Signifikan: Jurnal Ilmu Ekonomi
Volume 15(1), 2026: 67 - 82
P-ISSN: 2087-2046; E-ISSN: 2476-9223
https://doi.org/10.15408/sjie.v15i1.49654

Revisiting Trade Liberalization for Agriculture Productivity: Dynamic Evidence from a Global Panel of Countries

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JEL Classification:
F13
Q17
O47
C23

Received: 15 December 2025

Revised: 05 March 2026

Accepted: 15 March 2026

Available online: April 2026

Published regularly: April 2026

ABSTRACT

Research Originality: This study contributes to the literature by providing a comparative analysis of the dynamic relationship between agricultural trade liberalisation and total factor productivity (TFP) growth across income groups. It highlights how differences in structural capacity and innovation systems shape heterogeneous productivity outcomes across countries.

Research Objectives: This study re-examines the dynamic impact of agricultural trade liberalisation on TFP growth across income groups and identifies the mechanisms underlying divergent productivity outcomes.

Research Methods: A panel Autoregressive Distributed Lag (ARDL) model is applied to panel data from 35 major agricultural-producing countries over the period 2007–2024 to capture heterogeneous short-run dynamics and common long-run relationships.

Empirical Results: The results reveal heterogeneous effects. Trade liberalisation significantly increases TFP growth in high-income countries through stronger technology diffusion and absorptive capacity. However, it generates weak or negative effects in middle-income countries due to structural constraints and limited innovation capacity.

Implications: Agricultural trade liberalisation does not automatically enhance productivity; its benefits depend on domestic structural readiness and innovation capacity.

Keywords:

heterogeneous trade effects; transmission channels; structural readiness; cross country Analysis

How to Cite:

Yunita, M., Setyaningrum, I., & Hariadi, S. (2026). Revisiting Trade Liberalization for Agricultural Productivity: Dynamic Evidence from a Global Panel of Countries. *Signifikan: Jurnal Ilmu Ekonomi*, *15*(1), 67-82. https://doi.org/10.15408/sjie.v15i1.49654.

INTRODUCTION

Agricultural trade liberalization has long been promoted as a key strategy to improve efficiency, facilitate technological diffusion, and enhance productivity in global agriculture (Barros & Martínez-Zarzoso, 2022; Bilgin, 2019; Ma et al., 2025; Sukoco et al., 2020). Reducing trade barriers through liberalization is expected to intensify competition, expand access to modern inputs, and support reallocation of resources toward sectors with comparative advantage (Dinh et al., 2020; Zhou & Ji, 2022). Within this framework, total factor productivity (TFP) represents the primary mechanism through which trade openness translates into sustained agricultural performance (Solow, 1957).

Nevertheless, the empirical relationship between agricultural trade liberalisation and productivity remains highly contested. A substantial body of research has documented the positive impact of trade openness on productivity, particularly in developed countries (Farrokhi & Pellegrina, 2023; Xu et al., 2023). While some countries have experienced sustained TFP growth following trade openness, others have faced stagnant or declining productivity despite deeper integration into global market structures (Sunge & Ngepah, 2022).. These outcomes, which are divergent from the conventional assumption that trade liberalisation is inherently productivity-enhancing, point to a trade liberalisation paradox in global agriculture. As demonstrated by Bai et al. (2024), there is clear evidence that comparable liberalisation policies result in significantly divergent productivity levels across countries.

Theoretically, trade liberalization influences agricultural productivity through several interconnected transmission channels rather than through a direct and automatic mechanism (Dinh et al., 2020; Zhou & Ji, 2022). These channels include technology diffusion through imported machinery and intermediate inputs (Wang et al., 2021). Incentives for domestic research and development (R&D) arising from competitive pressure (Barros & Martínez-Zarzoso, 2022). The real exchange rate that shapes the price competitiveness of agricultural production (Hung, 2021). When these mechanisms function effectively, liberalization can support long-run productivity growth. When domestic innovation capacity is weak or macroeconomic conditions are unstable, however, exposure to global competition may undermine agricultural productivity (Fiankor et al., 2021; FAO, 2022).

