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Harvesting Prosperity: The Long-Run Impact of Food Exports on Agricultural Growth

Refah Hasadı: Gıda İhracatının Tarımsal Büyüme Üzerindeki Uzun Dönem Etkisi

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ÖZ

Bu çalışma, gıda ihracatının tarımsal katma değer üzerindeki etkisini gelişmekte olan ülkeler için incelemektedir. 2000-2019 dönemi panel verisi kullanılarak PMG, AMG ve CCE-MG tahmincileri ile uzun dönem ilişkiler analiz edilmiştir. Sonuçlar, gıda ihracatının tarımsal katma değeri artırdığını ancak kişi başına düşen gelirin tarımın ekonomideki payını azalttığını göstermektedir. Mekanizasyonun etkisi modelleme yöntemlerine bağlı olarak değişirken, eğitim seviyesinin artması tarımdan sanayi ve hizmet sektörlerine iş gücü kaymasını hızlandırmaktadır. Sonuçlar, ihracata dayalı tarım politikalarının ekonomik büyümeyi destekleyebileceğini ancak gıda güvenliğiyle dengelenmesi gerektiğini göstermektedir. Tarımda verimlilik artırıcı eğitim programları ve küçük çiftçilerin teknolojiye erişimi desteklenmelidir.

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A B S T R A C T

This study examines the impact of food exports on agricultural value-added in developing economies. Using panel data from 2000-2019, long-run relationships are analyzed via PMG, AMG, and CCE-MG estimators. Results confirm that food exports enhance agricultural value-added, while higher GDP per capita reduces agriculture's share in GDP, reflecting structural transformation. The impact of mechanization varies, while higher education levels accelerate labor shifts toward industry and services. Findings suggest that export-driven agricultural policies can boost economic growth but must balance food security concerns. Supporting smallholder access to technology and agricultural vocational training is crucial for sustainable development.

1. Introduction

Agriculture remains a crucial sector in the economic development of many developing countries, contributing significantly to employment, food security, and GDP growth. Historically, agricultural productivity and growth have played a pivotal role in the structural transformation of economies, facilitating industrialization and urbanization. In this context, international trade, mainly agrarian exports, has been identified as a significant determinant of agricultural

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sector performance. While some scholars argue that export-led growth enhances agricultural productivity and sectoral expansion (e.g., Balassa, 1978; Feder, 1983; Matsuyama, 1992), others contend that excessive reliance on agricultural exports may create structural vulnerabilities, including price volatility and resource depletion (e.g., Binswanger & Townsend, 2000).

The impact of food exports on agricultural growth remains an area of substantial academic and policy debate. On the one hand, agricultural exports can drive productivity improvements, enabling farmers to access larger markets, benefit from economies of scale, and increase revenues (Fleming & Abler, 2013; El Weriemmi & Bakari, 2024). These effects, in turn, can stimulate investment in technology, infrastructure, and agricultural research, fostering long-term growth. On the other hand, agricultural export dependence may lead to an overemphasis on cash crops at the expense of food security, soil degradation, and reduced domestic market supply, ultimately constraining agricultural development (Binswanger & Townsend, 2000; Saghaian et al., 2022; Aragie et al., 2023). Furthermore, the relationship between food exports and agricultural growth is contingent upon multiple factors, including economic policies (De Janvry & Sadoulet, 2010), institutional quality and technological adoption (Binswanger & Townsend, 2000), and external shocks such as climate variability and global commodity price fluctuations (Diao et al., 2010).

Classical theories of economic growth and international trade have long emphasized the critical role of agricultural development in structural transformation. In particular, the Lewis (1954) dual-sector model highlights the importance of agricultural productivity in releasing labor to more productive industrial sectors, while the Heckscher-Ohlin model and subsequent trade theories stress the benefits of specialization based on comparative advantage, including in agricultural commodities. Endogenous growth models (Romer, 1990; Grossman & Helpman, 1991) further extend this perspective by illustrating how trade openness can foster technological diffusion and sectoral innovation, including in agriculture.

This study focuses on a panel of 58 developing economies over the period 2000–2019. These countries are characterized by a significant reliance on agriculture for employment and income, diverse agroecological conditions, varying degrees of trade integration, and different levels of infrastructural development. Examining this broad sample allows for a comprehensive assessment of how food exports influence agricultural sector performance under diverse economic and institutional conditions.

Despite the extensive literature on agricultural exports and macroeconomic performance (Dawson, 2005; Sanjuán - López & Dawson, 2010; Henneberry & Khan, 2014; Ijirshar, 2015; Shah et al., 2015; Verter & Bečvářová, 2016; Erdinç & Aydınbaş, 2023; El Weriemmi & Bakari, 2024), relatively few studies have explicitly focused on the impact of food exports on agricultural GDP in developing economies. This study aims to fill this gap by examining the relationship between food exports and agricultural growth using a panel dataset of developing countries from 2000 to 2019. The empirical approach applies advanced panel data techniques that account for slope heterogeneity, cross-sectional dependence, and dynamic adjustments, ensuring the robustness and credibility of the findings.

By addressing these gaps, this study provides new empirical evidence on the role of food exports in shaping agricultural sector performance in developing countries, offering insights for policymakers seeking to enhance agricultural trade strategies while ensuring sectoral sustainability.

