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Understanding the Determinants of Participation in Agri-Food Global Value Chains

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ABSTRACT

This paper investigates the determinants of participation in agri-food global value chains (GVCs), with a specific focus on forward and backward linkages across countries at different stages of economic development. The objective of the study is to identify the most important policy and market-related factors that drive or hinder agri-food GVC participation. Using panel data from 2014 to 2023 and a fixed-effects econometric model, the study analyses how factors such as trade openness, regional integration, foreign direct investment (FDI), and institutional quality influence GVC participation. The results show that trade openness is a key driver of GVC integration across all country groups, while Eurozone membership significantly enhances forward participation. FDI plays a mixed role, promoting GVC participation in low- and middle-income countries but having less impact in high-income economies with more developed domestic industries. The study also highlights that backward GVC participation is primarily driven by market size and trade facilitation, while forward participation depends on strong institutions and advanced logistics systems. The findings suggest that policymakers should prioritize reducing trade barriers, improving infrastructure, and attracting FDI to enhance GVC integration, particularly for developing countries. The study contributes to the literature by providing a sector-specific analysis of agri-food GVCs and offers insights into how countries can better integrate into global supply chains to achieve economic growth and development.

Keywords: trade; sustainability; value chains; participation; agri-food trade; development

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INTRODUCTION

Since WWII, the role of GVCs has been continuously increasing as the main driver of global production and trade patterns. According to Antràs [1], a GVC "consists of a series of stages involved in producing a product or

service that is sold to consumers, with each stage adding value, and with at least two stages being produced in different countries. A firm participates in a GVC if it produces at least one stage in a GVC". Based on Borin and Mancini's [2] definition, there are two types of trade flows: direct trade, where a product (or service) crosses only one border, and GVC trade, where a product crosses at least two national borders. With the continuous rise of globalization, and thanks to the development and growth of information and transportation technologies, at least until 2008, GVCs led to increasing specialization and vertical integration in the global economy, thereby connecting different parts of the world. The activities and value creation of more and more organizations are linked to two or more countries. The unbundling of tasks and business activities, as well as functions, has provided new opportunities for developing countries and also developed ones to continuously increase their participation in global production and trade flows without having to develop completely new products or value chains [3].

GVC participation plays a crucial role in economic development as the ability of countries to prosper significantly depends on their level of participation in the global economy [4,5]. Participating in global trade and GVC contributes to economic development, which could increase local employment, local incomes, and food security [6–8]. Even small countries with limited resources can benefit from global trade through GVC participation, with significant variation across countries and sectors. As is evident from the majority of the literature in the field [5], GVC participation represents a perfect opportunity for supporting the commercialization and productivity of local agri-food markets, thereby increasing local incomes as well as stability and food security. It is also evident that agricultural sectors participate in value chains predominantly as suppliers of raw materials, whereas food sectors participate mainly in terms of sourcing inputs from global markets [9].

At the same time, many low-income countries have faced serious challenges integrating into these GVCs for a number of reasons, including low educated human capital, poor infrastructure, weak capital endowment, versatile political and business climates, and poor institutions [10–12]. After the economic and financial crises in 2008 and 2009, globalization began to slow down, and the world entered an era of 'slowbalisation.' In line with this, GVC production length (the average number of production stages between primary inputs and final products) also decreased, indicating fewer border crossings. This tendency is fully in line with the rise of protectionism, the substitution of domestically produced intermediate inputs for imported ones in major emerging economies like China, together with the upgrading of their industries, and the deepening domestic division of labor in developed economies like the United States [1,13], not to mention the effects and consequences of trade disputes (e.g., between the USA and China), the COVID-19 pandemic, and the Russo-Ukrainian war. GVCs are adapting to these recent shocks and

events while trying to remain flexible and resilient. For local, regional, and global policymakers, the question is, therefore, what the key determinants of developing countries' GVC participation are and how targeted policies can help foster better integration.

As to a sectoral breakdown, manufacturing and the electricity, gas and water sectors were most involved in cross-country value-added trade in the last decades, however, backdrops are the highest here as well. Agriculture had the lowest GVC participation rates recently, but this sector seems to have remained the most resilient after several economic shocks [14]. Clarifying which factors actually drive participation—overall, backward, and forward—is therefore a timely empirical task for governments and firms shaping trade, investment, and logistics reforms.

Despite a vast GVC literature, three gaps remain for agri-food. First, most evidence is either manufacturing-focused or economy-wide, overlooking agri-food specificities (perishability, standards and certification, SPS/TBT compliance, services intensity). Second, determinants of participation are rarely disaggregated into backward vs. forward linkages, even though policies plausibly affect these margins differently. Third, heterogeneity by development level is under-explored, yet policy elasticities likely differ across low/average/high performers. Recent multi-regional input–output releases now permit a current, sector-specific assessment over the last decade.

Therefore, this article aims to identify the most critical determinants of the successful integration of countries into agri-food GVCs. In doing so, it contributes to the literature in three ways. First, it focuses primarily on the agri-food sector, unlike the majority of the literature, which overlooks important sectoral differences, and it analyses a comprehensive and timely dataset. Second, by differentiating between forward and backward GVC participation, the article offers a more nuanced understanding of how countries engage with global supply chains. Third, the article contributes to the debate on whether GVCs only benefit developed countries or can be an engine of economic development in low and middle-income countries.

Guided by recent GVC scholarship, we have the following research questions: RQ1: Does greater trade openness associate with higher agri-food GVC participation? RQ2: Is regional integration (Eurozone membership) associated with stronger forward participation? RQ3: Does inward FDI raise participation more in low-/middle-income economies than in high-income ones? RQ4: Are the drivers of backward participation (market size, trade facilitation) distinct from those of forward participation (institutional quality, logistics performance)?

The paper is structured as follows. The next section provides a review of the literature, followed by a description of the methodology, including the dataset and econometric models that were applied. The next section provides the results, while the last section discusses and concludes with policy and managerial implications.

