

STRUCTURAL BREAKS AND TRADE INTEGRATION: EVALUATING EXOGENOUS SHOCKS IN PAKISTAN'S AGRICULTURAL SECTOR

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Abstract

Global trade patterns have evolved significantly in recent years, shifting toward supply chains rather than relying on exports of high-volume raw materials and on economies of scale. Given Pakistan's agrarian economy, agricultural trade is a key driver of the country's economic growth. Vertical relationships are facilitated by intra-industry trade (IIT), which increases market integration. In this regard, studying IIT's behavior is crucial for Pakistan. The study aims to explore the dynamics of Pakistan's agricultural IIT by analyzing trade patterns, AIIT stability and mobility as well as structural shifts from 2003 to 2023. The Grubel-Lloyd intra-industrial trade index is used for further analysis. Macroeconomic convergence and structural mobility have been evaluated by using Galtonian regression and Markov transition probability matrices. Moreover, the 2008 Global Financial Crisis, the 2025 China-Pakistan Economic Corridor, and the COVID-19 structural breaks have been studied using piecewise regression. Overall, major economic events such as the 2008 financial crisis and the 2020 COVID-19 pandemic had a significant negative impact on Pakistan's AIIT, whereas the 2015 CPEC had a substantial positive impact. We observe a macroeconomic paradox: overall trade distribution exhibits structural divergence, while some individual commodities show slight upward trends despite an initial lack of competitiveness. The lowest level of integration is observed with 83.58% chances as a result of the low IIT trap. Not all exogenous shocks disturb IIT to the same extent; rather, they trigger disturbances in the perishable supply chain by causing structural breaks. It is necessary to break this Low-IIT trap by motivating processed supply chains through technological advancements and agro-processing, and by discouraging raw material exports.

INTRODUCTION

International trade is undergoing a paradigm shift from relative advantage to a competitive edge, with a focus now on product diversification, efficient production, and economies of scale rather than on available resources and the export of raw materials (Marius-Răzvan and Camelia 2015, Yazdani and

Pirpour 2020). Trade in value-added (refined) goods within the same industry is part of the modern trade model, whereas factor endowments were an important component of earlier trade traditions (Sawyer, Sprinkle et al. 2010, Yoshida 2013). The theory of Intra-Industry trade focuses on the simultaneous export and import of

essentially similar goods within the same sector, in contrast to inter-industry trade, which focuses on factor endowments (Marius-Răzvan and Camelia 2015). This evolution in trade trends focuses on value chains rather than the export of large volumes of raw materials. For instance, this new trade trend does not approve the export of large volumes of oranges and the import of large volumes of concentrated essential oils (Yoshida 2013, Hoang 2019). IIT is more compelling when better integrated, focusing on manufacturing phases and economies of scale, rather than on large-volume raw materials (Sawyer, Sprinkle et al. 2010).

Being an agrarian economy, Pakistan's agricultural trade is a key driver of the country's economic growth. According to the Government of Pakistan (2024-25) statistics, agriculture is an important sector of Pakistan's economy, contributing 23.37% to GDP and retaining about 37% of the labor force (70% in rural areas). Given agriculture's crucial contribution, transitioning to the current complex global trade network, rather than relying on exports of traditional raw materials, is unavoidable. Such evolutions in global trade models emphasize the export of final goods and product diversification but not the export of raw materials, to integrate into global value chains, to achieve sustainable economic supply chains, and food security (Saboori, Alhattali et al. 2023, Arndt and Helming 2025). Although inter-industry trade has been considered the basic trade model of Pakistan, where raw cotton was traded for heavy machinery, the current intra-industry trade model has been shown to be a potentially viable economic model, consisting of trade of various qualities and types within the same industry (Affortunato, Ciommi et al. 2013).