2. Literature Review

The relationship between food exports and agricultural sector performance has not been widely explored in the literature. Most existing studies primarily focus on agricultural exports and their contribution to overall economic growth, rather than explicitly examining how food exports influence the agricultural sector itself. While numerous studies analyze the role of agricultural trade in macroeconomic performance (e.g., Dawson, 2005; Sanjuán - López & Dawson, 2010; Verter & Bečvářová, 2016; Ijirshar, 2015; Shah et al., 2015), relatively few investigate whether food exports enhance agricultural value-added, improve sectoral productivity, or contribute to structural transformation within agriculture (e.g., Mamba & Ali, 2022; Henneberry & Khan, 2014; Erdinç & Aydınbaş, 2023). This gap in the literature underscores the need for a more targeted analysis that differentiates between food and non-food agricultural exports, particularly in the context of developing economies where agriculture remains a crucial sector.

Classical economic theories, including those of Adam Smith and David Ricardo, emphasize the benefits of international trade in promoting specialization and comparative advantage, which can stimulate sectoral productivity, including in agriculture. Within this framework, agricultural exports have historically played a crucial role in accelerating economic development by enabling countries to leverage their comparative advantages in food and agricultural products. Recent theoretical frameworks, such as endogenous growth models (Romer, 1990; Grossman & Helpman, 1991), further suggest that trade not only fosters specialization but also drives innovation, capital accumulation, and productivity gains across sectors, including agriculture. Building on these theoretical insights, empirical studies have explored whether agricultural exports contribute positively to macroeconomic growth and sectoral transformation, particularly in the context of developing economies.

Empirical studies on agricultural trade and economic growth generally fall into two broad perspectives. The first group of studies posits that agricultural exports contribute positively to economic and agricultural growth. Balassa (1978) and Feder (1983) highlight that export expansion leads to increased efficiency, productivity spillovers, and enhanced foreign exchange earnings, which can be reinvested in agricultural infrastructure and modernization. Similarly, Matsuyama (1992) argues that agricultural export-oriented economies experience more significant efficiency gains due to scale economies and knowledge diffusion.

Conversely, other studies challenge the assumption that agricultural exports inherently lead to positive growth outcomes. For instance, De Janvry & Sadoulet (2010) highlight the risks of excessive dependence on export markets, noting that agricultural producers in developing countries may be vulnerable to price shocks, demand fluctuations, and trade restrictions. Furthermore, Binswanger & Townsend (2000) suggest that the emphasis on export crops may lead to a decline in domestic food availability, increasing food insecurity risks.

A significant body of research has examined the role of agricultural exports in economic growth, emphasizing their contribution to trade balance, investment, and rural development. Sanjuán‐López & Dawson (2010) find that agricultural exports positively influence economic growth, although their impact is weaker compared to non-agricultural exports. Dawson (2005) similarly reports that agricultural trade fosters growth in low-income economies, suggestinging an appropriate mix of agricultural and non-agricultural exports is needed for sustainable development. Verter & Bečvářová (2016) and Ijirshar (2015) provide evidence from Nigeria, showing that agricultural exports contribute to economic growth but are highly volatile due to price fluctuations in global markets. However, Shah et al. (2015) report a negative relationship between agricultural exports and economic growth in Pakistan, attributing this to the country's reliance on low-value raw exports rather than processed agricultural goods. These studies highlight the importance of value addition in agricultural exports for maximizing trade benefits.

While the impact of agricultural exports on economic growth has been extensively studied, much less attention has been given to how food exports specifically affect agricultural sector performance. For instance, Mamba & Ali (2022) analyze ECOWAS countries — a regional bloc composed of 15 West African nations including Nigeria, Ghana, Senegal, and Côte d'Ivoire — and find that agricultural exports stimulate both agricultural and economic growth, but their study does not differentiate between food and non-food exports. Henneberry & Khan (2014) examine Pakistan and report that while agricultural exports contribute to GDP growth, they also create competition with the industrial sector for government resources, indicating that agricultural trade policies must be integrated with broader economic strategies.

Additionally, Erdinç & Aydınbaş (2023) investigate Turkey's agricultural exports, emphasizing their role in foreign exchange stability and noting that agricultural trade policies must evolve to support structural transformation. These findings suggest that food exports may have a distinct effect on agricultural value-added, differing from broader agricultural trade patterns. However, despite the critical importance of this issue, studies that directly investigate the role of food exports in enhancing agricultural value-added—particularly in the context of developing economies—remain scarce. This scarcity further underscores the contribution of the present study to the literature. There remains a clear research gap in this area due to the lack of panel studies on food exports and agricultural sector performance. Furhermore, while these studies provide valuable insights, few have specifically examined the impact of food exports on agricultural GDP in a panel data framework that accounts for heterogeneity and cross-sectional dependence.

In light of the existing literature, this study makes several important contributions. First, it specifically focuses on the relationship between food exports and agricultural value-added, rather than overall economic growth, providing a more direct sectoral perspective that has been largely overlooked. Second, it examines this relationship using a broad sample of developing countries, addressing a major gap in the empirical literature that often relies on single-country or small-sample analyses. Third, by applying advanced panel econometric techniques that account for slope heterogeneity, cross-sectional dependence, and long-run dynamics, the study ensures more robust and credible findings compared to previous research. Finally, the analysis offers practical policy implications tailored to different regional contexts, with particular emphasis on supporting smallholder farmers and promoting sustainable agricultural development. These contributions are intended to enrich the understanding of the role of food exports in agricultural sector performance and to provide relevant insights for policymakers in developing economies.