LITERATURE REVIEW

We are now living in the era of 'trade in tasks' because production is fragmented and divided into activities and tasks that are carried out in multiple countries. Before this, in the era of 'trade in goods,' most production and value chains existed within a single country [15,16]. In this new era, we can distinguish 'value added' flows from the traditionally measured 'gross' trade flows. According to the literature, there are two views regarding GVC participation. According to the first, GVC participation only and exclusively benefits developed countries, while developing countries have few opportunities. Developed countries are able to outsource activities and processes associated with lower added value and, thanks to this, are better able to concentrate and specialize in activities and processes with greater added value [15,17] to minimize total production costs and allocate resources. Of course, 'offshoring' activity in a developed country can also lead to job losses, but according to Jones and Kierzkowski [18], in a somewhat paradoxical manner, this may also result in wage increases. This also means that for developing countries, GVC participation, in most cases, only involves the exploitation of natural resources (e.g., agricultural land or raw materials) and cheap labor [19].

However, according to the second view, participation in GVCs offers developing countries more opportunities. Developing countries can participate or become integrated into GVCs without having to build them themselves, for which they would need knowledge and resources that often do not exist [20,21]. GVC participation can contribute to the development of a country and economy (e.g., more modern production or manufacturing) thanks to technological [22,23] and knowledge [24,25] transfers, which increase competitive advantage. Furthermore, it can increase competition in exports and imports between companies in the domestic market, which improves the capabilities, efficiency, and productivity of local firms [26–29].

The literature identifies several factors that determine GVC participation but measuring them is not an easy task. The emergence of GVCs has also challenged the conventional use and interpretation of trade statistics and associated methods of measurement [13,15]. Traditional trade measures record trade flows of goods and services on a gross basis, suggesting that trade in intermediate inputs is calculated each and every time the former crosses the border for further processing, resulting in double-counting. This traditional way of thinking can lead to serious misinterpretations of the contribution of countries to global trade flows. As a solution, the concept of trade in value-added has been elaborated, whereby gross exports are broken down according to the origin and destination of the value added by country and by industry, implying better tracking of global trade flows across borders. At the broadest level of disaggregation, countries participate in GVCs by engaging in backward and/or forward linkages. Backward (or upstream) participation refers to the share of foreign value added embedded in a country's total gross

exports, while forward (or downstream) participation means the share of domestically produced value-added embedded in a country's exports, which is further re-exported by the destination country [15].

One of the main drivers of GVC participation is FDI [20,30–32]. FDI may contribute to the development of capital markets, the expansion of job opportunities (associated with higher salaries), and access to technologies, know-how, and knowledge [33,34]. Beugelsdijk, Pedersen [31] concluded that GVC specialization and participation are driven by exports within multinational enterprises and foreign affiliates in terms of trade in intermediates.

It is also important to mention the importance of the existence of a well-functioning business and economic environment [35,36]. For example, the strategic decisions of larger, dominant firms affect GVC participation and the type of GVC participation. In the countries of Central and Eastern Europe, growth in the rate of exports has increased participation in GVC [37]. This leads to more modern export-oriented production facilities in the region (and even in Asia), thanks to which these countries may become even more involved in GVCs. As a result, GVC participation increases wages in participating countries [38].

In addition to the need for the appropriate economic and institutional background, [19] highlighted the importance of governance, governance structure, and policy since different government arrangements affect GVC participation in different ways. One of the best-studied areas is the link between the exchange rate and participation in trade and GVC [39–41]. According to Bang and Park [39], who examined some large Asian economies, the interaction term between the real effective exchange rate (REER) and GVC participation or export growth may be positive. Kharroubi [40] concludes that more participation in GVCs makes the trade balance less sensitive to real exchange rate movements. Leigh, Lian [41] suggest that the depreciation of REER has the effect of boosting exports, thus GVC participation.

International trade agreements concluded by governments are also crucial concerning the extent to which a given country or its companies can be involved in international value chains [30,42]. The EU-New Zealand Free Trade Agreement and African Continental Free Trade Area can contribute to increasing GVC participation, for example, but at the same time, there are examples of protectionist measures, such as Brexit or America's increase in tariffs on steel and aluminum imports. Natural disasters can also affect both participation in GVC and international trade agreements [43]. A literature review by Osberghaus [44] concluded that exports are adversely affected by natural disasters, although in the case of imports, the effects are less clear.

This paper provides an empirical analysis of the determinants of agri-food GVC participation (backward and forward) of countries at different levels of economic development, especially focusing on developing countries. Based on the review of the literature, few studies have dealt

with this topic so far; instead, only the effects of GVC participation have been examined. Agricultural GVCs affect agricultural productivity in many ways. Backward and forward agricultural GVC participation has a positive effect on agricultural productivity in high-income and upper-middle-income countries, while only backward participation improves agricultural productivity in lower-middle-income states [45]. Border protection policies and measures (e.g., import tariff and non-tariff barriers) have a negative impact on agricultural GVC participation [46,47]. Thus, bilateral trade policies or free trade agreements and customs unions are key determinants of backward and forward GVC participation in the agricultural and food sector [46,48]. This analysis is particularly relevant for developing countries as it increases understanding of the overall context and the key determinants of success, thereby potentially increasing their involvement in global agri-food GVCs.

DATA AND METHODOLOGY

Description of the Data

All GVC time series data were collected from the Asian Development Bank's Multiregional Input-Output (ADB MRIO /2023/) tables. Data for the independent variables were collected from various sources, as is evident from Table 1. Development indicators were downloaded from World Bank databases. Market size, Level of development, and Openness to inward FDI values had to be transferred due to their relatively greater values compared to the other variables. For Market size and Level of development, we applied natural logarithm transformation. For Openness to inward FDI, min/max normalization was performed due to the possibility of negative values. During this process, the minimum was subtracted from the given value, and then the result was divided by the range (the difference between the maximum and minimum values). The purpose of these transformations was to prevent variables with larger values from dominating the analysis. In some cases, data for the last year was missing. Data for 2023 was estimated by calculating the average annual difference, taking the 2020/2021 and 2021/22 periods into consideration, and then adding the change to the 2022 value to calculate the 2023 value. Based on previous studies, the following trade policy-related variables were used in the analysis: the number of standards, harmful and liberalizing interventions, and Foreign Direct Investment. Market (non-policy) related variables are Eurozone membership, market size, level of development, the Logistic Performance Index (LPI), trade openness, trade across borders, and contract enforcement.