The observed heterogeneity in productivity responses highlights the importance of country-specific absorptive capacity. Developed countries typically possess stronger innovation systems, more developed financial markets, and better infrastructure (Yunita et al., 2022). This condition enables them to internalize foreign technologies and convert trade openness into productivity gains (Xu et al., 2023). In contrast, many developing countries face structural constraints, including limited human capital and weak innovation institutions (Feriansyah, 2020). Under such conditions, trade liberalization may intensify import competition without generating compensating productivity improvements, leading to weak or negative long-run effects on agricultural TFP (Sunge & Ngepah, 2022).

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Despite the substantial research conducted on trade liberalisation and productivity, several significant gaps remain. A substantial proportion of the extant literature relies on static or semi-dynamic panel approaches to estimate average effects, including fixed effects, GMM, and DEA (Dai et al., 2023; Liu et al., 2020; Xu et al., 2023). This tendency to prioritise average effects can lead to misinterpretations of short-run adjustment dynamics and long-run productivity divergence across countries. Furthermore, trade liberalisation is frequently regarded as a homogeneous catalyst for productivity enhancement. However, limited attention has been paid to the transmission mechanisms and structural conditions that generate asymmetric outcomes across countries. Consequently, extant studies furnish a paucity of responses to the question of why analogous liberalisation policies engender advantageous outcomes for certain nations while concomitantly engendering disadvantageous outcomes for others (Hung, 2021; Wang et al., 2021)

The present study aims to address the aforementioned gaps by conducting a thorough examination of the dynamic effects of agricultural trade liberalisation on TFP growth. The study also explicitly identifies the key factor that drives asymmetric productivity outcomes across different country contexts. The analysis uses panel data from 35 major agricultural producing countries over the period 2007–2024. Employing a panel autoregressive distributed lag (ARDL) framework, the study captures heterogeneous short-run dynamics alongside common long-run relationships (Jabuya et al., 2023; Pesaran et al., 1999). It also implicitly incorporates transmission channels, such as technology diffusion, R&D investment, and real exchange rate (Wang et al., 2021; Yunita et al., 2017).

The novelty of this study lies in its methodological innovation and in its integrated explanation of why trade liberalisation generates asymmetric productivity outcomes across countries. The present study has sought to demonstrate that trade liberalisation is not, in itself, a productive force. To achieve this objective, the study has documented and explained the paradox of trade liberalisation. The findings further emphasise the importance of aligning liberalisation strategies with domestic absorptive capacity and structural readiness.

METHODS

The present study employs balanced panel data covering 35 countries over the period 2007–2024. The selection of these countries is based on two main considerations. Firstly, the sample includes countries that make significant contributions to global agricultural production. The analysis is thus guaranteed to reflect economies that are highly relevant to global agricultural productivity and trade. Secondly, the selected countries represent a range of income levels, thus enabling the study to examine how the effects of agricultural trade liberalisation vary across stages of economic development. In accordance with the World Bank's income classification system, countries are categorised into three distinct income groups: high income, upper-middle income, and lower-middle income. The following countries have been designated as high-income countries: the United States, France, Australia, Japan, Italy, Spain, South Korea, Canada, Germany, the United Kingdom, the Netherlands, Poland, and Chile. The following countries have been designated as upper-middle-income countries: China, Brazil, Russia, Argentina, Turkey, Mexico, Iran, Thailand, Malaysia, Colombia, and Peru. The following countries have been designated as lower-middle-income countries: India, Indonesia, Nigeria, Pakistan, Bangladesh, Vietnam, the Philippines, Kenya, Egypt, Morocco, and Ukraine. This classification facilitates a comparative analysis of structural differences in productivity, trade openness, and technological capacity across income groups (Martínez-Zarzoso & Chelala, 2021).

