	0.101	0.261
Lower middle income	0.109	0.086	0.196

Source: WIOD database.

Note: Services include the following set of variables: Electricity, gas, steam and air conditioning supply; Land transport and transport via pipelines; Warehousing and support activities for transportation; Telecommunications; Computer programming, consultancy and related activities; information service activities; Financial service activities, except insurance and pension funding; Insurance, reinsurance and pension funding, except compulsory social security; Advertising and market research; Other professional, scientific and technical activities; veterinary activities; Administrative and support service activities.

Table E. GFD farm share estimates of consumer food expenditures

	I	II	III[a]	IV	V
			Farm share of global food dollar (GFD)		
GDP_PPP (log)	-0.0675***	-0.0183	-0.0673***	-0.0201	-0.0189
Ag. TFP	0.0008	0.0001	0.0004	0.0001	0.0001
Type of estimate (baseline = FAH					
Ftah (dummy)	-0.0293	-0.0140	-0.0321**	-0.0144	-0.0140
Faafh (dummy)	-0.1970***	-0.1926***	-0.1974***	-0.1926***	-0.1926***
Constant	0.8740***	0.4535**	0.9001***	0.4727*	0.4596**
Country Fixed Effects	NO	YES	NO	YES	YES
Year Fixed Effects	NO	NO	NO	YES	NO
Time Trend	NO	NO	YES	NO	YES
R-squared	0.690	0.948	0.699	0.948	0.948

Note: 873 observations. *** p<0.01, ** p<0.05, * p<0.1. [a] Specification III is not reported in Yi et al. (2021); the sample includes 64 countries: Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Chinese Taipei, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Korea Rep., Latvia, Lithuania, Luxembourg, Malaysia, Malta. Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, and Vietnam.

Table F. Sensitivity of GFD farm share estimates to indicator weighting and income

	Farm share of global food dollar (GFD)			
	I[a]	I[b]	II[a]	II[b]
GDP_PPP (log)	-0.0573***	-0.0671***		
	(0.0036)	(0.0042)		
	[19.9362]			
Type of estimate (baseline = High-Income)				
Income LM (dummy)			0.1254***	0.1427***
			(0.0077)	(0.0083)
			[16.2995]	
Income UM (dummy)			0.0482***	0.0515***
			(0.0040)	(0.0056)
			[3.4212]	
Year	0.0013***	0.0029***	0.0004	0.0008
	(0.0005)	(0.0006)	(0.0005)	(0.0006)
	[1.8012]		[1.4970]	
Type of estimate (baseline = FAH)				
FTAH (dummy)	-0.0342***	-0.0328***	-0.0265***	-0.0234**
	(0.0087)	(0.0088)	(0.0100)	(0.0112)
	[27.5660]		[27.9099]	
FAAFH (dummy)	-0.2012***	-0.1985***	-0.2009***	-0.2011***
	[0.0081]	[0.0080]	[0.0093]	[0.0092]
	[50.6966]		[50.8725]	
Constant	0.8418***	0.9316***	0.2434***	0.2397***
	[0.0395]	[0.0440]	[0.0096]	[0.0103]
N. of Observations	895	895	910	910
R-squared	0.7563	0.7073	0.7538	0.7054

Note: LM: lower middle; UM: upper middle. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. a Regression models without weights, but with Shapley decomposition in square brackets. b Regression models with individual observations weighted by the inverse of the number of total observations. The sample includes 61 countries: Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Chinese Taipei, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Israel, Italy, Japan, Kazakhstan, Korea Rep., Latvia, Lithuania, Malaysia, Malta. Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, United Kingdom, United States, Vietnam).