Table 1. Data sources for the variables.

Variable Name (*Type*)	Description	Source	Transformation	Time Span
GVC participation (*dependent variable*)	-	ADB MRIO	-	2000–2022
Forward participation (*dependent variable*)	-	ADB MRIO	-	2000–2022
Backward participation (*dependent variable*)	-	ADB MRIO	-	2000–2022
Market size (*independent variable*)	Market size is proxied by GDP, measured in million USD PPP	Word Bank WDI (https://databank.worldbank.org/source/world-development-indicators; access on: 10 Feb. 2025)	natural logarithm	1960–2023
Level of development (*independent variable*)	Level of development is proxied by GDP per capita, measured in USD	Word Bank WDI	natural logarithm	1960–2023
Trade openness (*independent variable*)	Share of exports/imports in GDP at current prices	Our World in Data, National account (https://ourworldindata.org/grapher/trade-as-share-of-gdp; access on: 10 Feb. 2025)	-	1950–2022
Openness to inward FDI (*independent variable*)	FDI net inflows (BoP, million USD)	Word Bank WDI	min/max *	1960–2022
LPI (*independent variable*)	composite measure of the speed of trade with indicators derived from big datasets that track shipments	Word Bank WDI	-	2007–2022
Ease of doing business (Trade across borders) (*independent variable*)	composite measure of the time and cost of exporting and importing	World Bank Doing Business archive (https://archive.doingbusiness.org/en/data, access on: 10 Feb. 2025)	-	2005–2021
Ease of doing business (Contract enforcement) (*independent variable*)	composite measure of the time and % of claims and quality of the judicial process	World Bank Doing Business archive	-	2005–2021
Harmful interventions (*independent variable*)	export/import quotas, export/import bans, anti-dumping-, anti-subsidy- and licensing measures	Global Trade Alert (www.globaltradealert.org, access on: 10 Feb. 2025)	-	2009–2023
Liberalizing interventions (*independent variable*)	tariff measures, subsidies, quotas, credits, import licensing, internal taxes and charges	Global Trade Alert	-	2009–2023
Number of standards (*independent variable*)	review of 300+ standards by product, sector, area, or focus	International Trade Center (https://standardsmap.org/en/identify?origin=, access on: 10 Feb. 2025)	-	2002–2023
Eurozone membership (*independent variable*)	Eurozone membership	Statistisches Bundesamt (DESTATIS) (https://www.destatis.de/Europa/EN/Country/EU-Member-States/_EU_EZ_Zeitverlauf_en.html, access on: 10 Feb. 2025)	-	2002–2023

Source: Authors' composition; * Minimum and maximum values observed in the sample

Table 2 presents the basic descriptive statistics for the variables used in the analysis, indicating the high level of diversity in the dataset. Standard deviations are quite high in general, suggesting that our database includes a wide diversity of cases from different countries.

Table 1. Basic descriptive statistics of variables.

Variable Name	Min	Max	Mean	Standard Deviation
Market size (million US$)	14,923	34,643,707	2,174,531	4,500,741
Level of development (current US$)	1098.07	133,711.8	31,151.11	25,947.39
Trade openness	23.38	425.98	115.51	80.72
Openness to inward FDI (million US$)	−488,000	512,936	32,153	80,935
LPI	1.34	4.40	3.44	0.52
Ease of doing business (trade across borders)	8.2	115.19	87.06	15.17
Ease of doing business (contract enforcement)	20.8	89.2	64.37	13.05
Harmful interventions	0	1523	94.52	136.94
Liberalizing interventions	0	335	22.33	24.95
Number of standards	1	30	19.42	4.82
Eurozone membership	0	1	-	-

Source: authors' composition based on datasets identified in Table 1.

Econometric Specification

Although the empirical literature on the determinants of GVC trade is developing rapidly, there is still no 'gold standard' for investigation [11]. The following fixed-effects panel regression model [49], with GVC participation as the dependent variable, was employed to measure individual country characteristics using a set of influential factors between 2014 and 2023. According to Brüderl, Ludwig [49], the equation underlying the economic model is as follows:

$$Y_{it} = \sum_{j=1}^{M} \beta_j X_{it}^{(j)} + \alpha_i + \varepsilon_{it}, \quad (1)$$

where i $(1 \leq i \leq 54)$ indicates a given country, and t $(1 \leq t \leq 10)$ denotes a given year from 2014 to 2023. The given policy variable is denoted by j $(1 \leq j \leq M)$, where M is the total number of factors (policy and market-related factors).

Backward and forward participation were also integrated into the second and third models as dependents (Y_{it}) for the *i*-th country in the *t*-th year. β_j is the regression coefficient for the *j*-th variable and $X_{it}^{(j)}$ is the value of the *j*-th variable for the *i*-th country in the *t*-th year. The individual country characteristics were represented by α_i, while ε_{ij} denotes the error term for the *i*-th country in the *t*-th year. All variables were given in a wide table format, with countries as the rows and years as the columns. The econometric modelling began with the conversion of the wide-format data to a 'tidy' long-format. In this format, the variables are organised into different columns, with time being represented as an additional variable in a separate column. R 4.2.3 was used for all the calculations (R Core Team, 2023). The long-format conversion was performed by using the tidyr package. To estimate the fixed-effects panel model, plm, lmtest and tseries

packages were applied. The Hausman test was used to decide between the fixed and random effect models. The Breusch-Godfrey/Wooldridge test was employed to test serial correlation in the time series, and the Breusch-Pegan test tested the presence of heteroskedasticity. A robust covariance matrix was estimated using Arellano's method to control both heteroskedasticity and serial correlation. All the PCAs were performed on the correlation matrix, and Varimax rotation was used. Kaiser-Meyer-Olkin (KMO) and Bartlett tests were calculated using the psych package, and the principal function was used to calculate PCA.