Table 1 summarizes the variables used in this study along with their definitions, measurements, and data sources. Agricultural productivity is measured as the percentage growth in TFP relative to 2005, in accordance with the methodology developed by Fuglie (2019). The term 'Agricultural TFP' denotes the efficiency with which the agricultural sector converts all inputs (land, labour, capital, and intermediate inputs) into agricultural output. It has been demonstrated that such gains are not driven by increased input use, but rather by improvements in technology, efficiency, management practices, institutional quality, and resource allocation. The concept of agricultural trade liberalization is measured by an agricultural trade openness index, calculated as the ratio of total agricultural exports and imports to GDP. The data for this variable is obtained from FAOSTAT.

Table 1. Description of Variables

Data	Definition	Unit of Measurement	Literature Source
Agricultural Productivity	Represents the percentage growth of Total Factor Productivity (TFP) in the agriculture and livestock sectors, calculated relative to the base year 2005.	Percentage	Fuglie (2019)
Agricultural Trade Liberalization	% GDP	FAOSTAT	Sunge & Ngepah (2022)
Technology Transfer	Index	Unesco institute for statistic	Sunge & Ngepah (2022)
Research and development	% GDP	Govdata world bank	Sunge & Ngepah (2022)
Real effective exchange rate	Percentage	Brugel Dataset	Sunge & Ngepah (2022)

Source: Author Calculation

Research and development (R&D) is measured as total R&D expenditure as a percentage of GDP, reflecting national investment in innovation capacity. The data have been sourced from UNESCO, in accordance with the approach of Sunge and Ngepah (2022). The transfer of technology is measured using an index ranging from 1 to 7. Higher values indicate greater technology transfer through international trade. This

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index is derived from the Global Competitiveness Index, which is published by the World Economic Forum, and reflects firms' access to foreign technologies embedded in imports. The real effective exchange rate (REER) is constructed from the Consumer Price Index (CPI) and incorporates trade with 172 partner countries. The REER data are obtained from Bruegel and capture international price competitiveness effects relevant for agricultural exports and imports.

To analyze both short-run and long-run relationships between agricultural trade liberalization and productivity growth, this study employs the panel Autoregressive Distributed Lag (ARDL) model developed by Pesaran et al. (1999). The panel ARDL is particularly appropriate for this study for three main reasons. First, it accommodates variables with mixed orders of integration, I(0) and I(1), without requiring all variables to be stationary at the same level. Second, it allows for the estimation of long-run equilibrium relationships alongside short-run dynamic adjustments. Third, it permits heterogeneity across countries, enabling country-specific short-run coefficients while maintaining common long-run relationships within income groups.

In the model, agricultural TFP growth is the dependent variable. The explanatory variables include agricultural trade openness, technology transfer, R&D expenditure, and the real effective exchange rate. The panel ARDL framework is specified as ARDL (p, q, q, q, q). The lag structure captures dynamic adjustments over time. The error correction term reflects the speed at which short-run deviations converge toward the long-run equilibrium. These variables can be expressed in the form of a panel ARDL (*p,q,q,...,q*) equation as follows:

$$gtfp_{it} = \theta_i(\Delta gtfp_{it-1} - \lambda_i^{'}Xit) + \sum_{j=1}^{p-1}\xi_{ij}\Delta gtfp_{it-j} + \sum_{j=0}^{q-1}\beta_{ij}^{'}\Delta X_{it-j} + \phi_i + e_{it} \qquad (1)$$

Where X is the vector of explanatory variables, X (agrTO, tech_trf, R&D, REER), $\theta_i = -(1-\delta_i)$ as the coefficient of the group specific of adjustment (which is expected to $(\theta_i < 0)$. λ'_i is the vector of long-run relationships. $ECT = (gtfp_{it-1} - \lambda'_i X_{it})$ is the error correction term, and finally ξ_{ij}, β'_{ij} is the dynamic short-run coefficient.