Table G – GFD farm shares and services (details)

	I[a]	I[b]	II[a]	II[b]
Farm share of global food dollar (GFD)				
GDP_PPP (log)	-0.0841***	-0.0893***	-0.0866***	-0.0917***
	(0.0115)	(0.0120)	(0.0119)	(0.0121)
	[9.5046]		[8.5026]	
Service Intensity A	-0.0636	-0.0112	-0.0638	-0.0177
	(0.0463)	(0.0406)	(0.0471)	(0.0410)
	[1.5267]		[1.2268]	
Service Intensity C	-0.2896***	-0.2994***	-0.2893***	-0.2939***
	(0.0552)	(0.0579)	(0.0553)	(0.0571)
	[3.9343]		[3.6638]	
LPI Score	0.0242**	0.0314***		
	(0.0094)	(0.0089)		
	[1.4910]			
Customs Score			-0.0186	-0.0093
			(0.0123)	(0.0130)
			[1.2402]	
Infrastructure Score			0.0413***	0.0360**
			(0.0150)	(0.0140)
			[0.7413]	
International Shipments			0.0094	0.0015
			(0.0123)	(0.0124)
			[0.3727]	
Logistics Score			0.0085	0.0170
			(0.0211)	(0.0215)
			[0.4508]	
Tracking-tracing Score			-0.0174	-0.0167
			(0.0144)	(0.0141)
			[0.4142]	
Timeliness Score			-0.0051	-0.0054
			(0.0100)	(0.0103)
			[0.2265]	
Year	0.0002	0.0001	-0.0001	-0.0002
	(0.0009)	(0.0009)	(0.0009)	(0.0009)
	[0.5679]		[0.6321]	
Type of estimate (baseline = FAH)				
FTAH (dummy)	-0.0379***	-0.0384***	-0.0335***	-0.0340***
	(0.0093)	(0.0098)	(0.0095)	(0.0104)
	[29.6718]		[29.6537]	
FAAFH (dummy)	-0.2060***	-0.2045***	-0.2035***	-0.2024***
	(0.0085)	(0.0089)	(0.0086)	(0.0093)
	[53.3038]		[52.8752]	
Constant	1.0932***	-0.2045***	1.1420***	1.1718***
	(0.0955)	(0.0089)	(0.1138)	(0.1155)
N. of Observations	237	237	237	237
R-squared	0.8721	0.8563	0.8773	0.8621

Note: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. a Regression models without weights, but with Shapley decomposition in square brackets. b Regression models with individual observations weighted by the inverse of the number of total observations. The sample includes 60 countries.

Methodological appendix (online)

Processing of the Global Food Dollar Dataset (*farm share, WB, FAO.xlsx*)

This appendix describes the procedure to expand the current GFD database, building on the four steps described in the Yi et al. (2021) and in the online repository (https://github.com/fedscornell/GlobalFoodDollar)

We describe the procedure to include information on agricultural production and productivity (step 5), imports and exports (step 6), and trade costs (step 7).

Step 5

Data addition: *Crops and livestock products, 2022 ed. (FAOSTAT_Imports_Exports_AP_LA.xls)*

- Variables: imports and exports value of agricultural products, imports and exports value of live animals.
- Countries: 64 Countries (Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Chinese Taipei, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Korea Rep., Latvia, Lithuania, Luxembourg, Malaysia, Malta. Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam).
- Unit: 1000 US$
- Time frame: 1961-2018
- Draw date: 27/04/2022
- Source: https://www.fao.org/faostat/en/#data/TCL

Step 6

Data addition: *WTO data, Trade cost index (1_TCI_economy_sector.xlsx)*

- Variables: trade, import and export cost index.
- Countries: 42 Countries (Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta. Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Spain, Sweden, Turkey, United Kingdom, United States).
- Time frame: 2000-2018
- Draw date: 29/06/2022
- Source: http://tradecosts.wto.org/

Data description:

Determinants of trade costs

Many different factors affect the ease of international trade. Some of them are related to policies and regulations, others are driven by geography, culture or institutions. In what follows, has been decomposed the bilateral variation in trade costs in each sector into five main components: transport and travel cost, information and transaction cost, information and communication technology (ICT) connectedness, trade policy and regulatory differences, and governance quality.