RESULTS

Identifying Country Clusters

In the first step, principal component analysis (PCA) was undertaken for GVC, backward and forward participation, and all the influential (policy and market-related) factors. The purpose of the analysis was to graphically represent the data matrix in a two-dimensional space and determine the interrelationships between the factors by creating two latent components.

Table 3 presents the components and the weights of the factors. The PCA analysis was adequate and satisfied the minimum conditions (KMO's measure of factor adequacy should be larger than 0.5), and the Bartlett test was also significant, indicating that the data were appropriate for the analyses. The variance explained by the first two principal components (PCs) is larger than 50%, and 30% of the explained variance may be attributed to the first PC. The first latent component is the major one. This describes the relationship between GVC and backward participation and mainly involves market-related factors, while the second component is mainly comprised of trade policy-related variables (standards, harmful and liberalizing interventions, FDI).

Table 3. PCA results for the sample.

Factor Name	Component Correlations	
	Component 1 Trade Policy-Related Factors	Component 2 Market-Related Factors
GVC %	**0.90**	0.01
Forward %	−0.30	**0.43**
Backward %	**0.81**	−0.27
Standards	−0.13	0.20
Liberal Interventions	−0.21	**0.28**
Harmful Interventions	−0.27	**0.68**
Eurozone	**0.66**	0.05
Market Size	−0.55	**0.55**
Level of Development	**0.58**	**0.65**
Trade Openness	**0.80**	−0.16
Trade across Border	**0.62**	0.45
FDI	−0.26	**0.58**
LPI	0.37	**0.71**
Contract Enforcement	0.39	**0.64**
Explained Variance (%)	30%	22%

Note: Significant variables are indicated in bold. Overall Measure of Sampling Adequacy = 0.6; Bartlett test was significant at the 5% level ($p < 0.001$)

Figure 1 shows a biplot, which was created to visualise information about the countries and the studied variables simultaneously, and to study the connections between them. The biplot also allows us to identify groups of countries and groups of variables. The green vectors present how much weight each factor has in the given PC. These weights can be determined by projecting each vector to the given PCs. For example, Component 2 differentiates standards, harmful and liberalizing interventions, and FDI from the other factors (market factors). The first component describes the GVC % and the level of development and contract enforcement and also correlates well with trading across the border (trade policy-related factors). Countries located to the right participate most in GVCs; most of them are in the Eurozone, where the level of contract enforcement and development is rather high. Countries located to the left of the first axis are just the opposite (less GVC and backward participation, low level of contract enforcement and development).

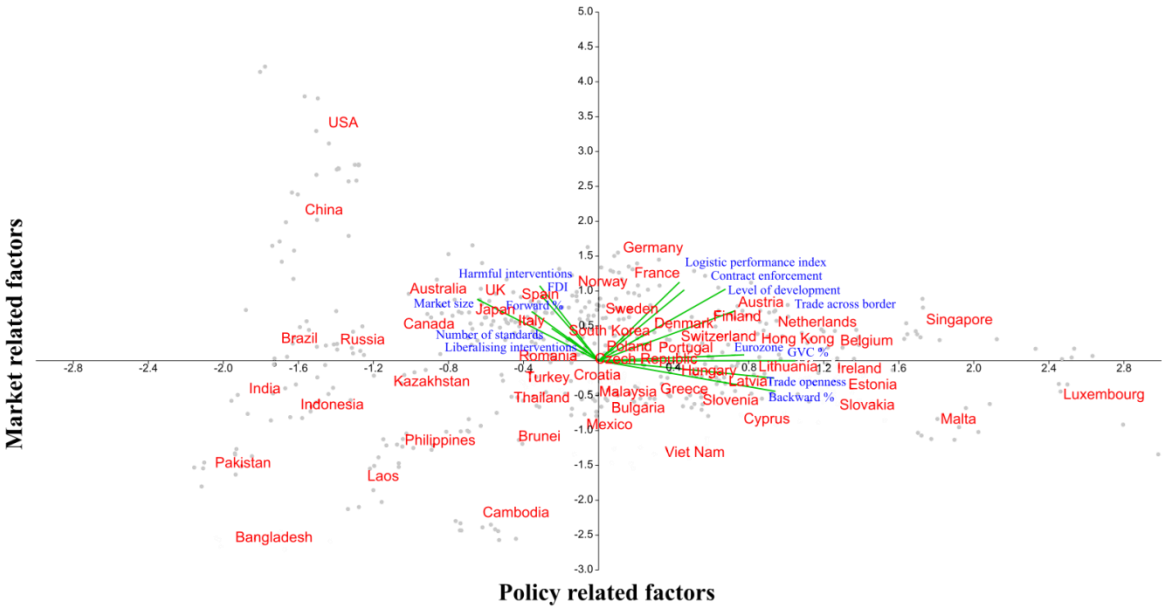

Figure 1. PCA biplot of the studied factors and countries. Source: authors' composition based on OECD (2023) data.

Backward and GVC participation are closest to trade openness, which is the main determinant of GVC participation. Being in the Eurozone and the level of development foster trade across borders, making it easier to enforce contracts and improve logistic performance. PCA is also useful for capturing cluster structures in the data. The following cluster structures can be obtained from the biplot of the PCA (Table 4).

Table 4. Categorization of agri-food GVC participation performance by country.