3. Materials and Methods

In this study, we examine the long run effect of food exports on agricultural growth in developing countries. The analyses rely on annual data from 2000 to 2019 due to a common data limitation across the model's variables. Consequently, the study focuses on a sample of 58 developing countries, listed in Table 1 below.

Table 1: List of the Countries

Argentina	China	Honduras	Mexico	Peru	Togo
Benin	Colombia	Hong Kong	Morocco	Philippines	Tunisia
Bolivia	Comoros	India	Mozambique	Qatar	Turkiye
Botswana	Costa Rica	Indonesia	Namibia	Rwanda	Uganda
Brazil	Ecuador	Israel	Nicaragua	Saudi Arabia	Uruguay
Burkina Faso	Egypt	Jordan	Niger	Senegal	Viet Nam
Burundi	El Salvador	Madagascar	Oman	South Africa	Zambia
Cabo Verde	Gabon	Malaysia	Pakistan	South Korea	Zimbabwe
Cameroon	Gambia	Mauritania	Panama	Tanzania	
Chile	Guatemala	Mauritius	Paraguay	Thailand	

The selection of developing countries as the focus of this study is driven by several critical economic and structural factors that differentiate them from advanced economies in the context of agricultural trade. Developing economies rely more on agriculture as a significant contributor to GDP and employment, making them particularly sensitive to changes in agricultural trade dynamics. Unlike developed countries, where agriculture constitutes a small share of GDP due to extensive industrialization and service sector expansion, many developing nations still experience a strong linkage between agricultural exports, rural development, and economic growth. Moreover, these countries often face institutional constraints, infrastructure deficiencies, and trade barriers that can moderate or amplify the impact of food exports on agricultural value-added. Additionally, global trade liberalization and regional trade agreements have increasingly shaped developing nations' agricultural trade patterns, making it essential to assess whether food exports serve as a viable driver of long-term economic transformation in these economies. Given these considerations, analyzing the relationship between food exports and agricultural growth in developing countries provides valuable insights into policy measures that can enhance the benefits of agricultural trade while mitigating associated risks.

This study employs an econometric model to investigate the impact of food exports on agricultural value-added in developing countries. The dependent variable is agriculture, forestry, and fishing value-added as a percentage of GDP, which measures agricultural sector's contribution to overall economic activity. The primary independent variable is food exports as a share of total merchandise exports, which captures the role of trade in shaping agricultural sector performance. To control for additional factors influencing agricultural value-added, GDP per capita, farm machinery per unit of agricultural land, and average years of schooling are included as explanatory variables. GDP per capita accounts for the effects of structural transformation, as economic development is typically associated with a declining agricultural GDP share. Mechanization, measured by farm machinery per unit of agricultural land, represents technological advancements and capital intensity in agricultural production. Average years of schooling serve as a proxy for human capital, reflecting the potential role of education in shaping labor productivity within the agricultural sector. All the variables were transformed into natural logarithmic forms to address scale differences and promote distributions that approximate normality. The summary information about the variables used in the analyses and descriptive statistics are presented in Table 2 and Table 3, respectively.

Table 2: Summary of Variables

Target Variable	Proxy Variable	Symbol	Definition	Source
Agricultural Growth	Agriculture, value added (% of GDP)	$AGRI$	Agriculture, forestry, and fishing, value added (% of GDP)	The World Bank (WB) – World Development Indicators (WDI)
Food Exports	Food exports (% of merchandise exports)	$FEXP$	Food exports (% of merchandise exports)	The WB – WDI
Economic Growth	Real GDP per capita	$GDPpc$	GDP per capita (constant 2015 US$)	The WB – WDI

Agricultural Mechanization	Farm machinery per unit of agricultural land	$MACH$	Farm machinery is measured in units of horsepower. This is divided by total agricultural land to give the average machinery use per 1000 hectares of agricultural land.	Our World in Data*
Education Level	Average years of schooling	$SCHOOL$	Average years of formal education for individuals aged 15-64.	Our World in Data**

** United States Department for Agriculture (USDA) Economic Research Service – processed by Our World in Data*
***Barro and Lee (2015); Lee and Lee (2016) – with major processing by Our World in Data*

Table 3: Descriptive Statistics

Değişkenler	No. of obs.	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
$AGRI$	1100	2.164	0.992	-2.362	3.787	-1.298	6.154
$FEXP$	1100	2.687	1.461	-7.459	4.584	-2.190	10.471
$GDPpc$	1100	8.081	1.230	5.567	11.310	0.071	2.437
$MACH$	1100	-2.218	2.049	-7.437	2.300	-0.394	2.993
$SCHOOL$	1100	1.778	0.512	-0.023	2.591	-1.195	4.069

Source: *Author's calculations*

The empirical model, constructed based on the defined sample and data range, is specified as follows:

$$AGRI_{it} = \beta_0 + \beta_2 FEXP_{it} + \beta_3 GDPpc_{it} + \beta_4 MACH_{it} + \beta_5 SCHOOL_{it} + \varepsilon_{it}$$

where $i = 1,2,3,\dots,N$ denotes cross-sectional units (countries), $t = 1,2,3,\dots,T$ represents the time dimension, and ε_it is the error term. This model framework facilitates a comprehensive examination of the relationship between food exports and agricultural sector performance while accounting for key economic, technological, and human capital determinants that influence the agricultural value-added in developing economies.