Prior to estimation, a series of diagnostic tests is conducted to ensure the validity of the panel ARDL framework. The results of the stationarity test presented in Table 2, using the Im, Pesaran, and Shin (IPS) approach variables across all income groups have a mixed order of integration (I(0) and I(1)). These findings confirm that the Panel ARDL model is suitable for capturing both short and long-run relationships.

The results of the Pedroni cointegration test in Table 3 indicate a long-run relationship between agricultural trade liberalization and agricultural productivity growth across all income groups, though with varying degrees of strength.These results justify the use of the panel ARDL methodology. Furthermore, the Pedroni panel cointegration test provides strong evidence of a long-run cointegrating relationship between agricultural productivity growth and its determinants across all income groups. Although the strength of cointegration varies, the overall results confirm the presence of long-term equilibrium relationships and validate the empirical model.

Table 2. Unit Root Test

Country Group	Variable	Im, Pesaran and Shin (IPS)	Level
High income	Gtfp	-8.887*** (0.000)	I(0)
	agrTO	-1.395* (0.081)	I(0)
	Tech_trf	-3.397** (0.003)	I(1)
	RnD	-4.026*** (0.000)	I(1)
	REER	-3.162** (0.008)	I(0)
Middle upper	Gtfp	-5.834*** (0.000)	I(0)
	agrTO	-2.129** (0.000)	I(0)
	Tech_trf	-4.704*** (0.000)	I(1)
	RnD	-2.934** (0.002)	I(1)
	REER	-5.166*** (0.000)	I(0)
Middle lower	Gtfp	-5.774*** (0.000)	I(0)
	agrTO	-8.439*** (0.000)	I(1)
	Tech_trf	-6.292*** (0.000)	I(1)
	RnD	-3.815*** (0.000)	I(1)
	REER	-3.806*** (0.0000)	I(1)

Source: Author Calculation

Table 3. Results of the Panel Cointegration Test

Country Group	Pedroni residual cointegration test common AR coefficients (within dimension)				Common AR coefficients (between dimensions)		
	Panel v-statistic	Panel rho-statistic	Panel PP-statistic	Panel ADF-statistic	Group rho-statistic	Group PP-statistic	Group ADF-statistic
High income	-0.967	-1.398	-17.24**	-4.075**	-0.074	-21.65**	-4.695**
Middle upper	-0.146	-2.044**	-15.29**	-4.382**	-0.934	-18.76**	-1.235
Middle lower	-0.223	-3.259**	-14.59**	-1.01	-2.207**	-18.76**	-0.225

Note: The t table value is 2.07387, and alpha 5%

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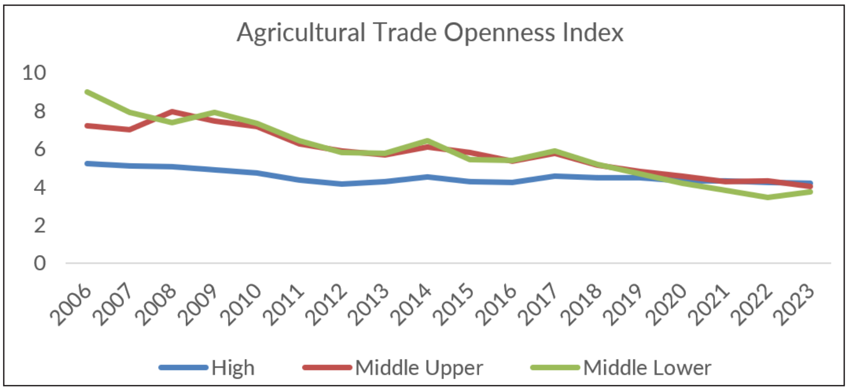
RESULTS AND DISCUSSION

The subsequent section provides a synopsis of the principal empirical findings, followed by an exhaustive discussion of the long-run and short-run mechanisms. The primary conclusions from this analysis are as follows. Firstly, the process of agricultural trade liberalisation has been shown to exert a positive and statistically significant long-run effect on TFP growth in high-income countries. Whilst the impact is deemed negative or insignificant in upper- and lower-middle-income countries. Secondly, technology transfer and R&D investment emerge as transmission channels. Thirdly, the short-run effects of trade liberalisation are highly heterogeneous across countries. The findings of this study provide robust empirical evidence supporting the existence of a trade liberalization paradox in global agriculture. The conclusion drawn is that analogous liberalisation policies engender disparate productivity outcomes across nations.