High Performing Countries 18 Countries	Average Performance 22 Countries	Low Performing Countries 14 Countries
Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Hong Kong, Ireland, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Singapore, Slovakia, Sweden, Switzerland	Australia, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Greece, Hungary, Italy, Japan, Latvia, Malaysia, Norway, Poland, Romania, Slovenia, South Korea, Spain, UK, USA, Vietnam	Bangladesh, Brazil, Brunei, Cambodia, India, Indonesia, Kazakhstan, Laos, Mexico, Pakistan, Philippines, Russia, Thailand, Turkey

Source: authors' composition based on OECD (2023) data

As is evident from Table 4, high-performing countries are mainly developed Eurozone countries with open markets and liberal trading policies, while low-performing countries are mainly developing countries with protectionist trade policies. Level of development, trade openness, trade across borders, and LPI are key for success, as well as contract enforcement, while market size, standards, FDI, and market interventions play only a limited role. In other words, market-related factors are more important than trade policy-related factors in pursuing GVC participation, at least in agri-food markets.

Determinants of Agri-Food GVC Participation

First, an F test was performed to determine whether the individual fixed-effects panel model is better than the simple OLS regression. The fixed-effects panel regression fitted the data better ($F(52,476) = 44.44$; $p < 0.001$). A Hausman Test was also performed to compare the fixed-effects panel model to the random effect model. We reject the null hypothesis ($Chi2(df = 10) = 38.52$; $p < 0.001$) that the random effect model is better. Therefore, the fixed effect model was used. An augmented Dickey-Fuller test ($ADF = -6.098$; $p < 0.01$) was also performed with lag order 2 to show that the series has no unit roots (stationary). The Breusch-Godfrey/Wooldridge test showed a serial correlation in the time series ($Chi2(df = 10) = 157.3$; $p < 0.001$), and the Breusch-Pegan test ($BP = 455.7$, $p < 0.001$) showed the presence of heteroskedasticity. Therefore, a robust covariance matrix estimation was applied using Arellano's method to control both heteroskedasticity and serial correlation.

The result of the OLS regression differs from the fixed-effects panel (Table 5). Eurozone membership and liberal trade interventions had a significantly positive effect on GVC participation in both models. Interestingly, the effect of market size differs depending on the model specification, though the level of development seems to have no influence on GVC participation, at least in the agri-food sector. Trade openness had some positive effects in both cases, but trade across the border and contract enforcement were only significant in the OLS model. Results also showed that FDI is negatively correlated with GVC participation in the case of the OLS regression.

Table 5. Fixed-effects panel and OLS regression model estimations for the whole dataset.

Policy Factor	OLS	Fixed Effect
Eurozone	**5.399 *** **	**1.535 *** **
	(7.756)	**(4.127)**
No. of Standards	**−0.196 ****	Not applicable
	(−3.079)	
Liberal Interventions	**0.033 ****	**0.018 *** **
	(2.756)	**(3.439)**
Harmful Interventions	**0.014 *** **	0.001
	(3.440)	(−0.033)
Market Size	**−2.597 *** **	**2.221 *** **
	(−4.423)	**(3.668)**
Level of Development	−0.595	−1.408
	(−1.525)	(−1.295)
FDI	**−1.129 ****	0.226
	(−3.090)	(0.885)
LPI	−0.202	0.026
	(−0.257)	(0.028)
Trade Openness	**0.063 *** **	**0.147 *** **
	(14.325)	**(8.751)**
Trade across Border	**0.228 *** **	−0.009
	(9.434)	(−0.462)
Contract Enforcement	**0.059 ***	0.040
	(2.216)	(0.821)
Constant Term	**21.626 *** **	Not applicable
	(7.116)	-
R-squared	0.687	0.335
F-statistic	105.10 ***	23.99 ***

Note: Significant variables are indicated in bold. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

Table 6 goes further and identifies determinants of GVC participation based on the performance of different countries. It appears that being in the Eurozone and market size increases GVC participation only for those countries that already have high GVC participation rates, while FDI fosters GVC participation but only for low and average performers. Trade openness seems to have some positive effect in all cases, while trade across borders and contract enforcement is positively related to GVC participation in the case of average performers. Obviously, the level of different trade policy interventions had a modest role in shaping GVC participation rates. Liberal interventions were related positively to GVC participation in the case of the high-performing countries, while harmful interventions decreased GVC participation in the case of the average-performance group and increased GVC participation in the low-performing group. Trading across borders and contract enforcement helped average-performing countries to participate in GVCs.

Table 6. Fixed-effects panel regression model estimations for high, low, and average performing countries for agri-food GVC participation.

Factors	High	Low	Average
Eurozone	**1.783 ***	Not applicable	Not applicable
	(2.082)	-	-
Liberal Interventions	**0.086 ****	0.011	−0.012
	(3.116)	(1.435)	(−0.349)
Harmful Interventions	−0.009	**0.008 ***	**−0.001 ***
	(−0.603)	**(2.337)**	**(−2.273)**
Market Size	**23.980 ****	1.973	**−0.708 ***
	(2.702)	(0.978)	**(−2.273)**
Level of Development	−0.994	5.780	−0.019
	(−0.529)	(1.458)	(−0.043)
FDI	0.052	**3.646 ****	**0.467 *****
	(0.194)	**(3.301)**	**(5.273)**
LPI	0.914	−1.021	−5.840
	(0.638)	(−0.483)	(−1.479)
Trade Openness	**0.128 *****	**0.167 *****	**0.385 *****
	(6.076)	**(4.734)**	**(15.809)**
Trade across Border	0.100	−0.036	**0.021'**
	(1.206)	(−0.822)	**(1.714)**
Contract Enforcement	0.120	0.001	**0.299 *****
	(1.644)	(0.012)	**(5.873)**
R-squared	0.442	0.291	0.856
F-statistics	12.05 ***	5.34 ***	20.46 ***

Note: Significant variables are indicated in bold. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

Determinants of Agri-Food Backward GVC Participation

The analysis was extended by applying the same models to both forward and backward participation. First, an F test was performed to determine whether the individual fixed-effects panel model is better than the simple OLS regression. The fixed-effects panel regression fitted the data better ($F(52,476) = 73.06$; $p < 0.001$). A Hausman Test was also performed to compare the fixed-effects panel model to the random effect model. This suggests rejection of the null hypothesis ($Chi2(df = 10) = 42.71$; $p < 0.001$) that the random effect model is better. Therefore, the fixed effect model was used. An augmented Dickey-Fuller test (ADF = −4.886; $p < 0.01$) was also performed with lag order 2 to show that the series has no unit roots (stationary). The Breusch-Godfrey/Wooldridge test showed a serial correlation in the time series ($Chi2(df = 10) = 143.36$; $p < 0.001$), and the Breusch-Pegan test (BP = 467.54, $p < 0.001$) showed the presence of heteroskedasticity. Therefore, we applied a robust covariance matrix estimation using Arellano's method to control for heteroskedasticity and serial correlation.