With a strong heritage in agricultural land, natural resources, and the environment, Pakistan has a relatively high comparative advantage in agriculture, including cotton, rice, and horticultural products, which have demonstrated significant export growth. A boost in agricultural trade is a key mechanism through which the country can achieve inclusive growth and rural

poverty alleviation (RASHID, SARWAR et al. 2022). The value-addition gap has been the most significant challenge for the Pakistani agricultural sector. The export of raw materials or labour-intensive goods, while the import of expensive final products is a common trade pattern in almost all developing and underdeveloped economies (Marius-Răzvan and Camelia 2015). In the current context, climate-related vulnerabilities and price volatility in international food markets have rendered the agricultural sector highly vulnerable, and it no longer supports the traditional trade model (Ullah, Shivakoti et al. 2016). A resilient economic system can be maintained only through broader export strategies that can absorb international price shocks and through a modern trade model that focuses on supply chains (Arndt and Helming 2025).

Given the dominance of the agricultural sector in Pakistan's economy, trade in agricultural goods plays a vital role. In this regard, studying IIT's behaviour is crucial for Pakistan. Many studies, for example, IIT contribution with SAARC countries was measured by Kemal (2004) while the major influencing factors with trading partners have been identified by (Shahbaz and Leitaó 2011). Trading of a few viable commodities within an industry is explored by (Haq 2014). Assessment of trade potential in IIT and its determinants was done by (RASHID, SARWAR et al. 2022). Still, there is a substantial lack of research on the dynamics of agricultural IIT in Pakistan. There is a lack of empirical studies and analysis of agrarian IIT for Pakistan, specifically at the Harmonized System (HS) 4-digit (i.e., tariff sub-headings) levels, particularly in terms of its trading partners, therefore, the present study is designed to bridge this gap by providing the dynamics of current agriculture IIT, and, hence, a wider interpretation of our agriculture sector integration with international supply chains

With changes in global trade patterns, it is essential to investigate the dynamics of Pakistan's agricultural IIT and its future trade potential. Hence, the study aims to examine the dynamics of Pakistan's agricultural IIT by analyzing trade patterns, stability, and mobility of IIT, and

structural shifts over time. For empirical analysis, following the methodology of (Hoang 2019), econometric techniques, including regression and Markov transition analysis, will be applied to assess the extent, nature, and trends of agricultural IIT. Furthermore, the structural breaks in agricultural IIT and the impact of major economic events, such as the 2008 Global Financial Crisis, the 2015 implementation of the China-Pakistan Economic Corridor (CPEC), and the 2020 COVID-19 pandemic, will be analyzed using a piecewise regression (Broken-Stick Model). The residual part of the article is as follows. Section 2 presents a brief literature review related to intra-industry trade and agricultural IIT. The data and methodology are placed in Section 3; Section 4 describes the empirical findings and discussion. Lastly, the article concludes with a discussion of the research's policy implications.

1 Methodology and Data

1.1 Data Sources

The trade dataset (export and import) for the purpose of the analysis has been drawn in Harmonized System (HS) classification at HS 2-digit (i.e., tariff sub-headings) and its subgroup 3-digit levels from the Trade Map database, maintained by the International Trade Centre (ITC, 2025). A balanced panel dataset of bilateral exports and imports for 111 agricultural products over the period 2003-2023 has been used. However, the empirical analysis in the present study includes only static and dynamic measures of AIIT and does not compute horizontal AIIT, vertical AIIT or trade specialization indices such as the Lafay index (LFI) and revealed Comparative Advantage (RCA).

1.2 Methodology

Overall, this paper presents static and dynamic analyses of Pakistan's agricultural intra-industry trade (AIIT) for the period 2003-2023. The paper's empirical study consists of two parts. (i) Static analysis; (ii) Dynamic analysis.

1.2.1 Static analysis of agricultural intra-industry trade (AIIT)

Static analysis of Intra-Industry Trade (IIT) refers to the examination of the structural characteristics of IIT at a particular point in time or over a specific period. To measure IIT, various indices have been developed, including the Balassa index, the Aquino index, the Bergstrand index, and the Glesjer index. However, most of the empirical analysis used the Grubel-Lloyd Index (Grubel and Lloyd 1975) for static analysis. The formula for empirical calculation of GLI is expressed as in equation 1:

$$GLI_g = 1 - \frac{|X_g - M_g|}{(X_g + M_g)} \quad 0 \leq GLI_g \leq 1 \quad (1)$$

(Qasmi and Fausti 2001) interpreted the value of GLI in four categories as follows

GLI=0-0.25, strong inter-industry trade (no overlap between export and import),

GLI=0.26-0.5, weak inter-industry trade

GLI=0.51-0.75, weak intra-industry trade

GLI=0.76-1, complete IIT (perfect overlap between exports and imports)

Whereas: X_g (trade volume of exports of agricultural commodities of Pakistan to the world) and M_g (trade volume of imports of agricultural commodities of Pakistan to the world).