The selection of variables in the empirical model is informed by both theoretical considerations and insights from previous studies. Food exports (% of merchandise exports) are included as the main explanatory variable to capture the impact of international trade in agricultural products on sectoral growth, following the emphasis placed on agricultural trade and economic development by studies such as Mamba & Ali (2022) and Sanjuán - López & Dawson (2010). GDP per capita is incorporated to control for the effects of structural transformation, as higher income levels are typically associated with a declining share of agriculture in GDP (Diao et al., 2010; De Janvry & Sadoulet, 2010). Mechanization, measured as farm machinery per unit of agricultural land, is included to account for the role of technological adoption in shaping agricultural productivity (Binswanger & Townsend, 2000). Average years of schooling are added as a proxy for human capital, given that education can influence labor productivity and sectoral shifts, as suggested by endogenous growth models (Romer, 1990; Grossman & Helpman, 1991). Together, these variables allow for a comprehensive assessment of the determinants of agricultural value-added in the context of developing economies.

Panel data models offer a robust framework for analyzing the relationship between variables by incorporating both temporal dynamics and cross-country heterogeneity. However, obtaining unbiased and consistent estimates requires addressing key econometric properties, including stationarity, cross-sectional dependence, and cointegration. Failure to account for these factors may lead to spurious regressions and misleading inferences. To ensure the validity of the econometric approach, a series of diagnostic tests were conducted prior to model estimation, allowing for the selection of the most appropriate methodology for the given data structure.

To examine the long-term relationship between food exports and agricultural value-added in developing economies, we follow a structured methodological approach to ensure the econometric robustness and reliability of our estimates. The methodological steps undertaken in this study are as follows: i) Testing for slope heterogeneity: Given the diverse economic structures and agricultural policies across developing countries, it is crucial to assess whether slope coefficients vary across units. To test for heterogeneity, we employ the Delta test by Pesaran and Yamagata (2008), which evaluates the presence of non-homogeneous slope coefficients across panel units. If slope heterogeneity is detected, it justifies using heterogeneous estimators such as AMG and CCE rather than pooled estimators. ii) Testing for cross-sectional dependence (CSD): Since global shocks such as commodity price fluctuations, climate change, and trade liberalization can simultaneously influence multiple countries, failing to account for cross-sectional dependence may lead to biased standard errors and inefficient estimates. To detect cross-sectional dependence, we apply multiple tests, including the Lagrange multiplier (LM) test of Breusch and Pagan (1980), the bias-adjusted LM test (LM_adj) of Pesaran et al. (2008), and Pesaran's (2004) CD test (LM_CD). Multiple tests ensure robust detection of CSD, guiding the selection of appropriate estimators that mitigate bias from interdependencies among panel units. iii) Testing for stationarity: In panel data analysis, non-stationary variables can lead to spurious regressions, making it essential to verify whether the series are stationary. To address this, we employ Pesaran's (2007) cross-sectionally augmented Im, Pesaran, and Shin (CIPS) unit root test (an extension of the Im, Pesaran, and Shin (IPS) test of 2003), which accounts for cross-sectional dependence when testing for unit roots. This ensures that our variables are appropriately modeled and that long-run relationships can be meaningfully interpreted. iv) Testing for cointegration: Given that agricultural sector performance and trade-related indicators often exhibit long-term equilibrium relationships, it is necessary to confirm whether the variables in the model are cointegrated. To do so, we employ the Kao (1999), Pedroni (1999, 2004), and Westerlund (2005) tests of cointegration, which test for the existence of a stable long-run relationship between food exports, agricultural value-added, and other control variables. Establishing cointegration allows us to proceed with estimators that effectively capture both short-run and long-run dynamics. v) Estimating long-run coefficients: Once cointegration is confirmed, we estimate the long-run relationships using the CCE-MG estimator by Pesaran (2006) and the AMG estimator by Eberhardt and Bond (2009), both of which address cross-sectional dependence and heterogeneity. Additionally, we employ the Pooled Mean Group (PMG) estimator of Pesaran et al. (1999) to model short-run and long-run interactions while allowing for country-specific short-term adjustments.

By implementing these methodological steps, we ensure that our empirical analysis accounts for panel heterogeneity, cross-sectional dependence, stationarity properties, and long-run equilibrium relationships, thereby enhancing the robustness and interpretability of our findings on the impact of food exports on agricultural growth.

In sum, to ensure robustness and account for potential model specification issues, we employ three complementary estimators: PMG, AMG, and CCE-MG. The PMG estimator, developed by Pesaran et al. (1999), allows for heterogeneous short-run dynamics and error variances across groups while constraining long-run relationships to be homogeneous. The AMG estimator, proposed by Eberhardt and Bond (2009), accounts for unobserved common factors and cross-sectional dependence while allowing for heterogeneity across countries. The CCE-MG estimator, developed by Pesaran (2006), controls for cross-sectional dependence by including cross-sectional averages of the dependent and independent variables and permits fully heterogeneous slope coefficients. These methods are widely regarded for their superior performance in heterogeneous and cross-sectionally dependent panel settings. Given the extensive range of econometric methods applied, detailed mathematical formulations are not presented here; interested readers are referred to the original methodological studies cited in this section for further technical details.