As is evident from Table 7, the main determinants of GVC participation were the Eurozone, market size, level of development, FDI, trade openness, and trade across the border regarding the fixed effect model. Eurozone, level of development, FDI, and trade across borders all have a negative and significant impact on backward GVC participation, suggesting that these market and policy-related factors may hinder countries from adding value to the whole value chain when importing from other countries. Only

trade openness and market size had a significant and positive impact on backward GVC participation.

Table 7. Fixed-effects panel and OLS regression model estimations for the whole dataset for backward GVC participation.

Policy Factor	OLS	Fixed Effect
Eurozone	**3.893 *** **	**−1.207 ** **
	(5.620)	**(−2.925)**
No. of Standards	0.064	Not applicable
	(1.011)	-
Liberal Interventions	−0.013	0.002
	(−1.080)	(0.327)
Harmful Interventions	0.006	−0.002
	(1.431)	(−1.537)
Market Size	−0.738	**1.752 ** **
	(−1.264)	**(2.931)**
Level of Development	**−2.023 *** **	**−3.293 *** **
	(−5.213)	**(−4.871)**
FDI	**−1.492 *** **	**−0.329 * **
	(−4.105)	**(−1.974)**
LPI	**3.164 *** **	0.339
	(4.046)	(0.501)
Trade Openness	**0.076 *** **	**0.113 *** **
	(17.468)	**(6.040)**
Trade across Border	**0.053 * **	**−0.036 * **
	(2.207)	**(−2.474)**
Contract Enforcement	**−0.082 *** **	0.082
	(−3.090)	(1.410)
Constant term	1.045	Not applicable
	(0.346)	-
R-squared	0.578	0.299
F-statistic	65.82 ***	20.30 ***

Note: Significant variables are indicated in bold. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

Regarding the determinants of backward GVC participation in relation to performance, it is evident (Table 8) that developed countries with larger markets tend to have higher backward GVC participation levels, but market size also increases backward GVC participation in the low-performing group. FDI was also positively correlated with GVC backward participation in the low-performing group. Contract enforcement, LPI, and liberal interventions were only significant and positively influenced backward GVC participation in the high-performing group. Trade openness is necessary for being part of backward GVCs in all groups; trade across borders was the most significant in the average-performing group.

Table 8. Fixed-effects panel regression model estimations for the high, low, and average performing countries for agri-food GVC backward participation.

Policy Factor	High	Low	Average
Eurozone	−1.060	Not applicable	Not applicable
	(−1.562)	-	-
Liberal Interventions	**0.059 ****	0.016	−0.010
	(3.074)	(1.311)	(−0.697)
Harmful Interventions	**−0.019 ***	−0.004	<0.001
	(−2.007)	(−1.067)	(0.143)
Market Size	**22.808 *****	**3.087'**	**−0.560 ****
	(3.931)	**(1.904)**	**(−3.533)**
Level of Development	**−2.109 *****	−1.639	−0.385
	(−3.896)	(−0.408)	(−1.204)
FDI	**−0.482 *****	**2.585 ***	**−0.102**†
	(−3.545)	**(2.081)**	**(−1.748)**
LPI	**0.968**	−0.811	1.190
	(1.510)	(−0.807)	(0.486)
Trade Openness	**0.080 *****	**0.164 *****	**0.287 *****
	(7.667)	**(3.680)**	**(22.938)**
Trade across Border	**0.079**†	**−0.078 ***	**0.024 *****
	(1.772)	**(−2.329)**	**(5.905)**
Contract Enforcement	**0.134 ****	0.134	0.116
	(2.788)	(1.296)	(1.240)
R-squared	0.403	0.440	0.893
F-statistics	10.27 ***	10.20 ***	28.69 ***

Note: Significant variables are indicated in bold. † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

Determinants of Agri-Food forward GVC Participation

Again, when analyzing the determinants of forward GVC participation, an F test was first performed to test whether the individual fixed-effects panel model is better than the simple OLS regression. The fixed-effects panel regression fitted the data better ($F(52,476) = 56.603$; $p < 0.001$) and was used because of the Hausman Test ($Chi2(df = 10) = 28.20$; $p = 0.002$), which showed a better fit than the random effect model. An augmented Dickey-Fuller test ($ADF = -5.733$; $p < 0.01$) was also undertaken with lag order 2 to show that the series has no unit roots (stationary). The Breusch-Godfrey/Wooldridge test showed a serial correlation in the time series ($Chi2(df = 10) = 165.08$; $p < 0.001$), and the Breusch-Pegan test ($BP = 1079.1$, $p < 0.001$) showed the presence of heteroskedasticity. Therefore, we applied Arellano's correction for the covariance matrix.

Concerning the determinants of forward agri-food GVC participation, a different pattern of factors emerges (Table 9). Eurozone membership turned out to be the most significant factor impacting forward GVC participation, along with LPI and FDI. Market size did not have any influence on forward participation in both models. However, trade openness seemed to have a significantly negative role in both cases. Liberal interventions and trading across borders also facilitated participation in forward GVCs. All this suggests that more developed countries in the Eurozone with relatively higher FDI and liberal interventions are more likely to participate in forward GVC.

Table 9. Fixed-effects panel and OLS regression model estimations for the whole dataset for forward GVC participation.