1.2.2 Dynamic analysis of agricultural intra-industry trade (AIIT) indicators

This study utilizes various methodologies for empirical testing of the dynamics of AIIT of Pakistan, including the OLS regression analysis, trend analysis, Markov transition analysis, Shorrock mobility Index, and structural break analysis (piecewise regression).

1.2.2.1 OLS regression analysis

Ordinary least squares (OLS) regression for empirical testing (Dalum, Laursen et al. 2006, Hoang 2019) is used to assess microeconomic convergence or divergence in GLI patterns. GLI is bounded and violates the assumptions of normality in symmetrical error distribution. It involves the transformation of GLI by using $TGLI = 2GLI - 1$. This transformation normalizes

the data distribution by removing extreme values. Evolving patterns between two periods will be analyzed by using the OLS regression equation described as follows:

$$GLI_g^{t_2} = \gamma_0 + \gamma GLI_g^{t_1} + \mu_g \quad (2)$$

Where t_1 (initial year), t_2 (final year), g (agri-commodity group), γ_0 (constant), γ (regression coefficient), and μ (error term)

Equation (2) regression is linear in parameters with normally identically distributed residuals μ_g that is $(\mu_g = n.i.d.(0, \delta))$. Moreover slope coefficient γ has different explanations as following

if $\gamma=0$, (country has the unchanged pattern of AIIT from t_1 to t_2),

if $\gamma > 1$, (country attain higher AIIT),

if $0 < \gamma < 1$, (opposite economic implication),

if $\gamma=0$, (no relation between GLI in the two periods) and,

if $\gamma < 0$, (AIIT situation of the groups are reversed)

The method mentioned above is one of the best methods for comparison of two cross-sectional or cross-group commodities at two different points in time (Dalum, Laursen et al. 1998).

We will check the distribution convergence by using $\sigma = \gamma/R$, where γ is the regression coefficient and R is correlation coefficient. Overall decreased dispersion of the distribution is conformed if $\sigma < 1$ (Dalum, Laursen et al. 1998).

1.2.2.2 Trend analysis

It is used to determine whether the GLI trend of AIIT in Pakistan is increasing, decreasing, or maintaining. The trend model presented by (Hoang, 2019) is as follows

$$GLI_{g,t} = \theta_g + \gamma_g t + \mu_{g,t} \quad (3)$$

Where θ_g (constant), γ_g (slope coefficient indicating GLI trend) shows the annual change in commodity trend, t (time index, 1 to 21 for years 2003 to 2023) and μ (error term). Value of $\gamma_g > 0$ (increasing trend of AIIT) and $\gamma_g < 0$ (decreasing trend of AIIT) and $\gamma_g = 0$ (no change).

1.2.2.3 Markov transition analysis

This empirical examination is used to measure the stability and mobility of IIT over time. This empirical method was applied initially by (Proudman and Redding 2002, Hoang 2019). This also shows whether IIT is dynamic (frequent changes in trade patterns) or stable (consistent trade patterns). Construction of a Markov transition matrix also helps to study the probability of products moving between GLI categories (e.g., from strong IIT to weak IIT) over time. The diagonal elements of the probability matrix represent stability (commodities remaining in the same category) while the off-diagonal elements represent movement (instability/mobility) between IIT categories (Afreen 2021).

1.2.2.4 Shorrocks mobility index (M)

Shorrocks mobility index is used to compute overall systematic structural mobility in a single numerical value. This was first introduced by (Shorrocks 1978), used to quantify the overall mobility of IIT categories. Equation of M index is defined as follows:

$$Shorrocks\ Index\ (M) = \frac{n - tr(p)}{n - 1} \quad 0 \leq M \leq 1 \quad (4)$$

$M = 0$ (perfect immobility no movement between categories; trade patterns are completely stable)

$M = 1$ (perfect mobility maximum movement between categories; trade patterns are highly dynamic whereas: n (number of four categories of GLI), P (transition probability matrix), and $tr(P)$ (trace of P).