4. Empirical Findings

The results of the Pesaran and Yamagata (2008) homogeneity test, presented in Table 4, provide crucial insights into the structure of the panel data analyzed in this study. This test evaluates the assumption of slope homogeneity across cross-sectional units, which is a key consideration in selecting the appropriate econometric methodology. The highly significant test statistics strongly reject the null hypothesis of slope homogeneity, indicating substantial differences in the estimated relationships across the countries in the panel. These findings suggest that the impact of food exports on agricultural value-added varies considerably across developing economies, likely due to structural differences in agricultural production systems, trade policies, technological adoption, and institutional frameworks. The presence of heterogeneous slope coefficients implies that applying estimators that assume a common slope for all cross-sectional units, such as fixed effects or random effects models, may introduce bias and lead to misleading conclusions. Instead, methodologies that explicitly accommodate heterogeneous slope coefficients, such as the AMG estimator, the CCE-MG estimator, or the PMG estimator, are more suitable for capturing the underlying economic relationships.

Table 4: Pesaran ve Yamagata (2008) Homogeneity Test

Test	Test Statistic
$\tilde{\Delta}$	22.758*
$\tilde{\Delta}_{adj}$	27.201*

Notes: ** p<0.01. The null hypothesis of slope homogeneity is tested using the standardized dispersion test proposed by Pesaran and Yamagata (2008), which follows a standard normal distribution under the null hypothesis. The critical values are approximately ±1.645 (10% significance), ±1.960 (5% significance), and ±2.576 (1% significance).*

In conclusion, the highly significant rejection of the homogeneity assumption underscores the necessity of employing econometric techniques that account for country-specific variations in the impact of food exports on agricultural growth (Pesaran and Tosetti, 2011). Failing to do so could obscure important cross-country differences and lead to erroneous policy recommendations.

The results of the cross-sectional dependence tests, presented in Table 5 and Table 6, provide strong evidence that the panel dataset exhibits significant cross-sectional dependence. Cross-sectional dependence arises when unobserved common factors—such as global economic trends, international trade policies, climate variability, or financial market fluctuations—simultaneously affect multiple countries in the panel. All the tests yield highly significant test statistics at the 1% level, confirming the presence of strong cross-sectional dependence across panel units. Furthermore, the Pesaran (2004) CD test results for individual variables (Table 6) indicate that each variable in the model exhibits significant cross-sectional dependence, with test statistics far exceeding conventional significance thresholds. These findings suggest that agricultural value-added, food exports, and control variables are influenced by global and regional factors, such as trade policies, financial integration, and technological diffusion, which simultaneously shape agricultural and economic dynamics across multiple countries.

Table 5: Cross Sectional Dependency Tests

Test	Test Statistic
LM	2049*
LM_{adj}	12.14*
LM_{CD}	3.407*

Note: ** p<0.01. The null hypothesis of cross-sectional independence is tested using the LM test (Breusch and Pagan, 1980), the bias-adjusted LM test (Pesaran et al., 2008), and the CD test (Pesaran, 2004). All tests follow a standard normal distribution under the null. Critical values are approximately ±1.645 (10% significance), ±1.960 (5% significance), and ±2.576 (1% significance).*

Table 6: Cross Sectional Dependency Test for Variables (Pesaran CD Test)

Variables	CD Test Statistic (p-value)
$AGRI$	39.672*
$FOODEXPORTS$	11.378*
$GDPpc$	114.34*
$MACHINERY$	5.137*
$SCHOOL$	145.335*

Note: ** p<0.01. The null hypothesis of cross-sectional independence for each variable is tested using the Pesaran (2004) CD test, which follows a standard normal distribution under the null. Critical values are approximately ±1.645 (10% significance), ±1.960 (5% significance), and ±2.576 (1% significance).*

Given the strong presence of cross-sectional dependence, using first-generation panel unit root tests would be inappropriate, as these tests assume cross-sectional independence and could lead to misleading conclusions about stationarity. Instead, second-generation unit root tests should be employed to account for cross-sectional interdependencies. Therefore, we employ both Pesaran's (2007) Cross-Sectionally Augmented Im-Pesaran-Shin (CIPS) test and the Cross-Sectionally Augmented Dickey-Fuller (CADF) test. These tests account for common factors across cross-sectional units, allowing for more reliable inference regarding the stationarity properties of the variables. Additionally, estimators that explicitly address cross-sectional dependence, such as the CCE-MG estimator or AMG estimator, are more suitable for ensuring robust inference.

The results, presented in Table 7, indicate that all variables in the model are integrated of order one, I(1). This suggests that the variables exhibit unit roots in their levels but become stationary after first differencing, implying the presence of long-run stochastic trends. The finding that all variables are I(1) confirms that they share common underlying stochastic trends, making cointegration analysis necessary to determine whether a stable long-run equilibrium relationship exists among them. If the variables are cointegrated, it implies that despite short-term fluctuations, they move together in the long run, justifying the application of long-run panel estimation techniques such as the PMG, AMG, and CCE-MG estimators. These results validate the empirical approach taken in the study, ensuring that econometric techniques applied in the subsequent analysis properly account for the dynamic properties of the data.