Transport and travel costs are captured by geographical distance, being landlocked and the quality of transport infrastructure. Information and transaction costs are determined by common history, culture or language; all these factors proxy for path-dependent social and political factors that facilitate exchange. ICT connectedness is captured by broadband and mobile coverage. It affects trade costs by facilitating communication and search for foreign partners and products. In that way it plays a similar role to common language, but unlike language it is policy actionable. Trade policy and regulatory differences are captured by applied tariffs, non-tariff measures, international economic integration through regional trade agreements and deeper agreements such as the European Union or the Eurozone. They also include the level and heterogeneity of services trade restrictiveness. Finally, measures of governance quality capture the impact of formal institutions on transaction costs of doing business with a foreign partner.

For each sector and year, has been estimated a constrained gravity model proposed by Egger et al.(2021), from which we obtain the coefficients on directional country-pair dummies ($\widehat{d_{ij}}$). The basis for all applications is the estimated trade openness index $\widehat{d_{ij}}$ at the exporter-importer-sector-year level. It reflects all factors that increase sales to foreign partners relative to domestic sales.

- import cost index: $\widehat{d_{ij}}$averaged over all exporters and weighted by the estimated exporter fixed effects from the gravity model;
- export cost index: $\widehat{d_{ij}}$ averaged over all importers and weighted by the estimated importer fixed effects from the gravity model.
- trade cost index: $\sqrt{\widehat{d_{ij}} * \widehat{d_{ji}}}$ averaged over all importers and weighted by the geometric average of importer and exporter fixed effects.

To obtain trade costs (TCi) have been transform these indices using a sectoral trade costs elasticity (θ):

$$TC_i = (Trade\ index_i)^{-1/\theta}$$

The parameter θ is estimated according to the methodology introduced in Egger et al. (2021). A higher θ means a higher responsiveness of trade to trade frictions.

Reference

Egger, P., Larch, M., Nigai, S. and Yotov, Y. [ELNY] (2021). Trade Costs in the Global Economy: Measurement, Aggregation and Decomposition. ERSD Staff Working Paper no. ESRD-2021-2. World Trade Organization.

Step 7

Data addition: *USDA data, International Agricultural Productivity (AGTFPInternational2019.xlsx)*

- Variables: output of crop, output of animal, agricultural total factor productivity index, inputs, cropland, machinery, fertilizer, pasture, livestock, feed, land, labor, capital, materials, irrig

- Countries: 62 Countries (Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Chinese Taipei, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, Luxembourg, Malaysia, Malta. Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam).
- Unit: $1000 at constant 2015 global average farmgate price.
- Time frame: 1961-2020
- Draw date: 15/07/2022
- Source: https://www.ers.usda.gov/data-products/international-agricultural-productivity/

Data description:

- output_crop: Gross value of 162 crop commodities, $1000 at constant 2015 global average farmgate price;
- output_animal: Gross value of 30 animal and insect products, $1000 at constant 2015 global average farmgate price;
- agr_total_factor_productivity: Ratio of total output index to total input index, 2015=100;
- inputs: Index of Agricultural Inputs (Land, Labor, Capital, and Materials), 2015=100;
- land: Quality-adjusted agricultural area, 1000 hectares of rainfed-equivalent cropland;
- cropland: Total cropland (including arable land and land in permanent crops), 1000 hectares;
- irrig: Total area equipped for irrigation, 1000 hectares;
- pasture: Total area in permanent pasture, 1000 hectares;
- labor: Number of economically active adults (male & female) primarily employed in agriculture, 1000 persons;
- capital: Value of net capital stock, $1000 at constant 2015 prices;
- livestock: Farm inventories of livestock and poultry, measured in 1000s of Standard Livestock Units;
- machinery: Farm inventories of farm machinery, measured in thousands of metric horsepower (1000 CV) in tractors, combine-threshers, and milking machines;
- materials: Index of crop and animal intermediate inputs, 2015=100;
- fertilizer: Total N, P2O5, K2O nutrients from inorganic fertilizers and N from organic fertilizers applied to soils, in 1000 metric tons;
- feed: Total metabolizable energy from animal feeds, M Cal.