1.2.2.5 Structural break analysis (piecewise regression)

Piecewise regression is used to detect major shifts (e.g., economic events) via breakpoints or structural breaks in GLI. Pakistan's agricultural trade has been significantly affected by major economic events, policy shifts, trade agreements, and political instability; therefore, simple linear regression is unable to capture these effects. To address the structural breaks, piecewise regression

is the appropriate solution, which has recently been used by (Hoang, 2019) for Vietnam's agricultural intra-industry trade. For empirical testing, this paper identified major shifts in GLI of AIIT of Pakistan before and after three major economic events (e.g., 2008 – Financial crisis; 2015 – China Pakistan Economic Corridor (CPEC), and 2020 – Pandemic of COVID-19). The equations of three events are given as follows:

$$GLI = \gamma_0 + \gamma_1(Y_t - 2008) + \gamma_2(Y_t - 2008)D_t + \mu$$

$$GLI = \gamma_0 + \gamma_1(Y_t - 2015) + \gamma_2(Y_t - 2015)D_t + \mu$$

$$GLI = \gamma_0 + \gamma_1(Y_t - 2020) + \gamma_2(Y_t - 2020)D_t + \mu$$

Where γ_0 (constant term), γ_1 (slope before 2008, 2015, 2020), γ_2 (slope after 2008, 2015, 2020), Y_t (2003 to 2023), D_t (dummy variable for capturing the differential growth for period 2 ($D_t = 0$ for 2003–2008; 2003–2015; 2003–2020 and $D_t = 1$, otherwise) and μ (error term). The results will test whether the GLI indicators increase before the period of 2008, 2015, 2020 ($\gamma_1 + \gamma_2 > 0$) and decrease after the period of 2008, 2015, 2020 ($\gamma_1 + \gamma_2 < 0$).

The parameter γ_1 captures the pre-shock integration trend, while γ_2 isolates the differential impact induced by the shock. A statistically significant γ_2 confirms the presence of a structural break, facilitating the precise classification of sectoral resilience, trend reversals, or growth decelerations in response to global crises.

2 Results and Discussion

2.1 Results of static analysis

Table 2 presents the descriptive statistics of Grubel-Lloyd Index (GLI) values for agricultural intra-industry trade across 111 product categories from 2003 to 2023. The unadjusted Grubel-Lloyd index (Grubel and Lloyd 1975) has been used to compute a static measure of intra-industry trade, and we observed a consistent underlying sluggishness in Pakistan's AIIT. The cumulative average for 111 commodities in 2003 is 0.1581, which is strictly classified as “strong inter-industry trade” according to the classification criteria of

(Qasmi and Fausti 2001). A slight increased level of integration has been observed with numerical value of 0.2858 in 2011, and it surpassed the “Weak inter-industry Trade” and momentarily surpassing the “Weak Inter-Industry Trade” threshold limit for a very short time. The combined mean value reverted to 0.2364, thereby pushing the sector back into Weak Inter-Industry Trade. Inconsistency between the mean and median values implies a skewed distribution of trade patterns, in which the majority of products do not exhibit two-way trade, and “specialization trap” phenomena are observed in the sector (Hoang 2019). This reverse trend hints at the Pakistani agricultural sector's failure to take advantage of crop diversification recommended by New Trade Theory (Krugman 1979). This analysis shows agriculture sectors dependence on major raw staple crops resulting in increased monetary vulnerability to international price volatility and limiting progress within international value chains (Sawyer, Sprinkle et al. 2010, Jambor 2014). Our results on agricultural product distribution reveal a “Low IIT Trap” and significant embedded structural inertia. We find 85 out of 111 commodities fall in the category of strong Inter-Industry Trade with $GLI < 0.25$ according to the predefined criteria discussed in the methodology section. 81 commodities in the final year are still trapped in the lowest integration group. On the other hand, commodities in Strong Intra-Industry with $GLI > 0.75$ Trade have decreased from 8 to 7 in 2023 compared to 2003. Such stagnant situations point to limited intra-industry trade, in which exports and imports of final and differentiated products remain unintegrated despite global trade liberalization.