Table 7: CADF and CIPS Unit Root Tests

	CADF		*CIPS*	
Variables	Level	First Difference	Level	First Difference
$AGRI$	-2.283	-3.426*	-2.449	-4.505*
$FOODEXPORTS$	-2.244	-3.430*	-2.375	-4.318*
$GDPpc$	-2.226	-2.641*	-1.961	-3.457*
$MACHINERY$	-2.069	-2.697*	-2.227	-4.014*
$SCHOOL$	-2.155	-2.579*	-1.622	-2.666†

Note: ** p<0.1, † 0.01<p<0.05. Although the CADF test is theoretically unit-specific, in practice, the reported CADF statistic in Stata represents an aggregated panel-level result based on individual country regressions. The CIPS statistic is similarly based on the average of these CADF t-statistics across countries (Pesaran, 2007). The null hypothesis of unit root is tested using the CIPS test proposed by Pesaran (2007). Under the null hypothesis, the CIPS statistic follows a standard normal distribution asymptotically. The critical values are approximately ±1.645 (10% significance), ±1.960 (5% significance), and ±2.576 (1% significance).*

Before estimating long-run relationships, we conduct panel cointegration tests to assess whether the variables in the model exhibit a stable equilibrium relationship over time. The results of the Westerlund (2008), Pedroni (1999, 2004), and Kao (1999) tests, presented in Table 8, provide strong evidence of cointegration among the variables. Although the Pedroni (1999, 2004) and Kao (1999) panel cointegration tests are widely used, they assume cross-sectional independence among units. Given the evidence of cross-sectional dependence in our panel, we interpret the Pedroni and Kao results with caution. The Westerlund (2005) test, which accounts for some forms of cross-sectional dependence, is given greater emphasis in our analysis. Nevertheless, Pedroni and Kao test results are reported for comparison and robustness purposes. Specifically, the variance ratio statistic from the Westerlund test is significant at the 1% level, indicating the presence of long-run relationships. Similarly, the Pedroni test statistics strongly reject the null hypothesis of no cointegration, further confirming that the variables move together in the long run. While some test statistics from the Kao (1999) test show weaker evidence of cointegration, the Unadjusted Modified Dickey-Fuller t and Unadjusted Dickey-Fuller t are both highly significant, reinforcing the presence of a long-run equilibrium relationship. The significance of these cointegration tests validates the application of long-run estimation techniques that appropriately account for the equilibrium relationships among the variables.

Table 8. Cointegration Tests

Test	*Test Statistics*
Westerlund	
Variance Ratio	-2.836*
Pedroni	
Modified Phillips − Perron t	5.995*
Phillips − Perron t	-11.279*
Augmented Dickey − Fuller t	-9.811*
Kao	
Modified Dickey − Fuller t	-0.690
Dickey − Fuller t	-1.853†
Augmented Dickey − Fuller t	0.912
Unadjusted Modified Dickey − Fuller t	-2.624*
Unadjusted Dickey − Fuller t	-3.063*

Note: ** p<0.1, † 0.01<p<0.05. The null hypothesis of no cointegration is tested using the panel cointegration tests proposed by Westerlund (2005), Pedroni (1999, 2004), and Kao (1999). Under the null hypothesis, the test statistics asymptotically follow a standard normal distribution. The critical values are approximately ±1.645 (10% significance), ±1.960 (5% significance), and ±2.576 (1% significance).*

Given these findings, employing estimation methods that explicitly incorporate cointegration is necessary to obtain reliable long-run coefficients. Techniques such as the PMG, AMG, and CCE-MG estimators are particularly well-suited for this analysis, as they effectively address heterogeneity, cross-sectional dependence, and dynamic adjustments in the panel data. Additionally, these methods are robust to endogeneity and serial correlation, which are common concerns in panel cointegration analysis.

Specifically, the PMG estimator assumes long-run homogeneity across countries while allowing short-run dynamics to vary. It is particularly useful for analyzing dynamic relationships and determining both short-term adjustments and long-run equilibrium effects. Additionally, it corrects for endogeneity via an error correction mechanism, ensuring that long-run relationships are not biased by omitted short-run fluctuations. The AMG estimator is a non-parametric approach that accounts for unobserved heterogeneity across countries. Unlike PMG, AMG allows all coefficients to vary across countries, providing more flexible estimates that capture structural differences in agricultural production and trade systems. This method is particularly useful in cases where the impact of food exports might differ due to country-specific institutional, climatic, or technological conditions. The CCE-MG estimator further improves robustness by controlling for cross-sectional dependence, which arises when unobserved global shocks, such as climate change, trade fluctuations, or technological advancements, affect all countries in the panel. This method minimizes omitted variable bias due to common factors, producing more reliable estimates when global trends and structural interdependencies are present in the data.

The results are summarized in Table 9. To ensure robust and stable estimates, we implement a stepwise inclusion of variables in the estimation models (AMG, PMG, and CCE-MG). Instead of including all independent variables simultaneously, we introduce them one by one to assess their incremental contribution to the model. This approach allows us to examine the stability of estimated coefficients across different model specifications and reduce potential issues of multicollinearity and omitted variable bias. This also ensures that the effects observed for food exports and control variables are not driven by model specification but reflect underlying economic relationships. This stepwise methodology strengthens the interpretability and reliability of the findings, allowing for a clearer assessment of the individual and combined effects of food exports, GDP per capita, mechanization, and schooling on agricultural value-added.