Step 8

Generate:

- net_exp_agricultural_products= exp_agricultural_products - imp_agricultural_products
- gen net_exp_live_animals= exp_live_animals - imp_live_animals
- gen domestic_agricultural_products = (output_crop + imp_agricultural_products) - exp_agricultural_products
- gen domestic_live_animals = (output_animal + imp_live_animals) - exp_live_animals

Step 9

Data addition: *World Bank data (GDP per capita (PPP).xls)*

- Variables: income group (High/Low/Lower middle/Upper middle).
- Countries: 63 Countries (Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, Luxembourg, Malaysia, Malta. Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam).
- Draw date: 18/01/2023
- Source: https://data.worldbank.org/

Step 10

Data addition: *National Input-output tables (NIOT) (NIOTS.zip)*

- Variables: A01_D35, A01_H49, A01_H52, A01_J61, A01_J62_J63, A01_K64, A01_K65, A01_M73, A01_M74_M75, A01_N, C10C12_D35, C10C12_H49, C10C12_H52, C10C12_J61, C10C12_J62_J63, C10C12_K64, C10C12_K65, C10C12_M73, C10C12_M74_M75, C10C12_N.
  A01_ = Crop and animal production, hunting and related service activities.
  C10C12_ = Manufacture of food products, beverages and tobacco products.
- Countries: 43 Countries (Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Chinese Taipei, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, India, Indonesia, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Spain, Switzerland, Turkey, United Kingdom, United States).
- Unit: Values are denoted in millions of US dollars (MUSD).
- Draw date: 23/01/2023
- Source: https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release

Data description:

- A01_D35: Electricity, gas, steam and air conditioning supply, MUSD;
- A01_H49: Land transport and transport via pipelines, MUSD;
- A01_H52: Warehousing and support activities for transportation, MUSD;
- A01_J61: Telecommunications, MUSD;
- A01_J62_J63: Computer programming, consultancy and related activities; information service activities, MUSD;
- A01_K64: Financial service activities, except insurance and pension funding, MUSD;
- A01_K65: Insurance, reinsurance and pension funding, except compulsory social security, MUSD;
- A01_M73: Advertising and market research, MUSD;

- A01_M74_M75: Other professional, scientific and technical activities; veterinary activities, MUSD;
- A01_N: Administrative and support service activities, MUSD;
- C10C12_D35: Electricity, gas, steam and air conditioning supply, MUSD;
- C10C12_H49: Land transport and transport via pipelineS, MUSD;
- C10C12_H52: Warehousing and support activities for transportation, MUSD;
- C10C12_J61: Telecommunications, MUSD ;
- C10C12_J62_J63: Computer programming, consultancy and related activities; information service activities, MUSD;
- var C10C12_K64: Financial service activities, except insurance and pension funding, MUSD;
- C10C12_K65: Insurance, reinsurance and pension funding, except compulsory social security, MUSD;
- C10C12_M73: Advertising and market research, MUSD;
- C10C12_M74_M75: Other professional, scientific and technical activities; veterinary activities, MUSD;
- C10C12_N: Administrative and support service activities, MUSD.

Step 11

Data addition: *National Input-output tables (NIOT) (NIOTS.zip)*

- Variables: A01_total, C10C12_total.
  A01_ = Crop and animal production, hunting and related service activities.
  C10C12_ = Manufacture of food products, beverages and tobacco products.
- Countries: 43 Countries (Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Chinese Taipei, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, India, Indonesia, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Spain, Switzerland, Turkey, United Kingdom, United States).
- Unit: Values are denoted in millions of US dollars (MUSD).
- Draw date: 23/01/2023
- Source: https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release

Data description:

- A01_total: sum of variable A01 of all sectors;
- C10C12_total: sum of variable C10C12 of all sectors.