Over the past decade, agricultural trade liberalization has slowed, particularly in upper- and lower-middle-income countries. This trend does not indicate a simple reversal toward protectionism. It reflects a strategic recalibration of trade openness amid heightened global uncertainty. As countries become more exposed to external shocks, policymakers increasingly reassess the balance between efficiency gains from liberalization and the risks associated with excessive dependence on international markets, especially in food systems.

As shown in Figure 1, lower-middle-income countries experienced an initial expansion of agricultural trade openness. This expansion was followed by a sharp decline after the 2008 global financial crisis. This pattern indicates that trade liberalization in these economies is highly sensitive to global disruptions. Such disruptions include food price volatility, climate-related shocks, and geopolitical tensions (Anderson, 2022). Similar post-crisis retrenchment patterns are documented by Sunge & Ngepah (2022) and Fiankor et al. (2021). These studies find that trade openness in developing economies often amplifies vulnerability to external shocks when domestic productivity and innovation capacity are weak.

Figure 1. Trade Liberalization by Country Income Group



Source: FAOSTAT (2024)

In this context, selective adjustment of liberalization policies reflects an adaptive response aimed at safeguarding domestic agricultural production. It does not represent a rejection of openness. This finding is consistent with recent empirical evidence indicating that the stagnation of global trade since the 2010s has been driven more by structural adjustment and domestic capacity-building strategies. This phenomenon has been less driven by rising tariff protection (FAO, 2023). The present study draws upon the findings of Almeida et al. (2024) and Chiarella et al. (2024), which underscore the necessity for complementary domestic policies. Conversely, high-income countries have tended to maintain relatively stable levels of agricultural trade openness (Xu et al., 2023; Farrokhi & Pellegrina, 2023). Farrokhi & Pellegrina (2023) posit that diversified production structures, strong institutional frameworks, and specialisation in high-value-added commodities support system stability. The studies' findings indicate that advanced economies are better equipped to convert trade openness into sustained productivity growth through effective technology diffusion and innovation.

The Panel ARDL in this study was estimated using three approaches: Pooled Mean Group (PMG), Mean Group (MG), and Difference Fixed Effect (DFE). The selection of the appropriate estimator was based on the Hausman test to ensure consistency and efficiency in the long-run parameters. The results indicate that the PMG estimator is preferred for all country groups except the lower-middle-income, for which the MG estimator was applied. Table 4 reports the summary of the long-run Panel ARDL estimation results. The long-run results reveal a pronounced asymmetry in the productivity effects of agricultural trade liberalization across income groups. This asymmetry provides strong evidence of a trade liberalization paradox. In high-income countries, agricultural trade openness has a positive and statistically significant impact on TFP growth, with a relatively large coefficient (0.229). The magnitude of this coefficient suggests not only statistical relevance but also substantive economic importance. This result indicates that trade liberalization functions as a productivity-enhancing mechanism in structurally advanced agricultural systems.

Table 4. Long Run ARDL Estimation Results

Variabel	High	Middle upper	Middle lower
Agr_TO	0.229*** (0.000)	-0.004*** (0.002)	-0.021 ().533)
Tech_trf	0.005*** (0.000)	0.003*** (0.002)	0.0449 (0.800)
RnD	0.002 * (0.048)	0.003*** (0.003)	-1.164 (0.415)
Reer	0.0006*** (0.000)	0.009*** (0.000)	0.013 (0.307)

Note: *, **, and ** indicate estimated coefficients significant at the alpha 1%, 5% and 10%

This finding suggests that openness facilitates the reallocation of resources towards more productive farms and agribusinesses. Concurrently, it expedites the

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implementation of frontier technologies embedded in imported capital goods and intermediate inputs. This interpretation is consistent with recent empirical evidence showing that trade openness strengthens technical progress and allocative efficiency. (Farrokhi & Pellegrina, 2023). It is imperative to demonstrate that, within the G20 countries, technical change is the predominant source of agricultural productivity growth. The amplifying effect of trade openness on these phenomena is attributable to technology diffusion (Xu et al., 2023).