Policy Factor	OLS	Fixed Effect
Eurozone	−1.047	**1.935 *** **
	(−1.851)	**(5.147)**
No. of Standards	−0.193	Not applicable
	(−3.728)	-
Liberal Interventions	0.027	**0.011 ***
	(2.833)	**(1.962)**
Harmful Interventions	0.001	0.001
	(0.345)	(0.641)
Market Size	−0.740	−0.622
	(−1.550)	(−0.053)
Level of Development	1.969	**3.027 *** **
	(6.212)	**(3.839)**
FDI	0.983	**0.452 *** **
	(3.310)	**(4.723)**
LPI	−3.899	−0.505
	(−6.104)	(−0.744)
Trade Openness	−0.040	**−0.041 ***
	(−11.211)	**(−2.044)**
Trade across Border	0.056	**0.031 ***
	(2.842)	**(2.078)**
Contract Enforcement	0.158	−0.046
	(7.326)	(−0.819)
Constant Term	**25.780 *** **	Not applicable
	(10.439)	-
R-squared	0.361	0.124
F-statistic	27.06 ***	6.73 ***

Note: Significant variables are indicated in bold. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

According to Table 10, in the best-performing group, Eurozone membership, FDI, and LPI had a significant positive impact on forward participation, but market size hindered forward participation in GVCs in this group. The level of development played the most significant positive role in forward GVC participation in the case of the low-performing countries. In the average performance group, only FDI impacted GVC participation positively, while LPI had a negative influence.

Table 10. Fixed-effects panel regression model estimations for the high, low, and average performing countries for agri-food GVC forward participation.

Policy Factor	High	Low	Average
Eurozone	**1.463 *** **	Not applicable	Not applicable
	(3.563)	-	-
Liberal Interventions	**−0.027 ***	−0.005	−0.005
	(−2.461)	(−0.534)	(−0.223)
Harmful Interventions	**0.009**†	**0.012 *** **	−0.001
	(1.809)	**(3.593)**	(−1.616)
Market Size	**−7.033 ***	−1.629	0.070
	(−2.523)	(−1.504)	(0.270)
Level of Development	**1.022 ***	**7.548 ***	0.340
	(1.996)	**(2.031)**	(1.318)
FDI	**0.397 *** **	0.470	**0.508 *** **
	(5.245)	(0.510)	**(5.628)**
LPI	−0.717	−0.408	**−3.923 ***
	(−1.347)	(−0.344)	**(−2.124)**

Trade Openness	−0.007	**−0.094 ***	**−0.046 *****
	(−0.540)	**(−2.002)**	**(−4.445)**
Trade across Border	−0.037	**0.062 ****	**−0.016**[†]
	(−1.194)	**(3.347)**	**(−1.957)**
Contract enforcement	−0.030	**−0.164 ***	0.094
	(−1.336)	**(−2.014)**	(0.907)
R-squared	0.198	0.199	0.414
F-statistics	3.76 ***	3.23 **	2.44 *

Note: Significant variables are indicated in bold. [†] $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; t values can be seen in parenthesis; Source: authors' composition based on OECD (2023) data

DISCUSSION

Trade Openness and GVC Integration

Our panel estimates show a robust, positive association between openness and overall participation across all performance groups, consistent with recent cross-country evidence that deeper trade exposure expands both sourcing options and market reach in agri-food chains. Beyond tariff levels, the result likely captures non-tariff and procedural frictions whose reduction magnifies participation margins. Recent work emphasizes that openness effects are strongest where complementary reforms lower border and compliance costs; this aligns with our finding that openness remains significant even after controlling for other enablers ([30,32,50]).

Regional Integration and Forward Linkages

Eurozone membership has a significantly positive effect on GVC participation, suggesting that regional economic integration plays a crucial role in increasing market access and creating a conducive business environment. These findings are in line with previous studies [30,42], showing that economic unions and free trade agreements enhance GVC integration.

FDI and Heterogeneous Effects by Development Level

Interestingly, FDI results are mixed across country groups. While FDI promotes GVC participation in low- and middle-income countries, its role in high-income countries is ambiguous. Consequently, for less developed countries, FDI is critical for transferring technology, enhancing production capabilities, and thereby linking local industries to global markets [33,34]. In contrast, high-income countries with more developed domestic industries may benefit less from FDI in terms of GVC participation.

Drivers of Participation

The distinction between forward and backward participation reveals important further insights concerning how countries engage with GVCs. Backward participation is driven by market size and trade openness but is negatively impacted by Eurozone membership and FDI in developed

countries, suggesting that larger and more developed countries tend to rely more on domestic inputs, while smaller economies are more likely to import intermediate goods for further processing. According to [45], backward participation improves agricultural productivity in lower-middle-income states, meaning that more developed countries have greater capacity to source inputs from abroad for their industries, and they engage more in importing intermediate goods for further processing or re-export. However, more developed countries tend to source inputs domestically rather than rely on imported inputs for their exports [51,52].

For developing countries, backward participation is positively related to FDI, implying that foreign capital builds local capacity for integrating into GVCs. These countries need foreign inputs to export, and FDI may help create the infrastructure and technology required to participate more effectively in GVCs. In contrast, forward participation is significantly influenced by Eurozone membership and trade facilitation mechanisms, such as logistics performance and contract enforcement. This is especially true for developed countries with higher incomes, more advanced logistics, and stronger institutions [50,53].

Limitations

The analysis has limitations that merit acknowledgement. Measures of participation derive from multi-regional input–output accounts with standard assumptions that can mask within-country and within-sector heterogeneity; annual frequency restricts the study of short-run dynamics around reforms and shocks; and although fixed effects and robust inference are employed, potential endogeneity remains for policy variables such as openness, facilitation and FDI. Institutional and logistics indicators capture broad conditions rather than firm-level practices, and regional integration is proxied by Eurozone membership, which may not generalize to other deep agreements.