Step 12

Data addition: *Logistics Performance Index (LPI)*

- Variables: LPIRank, LPIScore, CustomsRank, CustomsScore, InfrastructureRank, InfrastructureScore, InternationalshipmentsRank, InternationalshipmentsScore, LogisticscompetenceRank, LogisticscompetenceScore, TrackingtracingRank, TrackingtracingScore, TimelinessRank, TimelinessScore.
- Countries: 63 Counties (Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia,

Ireland, Israel, Italy, Japan, Kazakhstan, Korea Republic, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Taiwan, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam).

- Unit: Score variables can take values from 1 (very low) to 5 (very high).
- Time frame: 2007, 2010, 2012, and 2014.
- Draw date: 22/05/2023
- Source: https://lpi.worldbank.org/international

Data description:

- LPI Score: summary indicator of logistics sector performance.
- Customs Score: measures the efficiency of customs and border management clearance.
- Infrastructure Score: looks at the quality of trade and transport infrastructure.
- International Shipments Score: verifies the ease of arranging competitively priced shipments.
- Logistics Competence Score: checks for the quality of logistics services.
- Tracking & Tracing Score: considers the ability to track and trace consignments.
- Timeliness Score: quantifies the frequency with which shipments reach consignees within scheduled or expected delivery times.

Step 13

Data addition: *World Bank data*

- Variables: Tot_Imports, Tot_Exports, Perc_Imports, Perc_Exports, Merch_Imports, Merch_Exports, Agr_Imports, Agr_Exports, IV_Imp, IV_Exp.
- Countries: 63 Counties (Argentina, Australia, Austria, Belgium, Brazil, Brunei Darussalam, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong SAR China, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kazakhstan, Korea Republic, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Morocco, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, Tunisia, Turkey, United Kingdom, United States, Vietnam).
- Unit: Value at current US dollars but Tot_Imports_CUSD, Tot_Exports_CUSD, Agr_Imports_CUSD, Agr_Exports_CUSD, IV_Imp, IV_Exp that are denoted at constant 2010 US dollars.
- Time frame: 2005-2015.
- Draw date: 30/05/2023
- Source: https://data.worldbank.org/indicator/NE.EXP.GNFS.CD

Data description:

- Tot_Imports: represents the value of goods and services received from the rest of the world in current US dollars.
- Tot_Exports: measures the value of goods and services provided to the rest of the world in current US dollars.

- Perc_Imports: considers the percentage of agricultural raw materials imports of merchandise imports.
- Perc_Exports: quantifies the percentage of agricultural raw materials exports of merchandise exports.
- Merch_Imports: shows the value of goods received from the rest of the world at current US dollars.
- Merch_Exports: shows the value of goods provided to the rest of the world at current US dollars.

Generate:

- Agr_Imports: is the result of the multiplication of Perc_Imports and Merch_Imports.
- Agr_Exports: calculated as the multiplication of Perc_Exports and Merch_Exports.
- IV_Imp: instrumental variable for agricultural imports given by the difference between Tot_Imports and Agr_Imports.
- IV_Exp: instrumental variable for agricultural exports obtained as the difference of Tot_Exports and Agr_Exports.

Step 14

Data addition: *National Input-output tables (NIOT) (NIOTS.zip)*

- Variables: Numerator, Total, IV_Serv.
- Countries: 40 Counties (Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Italy, Japan, Korea Rep., Latvia, Lithuania, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States).
- Unit: Values are denoted in millions of US dollars (MUSD).
- Time frame: 2000-2014.
- Draw date: 06/06/2023
- Source: https://www.rug.nl/ggdc/valuechain/wiod/wiod-2016-release

Data description:

- Numerator: is the sum for all sectors of the following services: D35, H49, H52, J61, J62_J63, K64, K65, M73, M74_M75, N.
- Total: is the sum for all sectors of all services.
- IV_Serv: given by the ratio between Numerator and Total.