Conversely, the estimated coefficients for upper- and lower-middle-income countries are either negative or statistically insignificant. This finding suggests that trade liberalisation does not necessarily lead to long-term productivity gains. In such contexts, heightened exposure to import competition may exceed domestic adjustment capacity. Consequently, local producers may experience a decline in competitiveness before substantial technological upgrades and institutional consolidations are implemented. Similar adverse or insignificant productivity effects are reported by Sunge & Ngepah (2022). Their study finds that trade openness in African agriculture often exacerbates vulnerability to external shocks when innovation systems are underdeveloped. Recent studies further document that in structurally constrained agricultural sectors, trade liberalization can generate adjustment costs that dominate potential efficiency gains (Almeida et al., 2024; Chiarella et al., 2023). These sectors are typically characterized by labor-intensive production and limited R&D investment.

Almeida et al. (2024) demonstrate that, in the absence of concomitant investments in institutions and technology, liberalisation can exacerbate disparities in productivity between nations. Rather than promoting convergence, it could widen existing gaps. These findings highlight a structural paradox at the core of agricultural trade liberalization. While openness has been demonstrated to expand market access and learning opportunities, its productivity benefits are conditional on domestic readiness.

This study also finds that in the long run, results further highlight the central role of technology transfer and R&D investment as some transmission channels. These channels explain how trade liberalization affects agricultural productivity. In high-income countries, both variables exhibit positive and statistically significant effects. This result indicates that openness enhances productivity primarily by facilitating access to advanced machinery, high-quality inputs, and embodied technological knowledge. Trade liberalization reduces the cost of importing capital goods.

Furthermore, this phenomenon has been shown to expand market incentives for innovation, thereby reinforcing cumulative productivity gains. These findings are consistent with recent literature emphasising the importance of absorptive capacity in determining the productivity impact of trade-induced technology diffusion. Graf et al. (2023) and Gollin (2023) demonstrated that economies with robust educational frameworks, advanced research infrastructures, and effective extension services are better equipped to assimilate foreign technologies. Furthermore, they are better able to adapt these technologies to local production conditions. In such contexts, trade openness serves as a complementary mechanism to domestic R&D investment, rather than a substitute. This interaction has been shown to result in sustained improvements in productivity.

In upper-middle-income countries, technology transfer and R&D exhibit weaker yet positive long-run effects. This finding suggests that foreign technologies are only partially absorbed. The fragmentation of innovation systems, limited coordination between research institutions and producers, and inconsistent policy support all constrain the depth and persistence of spillover effects. Consequently, productivity gains become increasingly constrained over time. Luo & Qu (2023) state that without sustained investment in domestic innovation ecosystems, trade-induced technology inflows remain shallow. Consequently, they fail to generate long-term productivity growth, a pattern consistent with the estimates reported in Table 4.

In lower-middle-income countries, insignificant coefficients for technology transfer and R&D may indicate persistently low investment levels. The importation of technologies is often undertaken without sufficient local adaptation. This curtails the potential for experiential learning and hinders the diffusion of innovations. These results align with Fuglie (2018), who emphasizes that R&D and capital accumulation remain the primary drivers of agricultural productivity growth. Trade liberalization, therefore, plays a complementary rather than a leading role. More recent evidence by Sunge and Ngepah (2022) demonstrates that, in contexts characterised by limited capacity, the influx of technology alone is inadequate. It has been demonstrated that such measures do not engender sustained productivity gains.