Policy and Managerial Interventions

In terms of policy and managerial implications, trade openness is a critical factor for GVC participation in all countries. Governments and policymakers should focus on reducing trade barriers (e.g., complicated customs procedures, tariffs or quotas). For countries with lower performance in agri-food GVCs, trade facilitation agreements and lowering transaction costs at borders are critical for increasing involvement in international trade. Moreover, decision-makers in average- or low-performing countries should focus on creating attractive environments for FDI that contribute to technological transfers, the creation of jobs, and increase productivity by ensuring legal and political stability and offering various benefits to foreign, multinational companies (e.g., tax incentives or infrastructure developments). Moreover, managers and decision-makers should establish partnerships in countries with favorable trade and regulatory environments in order to promote

transparent decision-making that supports competitiveness. This could lower entry barriers and facilitate integration into local supply chains. Moreover, economic policies in all countries should focus on promoting investment into logistics infrastructure and technology (e.g., digital tracking systems or supply chain automation), which will enable the faster and more efficient movement of products.

The countries of the Eurozone have higher (agri-food) GVC participation rates. Regional economic (and political) cooperation and common laws and standards could help boost GVC integration. Various regional trade agreements (e.g., the African Continental Free Trade Area) should be promoted and made more effective by optimizing logistics and supply chain strategies that take advantage of a harmonized regulatory environment. Liberal trade interventions, e.g., reducing tariffs and subsidies, positively affect agri-food GVC participation, but there are cases where harmful interventions and protectionist policies may be favorable for low-performing countries. Protectionist measures by governments could allow domestic firms to build competitiveness prior to international competition, but these measures should be temporary and aimed at fostering long-term global GVC integration. Companies in these emerging markets could take advantage of protectionist policies to build competitiveness, but in parallel, they must prepare for international competition by supporting technological development and innovation.

Policy and decision-makers should take into account the specificities of the country or company when making trade or business decisions. High-performing countries may focus more on innovation, while lower-performing countries may need more FDI attraction strategies. High-performing firms should focus on upgrading and specialization within GVCs, while companies in lower-performing regions should focus on improving competitiveness through integration into GVCs with support from government policies and incentives. Together, these efforts can help countries and firms develop their value chains and increase their participation in GVCs, improving the overall productivity and efficiency of the global economy.

Future Research Directions

Future research should therefore connect micro- and macro evidence by tracing how firm-level upgrading, contracting and standards compliance translate into country-level elasticities for backward and forward margins. It should also deploy causal identification strategies that exploit phased customs reforms, deep-agreement provisions or quasi-experimental logistics upgrades. Finally, future work could extend the analysis to resilience, distributional and environmental outcomes by quantifying how diversification, near-/friend-shoring and inventory strategies affect both participation and recovery from shocks, by mapping value capture across farmers, processors and services, and by linking participation to emissions intensity and sustainability compliance. These

extensions would sharpen the policy relevance of agri-food GVC research and clarify the conditions under which integration supports competitiveness, inclusiveness and climate objectives simultaneously.

CONCLUSIONS

This study examined what drives countries' participation in agri-food GVCs over 2014–2023, distinguishing overall, backward and forward linkages and allowing for heterogeneity across performance groups. The findings confirm that greater trade openness is consistently associated with higher participation across all country groups (addressing RQ1); that regional integration, proxied by Eurozone membership, is particularly relevant for forward participation where common rules, standards recognition and financial integration help domestic value added travel further downstream (RQ2); that inward FDI contributes more strongly to participation in low- and average-performing economies than in high-income ones where domestic linkages are already dense (RQ3); and that the determinants of backward and forward margins differ in intuitive ways, with market size and border facilitation more closely tied to backward participation and institutional quality and logistics performance more closely tied to forward participation (RQ4). Results on policy stance indicate that liberalization measures coincide with higher participation, whereas harmful interventions tend to depress it, albeit with some context-specific exceptions among low performers.

The research implications are twofold. Conceptually, disaggregating participation into backward and forward margins proves essential, as the levers that ease the import and processing of intermediates are not perfect substitutes for those that enable domestic value added to move reliably along downstream stages. Empirically, heterogeneous effects by performance cluster show that identical reforms can have different elasticities, underscoring the value of sequencing policies to countries' starting positions and bottlenecks.

These results carry practical recommendations for policy and management. Governments should give priority to trade-facilitation reforms that reduce time and compliance costs at the border and to complementary openness measures that widen sourcing and market access. Investment policy should emphasize the quality of FDI—linking incentives to supplier development, certification and technology transfer—so that foreign entry deepens domestic linkages rather than displacing them. Strengthening contract enforcement and time-definite logistics will be especially consequential for forward participation in time-sensitive food categories. Protectionist measures, where used in low-performing contexts, should be strictly temporary and paired with capability-building to prepare firms for open competition. Finally, deeper regional integration that advances SPS/TBT equivalence, mutual recognition of conformity assessment and services/data provisions is likely to sustain forward linkages. In practice, this implies cluster-specific

roadmaps: low performers focus on border and corridor logistics and supplier-oriented FDI; average performers prioritize judicial quality and standards compliance; high performers invest in innovation and services intensity to maintain and upgrade forward links.

Overall, the study analyses how trade openness, regional integration, and foreign investment influence countries' participation GVCs. By identifying policies that improve food security, rural livelihoods, and supply-chain resilience, it highlights pathways to reduce poverty and resource waste while enabling technology transfer and sustainable farming practices. Altogether, it shows that targeted trade and investment strategies can support economic growth and social well-being while strengthening environmental stewardship—key elements of socio-ecological sustainability.

DATA AVAILABILITY

The dataset of the study is available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

Conceptualization, ÁT, SK, AJ and ZMM; methodology, ÁT, SK, AJ and ZMM; software, SK; validation, ÁT, SK, AJ and ZMM; formal analysis, ÁT, SK, AJ and ZMM; investigation, ÁT, SK, AJ and ZMM; resources, AJ; data curation, SK and ZMM; writing—original draft preparation, ÁT, SK, AJ and ZMM; writing—review and editing, ÁT, SK, AJ and ZMM; visualization, SK and ZMM; supervision, ÁT, SK, AJ and ZMM; project administration, AJ; funding acquisition, AJ. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare that there is no conflicts of interest.

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