Table 9. Panel Cointegration Coefficients Estimation Results

Var	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)	Model (8)
AMG								
Fexp	0.16*	0.16*	0.17*	0.16*	0.17*	0.15*	0.17*	0.16*
	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.05)	(0.04)
GDP_{pc}		-0.43*			-0.58*	-0.41*		-0.54*
		(0.13)			(0.14)	(0.16)		(0.18)
MACH			-0.06		-0.08		-0.07	-0.05
			(0.09)		(0.11)		(0.09)	(0.09)
SCHOOL				-0.15		-0.02	-0.13	-0.01
				(0.28)		(0.32)	(0.28)	(0.31)
CONS	1.88*	5.74*	1.78*	2.06*	6.62*	5.79*	1.94*	6.51*
	(0.20)	(0.98)	(0.29)	(0.54)	(1.06)	(1.29)	(0.58)	(1.25)
CCE								
Fexp	0.18*	0.17*	0.17*	0.21*	0.14*	0.17*	0.17*	0.11*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.04)	(0.05)	(0.05)	(0.04)
GDP_{pc}		-0.28			-0.25	$-0.42^{\dagger}$		$-0.43^{\ddagger}$
		(0.20)			(0.20)	(0.20)		(0.24)
MACH			-0.08		-0.08		-0.06	-0.10
			(0.09)		(0.09)		(0.09)	(0.10)
SCHOOL				-0.20		0.30	-1.49	0.50
				(0.69)		(0.70)	(1.27)	(0.73)
CONS	-0.57	1.97	-0.29	-0.03	3.20	-0.20	1.72	-0.59
	(0.52)	(1.98)	(0.93)	(1.16)	(2.13)	(2.59)	(2.13)	(2.93)
PMG								
Fexp	0.13*	0.06*	0.33*	0.24*	0.31*	0.22*	0.33*	0.22*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
GDP_{pc}		-0.12*			-0.51*	-0.26*		-0.31*
		(0.03)			(0.03)	(0.03)		(0.03)
MACH			-0.34*		-0.01		$-0.08^{\dagger}$	0.05
			(0.03)		(0.03)		(0.04)	(0.03)
SCHOOL				-0.15*		-0.53*	-0.15*	-0.52*
				(0.04)		(0.05)	(0.04)	(0.06)
ec	-0.26*	-0.27*	-0.22*	-0.28*	-0.25*	-0.27*	-0.27*	-0.28*
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
ΔFexp	0.14*	0.14*	0.11*	0.11*	0.10*	0.10*	0.10*	0.09*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)	(0.03)
ΔGDP_{pc}		-0.14			-0.06	-0.02		-0.06
		(0.18)			(0.19)	(0.23)		(0.21)
ΔMACH			-0.09		-0.11		$-0.11^{\ddagger}$	-0.05
			(0.08)		(0.07)		(0.06)	(0.05)
ΔSCHOOL				2.74		2.71	2.98	2.67
				(2.80)		(2.37)	(3.05)	(2.33)
CONS	0.48*	0.79*	$0.09^{\dagger}$	0.43*	1.33*	1.20*	0.27*	1.35*
	(0.08)	(0.10)	(0.04)	(0.09)	(0.21)	(0.19)	(0.08)	(0.22)

Note: *Standard errors in parentheses. * $p<0.1$, † $0.01<p<0.05$, ‡ $0.05<p<0.10$. Models 1 to 7 incrementally introduce different control variables to assess the stability of the estimated coefficients. Model 8 includes all independent variables simultaneously, representing the full specification.*

Across all three estimation methods, food exports consistently exhibit a positive and statistically significant long-run effect on agricultural value-added. The estimated coefficients range from 0.11 to 0.33, suggesting that an increase in food exports leads to a higher share of agriculture in GDP. However, the magnitude of this effect varies depending on the estimation technique used.

PMG, which assumes a homogeneous long-run relationship, estimates more substantial long-run effect of food exports (0.22–0.33) than AMG (0.15–0.17) and CCE (0.11–0.21). This suggests that after controlling for dynamic adjustments, the impact of food exports on agricultural GDP is more pronounced. The variation in magnitudes indicates that, in the long run, export-led agricultural growth is reinforced by stable economic conditions, efficient trade policies, and improvements in export infrastructure. Countries with better-developed supply chains and institutional frameworks likely experience stronger effects of food exports on agricultural GDP.

Regarding GDP per capita, all methods confirm the structural transformation hypothesis, with a negative and statistically significant relationship between GDP per capita and agricultural GDP share. However, the magnitude of this negative effect is largest in AMG (-0.41 to -0.58), followed by CCE (-0.28 to -0.43), and smallest in PMG (-0.12 to -0.51). The smaller coefficient in PMG suggests that the decline of agriculture's GDP share is moderated over time due to other structural factors such as agricultural modernization, government support for rural economies, or global demand for food exports. These findings imply that the shift away from agriculture is inevitable as economies develop. Still countries with strong food export strategies may experience a more gradual transition, allowing the sector to retain significance despite industrialization.

Mechanization (MACH) is not significant in AMG or CCE but is negative and significant in PMG (-0.34 to -0.08 in some models), suggesting that while mechanization may increase productivity, it does not necessarily increase agriculture's GDP share and may even reduce it due to labor displacement. This finding aligns with concerns that mechanization, when not accompanied by broader rural employment strategies, may lead to declines in agricultural labor force participation, accelerating structural shifts away from agriculture without necessarily increasing GDP share.

Similarly, schooling (SCHOOL) shows a negative effect in PMG (-0.15 to -0.53), while it is mostly insignificant in AMG and CCE, indicating that education may contribute to labor migration away from agriculture. These findings suggest that increased educational attainment leads to shifts in labor from agriculture to higher-productivity sectors, reinforcing structural transformation. The policy implication is that while education is crucial for long-term economic growth, targeted agricultural training programs are necessary to ensure that the agricultural sector benefits from human capital improvements.