Overall, the empirical results are internally consistent and economically coherent across income groups. The analysis demonstrates that the productivity effects of agricultural trade liberalization are conditional rather than universal. Specifically, the direction and magnitude of the impact depend on structural characteristics, institutional quality, and domestic innovation capacity.

Trade openness enhances productivity in countries with strong absorptive capacity and well-developed innovation systems, whereas its effects are limited in economies with weak institutional and technological foundations. By explicitly linking the empirical estimates to structural mechanisms and recent empirical literature, this discussion provides a coherent explanation of the observed heterogeneity. The results, therefore, contribute to the broader debate by demonstrating that agricultural trade liberalization serves as a productivity multiplier only when complemented by domestic capabilities.

The short-run panel ARDL estimates are presented in Table 5. In contrast to the long-run coefficients, which reflect structural relationships, the short-run estimates represent adjustment processes characterised by learning costs, institutional frictions, and temporary responses to intensified competitive pressure. The heterogeneous short-run coefficients on agricultural trade liberalization are consistent with recent empirical

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evidence emphasising the presence of adjustment costs following trade liberalization. The positive short-run effects observed in several countries suggest that increased openness can generate immediate productivity gains through rapid factor reallocation and improved market integration. This is particularly evident in contexts where market institutions and production structures are highly flexible. Documented cases of short-run efficiency gains are numerous. Farrokhi and Pellegrina (2023) and Trakem and Fan (2024) highlight the importance of identifying which economic model exhibits stronger absorptive capacity, as this determines how quickly an economy can internalize competitive pressures arising from trade.

Conversely, the prevalence of adverse short-term effects across numerous countries suggests that import competition frequently escalates more rapidly than producers can adapt their production technologies and organizational structures. This finding is consistent with the conclusions of recent studies indicating that the initial phase of liberalization may result in a temporary decline in productivity due to transitional challenges, despite the subsequent realization of long-term benefits (Chiarella et al., 2023; Sunge & Ngepah, 2022). Consequently, these short-run productivity losses reflect adjustment costs rather than a failure of trade openness to enhance productivity. This finding reinforces the distinction between transitional dynamics and long-run equilibrium effects.

The short-run responses to technology transfer further underscore the non-linear nature of the adjustment process. In some countries, the presence of positive coefficients suggests that the diffusion of technology can lead to immediate productivity gains, provided that the learning channels and the economy's absorptive capacity are sufficiently developed. However, the negative short-run effects observed in other contexts suggest that adopting foreign technologies initially increases production complexity and coordination costs before efficiency improvements are realized. This pattern is consistent with the recent body of evidence emphasizing delayed productivity effects of technology diffusion in the presence of institutional and skill constraints (Sandström et al., 2024; OECD, 2023).

In a similar vein, the volatility of short-run R&D coefficients mirrors the inherently forward-looking nature of innovation activities. Although a few cases have demonstrated positive short-term effects, indicating the potential of applied R&D to deliver immediate productivity benefits, the preponderance of negative coefficients in many countries suggests that R&D primarily functions as an investment cost in the short term. This interpretation is corroborated by recent empirical studies, which demonstrate that the productivity impact of R&D is predominantly realized over extended periods. The short-run effects of R&D are often weak or negative, owing to implementation and learning delays (Xu et al., 2023).

A comprehensive analysis of the short-run outcomes reveals that heterogeneous and asymmetric adjustment dynamics influence the convergence toward a long-run equilibrium between trade openness and agricultural productivity. The short-term outcomes across countries are characterized by a combination of factors, including variations in adjustment speed, absorptive capacity, and institutional readiness. These elements contribute to the generation of mixed short-term outcomes (Hartwell, 2022). In line with recent empirical findings, these dynamics do not contradict the positive long-run relationship identified in this study; rather, they elucidate the mechanisms through which structural productivity gains from trade liberalization are gradually realized.

CONCLUSION

This study undertakes a re-examination of the dynamic relationship between agricultural trade liberalization and agricultural TFP growth across. The findings of this study demonstrate that agricultural trade liberalization exerts a positive, statistically significant long-run effect on TFP growth. However, this effect is observed only in high-income countries. In these economies, strong absorptive capacity, sustained R&D investment, and effective technology diffusion enable trade liberalization to translate into productivity gains. Conversely, upper- and lower-middle-income countries have been observed to exhibit weak, insignificant, or negative long-term productivity outcomes. The short-run impacts of these policies are also highly heterogeneous. These results confirm the existence of a trade liberalization paradox in global agriculture. The extant literature does not support the hypothesis that trade liberalization automatically enhances productivity. The effectiveness of this approach depends on the nation's structural readiness and domestic innovation capacity. Absent these conditions, heightened exposure to international competition may amplify adjustment costs and impede productivity growth.

These findings offer clear policy implications. The pursuit of agricultural trade liberalization should be a deliberate and strategic endeavor, carefully aligned with the domestic structural readiness of the respective nation. It is incumbent upon policymakers in upper- and lower-middle-income countries to prioritize strengthening agricultural research and development (R&D) systems, the effective transfer of technology, and the extension of services to cultivate absorptive capacity prior to further trade liberalization. A coordinated strategy that integrates gradual liberalization with investment in innovation and macroeconomic stability is essential to ensure that trade liberalization translates into sustained agricultural productivity growth.

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Table 5. Short Run ARDL Estimation Results

High				Middle upper				Middle lower			
Negara	Agr_TO	Tech_trf	R&D	Negara	Agr_TO	Tech_trf	R&D	Negara	Agr_TO	Tech_trf	R&D
United States	-	-	-	China	-	-	-0.13** (0.024)	India	-	-	-
France	0.08** (0.05)	0.002** (0.017)	-0.27** (0.014)	Brazil	-0.29*** (0.000)	2.48** (0.002)	2.23*** (0.000)	Indonesia	-0.-19** (0.016)	0.225** (0.05)	-
Australia	-0.13*** (0.000)	-0.13* (0.067)	(0.42** (0.015)	Russia	-0.48* (0.083)	0.145* (0.064)	-	Nigeria	-	-	2.778** (0.033)
Japan	-	-	0.089* (0.053)	Argentina	-	-	-1.15** (0.007)	Pakistan	-	0.097* (0.076)	-
Italy	-	-	-0.88** (0.044)	Turkey	-	-0.18*** (0.000)	0.248** (0.016)	Bangladesh	-	-	-
Spain	-	0.24*** (0.003)	0.80*** (0.003)	Mexico	0.043*** (0.000)	-0.091** (0.015)	-0.288** (0.007)	Vietnam	-	0.089* (0.085)	-1.203** (0.045)
Korea	-	-	-	Iran	-0.08*** (0.000)	0.85*** (0.000)	-1.08*** (0.000)	Philippines	0.156* (0.066)	-	1.742* (0.069)
Canada	-0.06** (0.046)	-	-1.39* (0.072)	Thailand	-0.03*** (0.000)	0.139*** (0.000)	0.47*** (0.000)	Kenya	0.021*** (0.000)	0.216*** (0.008)	-2.598*** (0.000)
Germany	0.015** (0.012)	-0.17** (0.030)	-	Malaysia	-	0.105* (0.064)	-	Egypt	-	-0.165** (0.018)	0.703*** (0.004)
United Kingdom	-	0.41*** (0.000)	0.19* (0.098)	Colombia	-	-0.168** (0.041)	1.12** (0.019)	Morocco	-	-	-
Netherland	-	0.25** (0.024)	-0.22* (0.097)	Peru	-.024** (0.036)	-	-	Ukraina	-0.29*** (0.000)	0.154*** (0.000)	0.373** (0.031)
Poland	0.012** (0.014)	0.018*** (0.000)	0.038*** (0.000)								
Chile	0.01*** (0.000)	0.012** (0.013)	-								