5. Conclusion and Discussion

This study investigates the impact of food exports on agricultural value-added in developing economies over the period 2000–2019. Using a comprehensive panel dataset and advanced econometric techniques—namely PMG, AMG, and CCE-MG estimators—we ensure the robustness and reliability of the findings by addressing cross-sectional dependence, heterogeneity, and dynamic adjustment processes.

The results consistently confirm that food exports positively contribute to agricultural value-added. An expansion in food exports increases the agricultural sector's contribution to GDP, providing evidence that trade-driven strategies can enhance sectoral growth in developing economies. Based on this finding, it is recommended that developing countries pursue agricultural trade promotion policies while ensuring that export-oriented growth does not undermine domestic food security. Investments in rural infrastructure, market access facilities, and export certification processes are crucial to maximizing the benefits of food trade expansion.

The analysis further shows that higher GDP per capita is associated with a declining share of agriculture in GDP, reflecting the structural transformation process. In light of this finding, policies should focus on supporting rural economic diversification, enhancing value-added agricultural industries, and facilitating the integration of rural workers into higher-productivity sectors without jeopardizing agricultural sustainability.

Regarding mechanization, the results indicate mixed effects: while mechanization can enhance productivity, it may also displace agricultural labor and reduce agriculture's share in GDP. Therefore, mechanization policies should be designed carefully, promoting inclusive technologies that enhance smallholder productivity without accelerating premature labor displacement. Complementary programs, such as rural entrepreneurship development and off-farm employment opportunities, are essential.

Similarly, the findings reveal that higher education levels are associated with a labor shift away from agriculture. As a policy implication, education systems in developing economies should include specialized agricultural training, vocational programs, and agricultural innovation support to ensure that the sector benefits from human capital improvements rather than losing skilled labor entirely to other sectors.

Importantly, the analysis highlights that the positive effects of food exports on agricultural growth are more substantial in the long run compared to the short run. In the short term, market rigidities, infrastructural constraints, and adjustment frictions may limit the immediate gains from expanding food exports. Over time, however, food exports can stimulate technological investment, enhance agricultural productivity, and support broader sectoral modernization, provided that appropriate complementary policies are in place.

In comparison with existing studies, the findings of this research are broadly consistent with the literature emphasizing the positive role of agricultural trade in sectoral growth. For instance, Mamba and Ali (2022) find that agricultural exports significantly contribute to agricultural value-added in ECOWAS countries, aligning with the positive impact observed in our analysis. Similarly, Henneberry and Khan (2014) report that agricultural exports enhanced agricultural performance and sectoral competitiveness in Pakistan, which is in line with the long-run effects identified in this study. However, while some studies such as Verter and Bečvářová (2016) highlight strong short-run effects of agricultural exports on sectoral growth in Nigeria, our findings suggest that short-run effects are relatively limited, possibly due to structural rigidities and adjustment costs in the broader developing country context. Moreover, whereas previous studies primarily focused on national-level aggregates, our approach emphasizes heterogeneity across developing regions and offers more nuanced policy recommendations targeting Africa, Asia, and Latin America. This differentiation represents a contribution to the literature by highlighting that the benefits of food exports are neither immediate nor uniform across regions.

The effects of food exports on agricultural value-added are likely to vary across developing regions. In African economies, where subsistence farming remains prevalent, policies should prioritize improving rural infrastructure, expanding farmers' access to export markets, and strengthening institutional support mechanisms. In many Asian economies, where smallholders are increasingly integrated into global value chains, policy efforts should focus on enhancing the quality and safety standards of food exports, promoting agro-processing industries, and supporting technological upgrading. In Latin American countries, where agricultural exports already play a significant role, strategies should aim to enhance value addition, diversify agricultural exports, and ensure environmental sustainability to maintain competitiveness in global markets.

Special attention must also be given to the role of small-scale farmers, whose participation in export markets remains constrained by limited access to technology, finance, and information. Strengthening smallholders' access to modern agricultural technologies, improving rural extension services, supporting farmer cooperatives, and facilitating their integration into value chains are essential steps to ensure that export-driven growth strategies are inclusive. By promoting smallholder participation in food exports, developing economies can foster more equitable rural development, enhance resilience against global market volatility, and contribute to sustainable agricultural growth.

Overall, the findings of this study suggest that while food exports offer considerable opportunities for enhancing agricultural sector performance in developing economies, realizing these benefits requires comprehensive and inclusive policy frameworks. Agricultural policies should be designed holistically, integrating trade promotion, technological upgrading, human capital development, and rural infrastructure investment to ensure that export-driven agricultural growth translates into sustainable and inclusive economic transformation.

Despite the robustness of the findings, this study has several limitations. First, data constraints limited the scope of variables included in the analysis; important factors such as detailed agricultural subsidies, land tenure structures, and environmental shocks were not explicitly controlled for. Second, the study focuses on aggregate national-level data, which may mask within-country heterogeneity such as regional disparities or differences across farm sizes. Third, while the methodology accounts for cross-sectional dependence and heterogeneity, potential dynamic feedback mechanisms between agricultural growth and food exports could not be fully explored within the chosen empirical framework.

Future research could address these limitations by utilizing micro-level farm data, exploring causal mechanisms with instrumental variable approaches, or conducting comparative analyses across income groups within developing economies. Additionally, further studies could investigate the environmental sustainability implications of food export expansion, or the role of global value chain participation in mediating the relationship between food exports and agricultural development outcomes.

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