Table 1: GLI Quartile Distribution Shift in Pakistan's Agricultural Sector (2003 vs. 2023)

Trade Integration State	GLI	Total Commodities (2003)	Total Commodities (2023)	Structural Shift
Strong Inter-Industry	0.00 – 0.25	85	81	-4
Weak Inter-Industry	0.26 – 0.50	12	14	+2
Weak Intra-Industry	0.51 – 0.75	6	9	+3
Strong Intra-Industry	0.76 – 1.00	8	7	-1
Total Panel	0.00 – 1.00	111	111	—

Although the overall distribution indicates stagnant inter-industry trade, a heterogeneous sectoral phenomenon has been exposed. We observe entirely unidirectional trade of some staple exports as revealed by GLI value of 0.019 in 2003 and 0.026 in 2023 for rice (code 1006). Some other final and processed categories reflect specified, volatile integration. A noticeable transition of code 0401(milk and cream) from strong inter-industry (GLI=0.01) in 2003 to strong intra-industry trade with GLI 0.86 in 2004. This product experienced high volatility and stabilized at GLI=0.2954 in 2023. These examples confirm the extremely limited intra-industry trade in very few commodities, and we find no evidence of structural changes across the entire agricultural sector. An increased Standard deviation from 0.2579 (2003) to 0.3016 (2023) signifies sectoral heterogeneity where some products are becoming highly integrated while others remain severely concentrated, that widens the trade gap between different products. Overall, Pakistan's agricultural trade is still not competitive, as shown by the mean GLI value of 0.23, indicating that our trade is not driven by scale of economies or value addition (Hoang 2019).

2.2 Dynamic analysis of AIIT

2.2.1 Pattern of AIIT by Regression Analysis

Galtonian regression has been applied to assess convergence and divergence, as well as structural transformations, of Pakistan's AIIT. These regression estimates were performed using TGLI

to overcome the limitations of nonnormality and skewness in unadjusted GLI. Table 2 presents the results for the full panel dataset over two decades and for the sub-periods 2003-2013 and 2014-2023. Details of TGLI have been provided in the supplementary Appendix B to format a concise manuscript.

We find convergence for all 3 regressions based on empirical results. The slope coefficient, with a value of 0.3947, is significant at the 1% level of significance and satisfies the convergence condition ($0 < \gamma < 1$) for the entire dataset over two decades. Regression coefficients for the other two sub-periods, with values 0.3424 and 0.4567, respectively, are also convergent. This convergence highlights the structural constant or decline of initially integrated commodities across sub-periods, compared with catch-up growth for commodities with weak IIT in the initial years.

However, the above discussion does not imply a reduction in the spread of trade distribution. We have assessed structural divergence by computing the $\sigma = \gamma/R$, where R is the correlation coefficient. We observe $\sigma > 1$ in all three cases, so we reject the hypothesis of convergence. For full data, R equals 0.3679, and sigma equals 1.0730, favoring divergence. Overall, these results reveal a wider trade distribution, although there is an upward drift in commodities with an initially low IIT. Structural divergence and macroeconomic diversification are both widening the gap between integrated commodities and commodities that focus on one-way trade.

The divergence in trade patterns across the three periods is due to trade policy, market disruptions, and the uncertainty of Pakistan's agricultural sector. Pakistan is also facing challenges in overall

trade and, specifically, in farm trade, and the negative trade balance in the agricultural sector is due to higher food imports (Javed 2023).

Table 2: Galtonian Regression Estimates for Agricultural TGLI Convergence

Period	Constant (γ_0)	Coefficient (γ)	R^2	R	γ/R	Structural Interpretation
2003 – 2013	-0.2274	0.3424***	0.0935	0.3057	1.1198	γ -convergence, σ -divergence
2014 – 2023	-0.3064	0.4567***	0.1895	0.4353	1.0493	γ -convergence, σ -divergence
2003 – 2023	-0.3219	0.3947***	0.1353	0.3679	1.0730	γ -convergence, σ -divergence (Increased dispersion)

Note: denotes statistical significance at the 1% level. The regression tests for both γ -convergence ($0 < \gamma < 1$) and σ -divergence ($\gamma/R > 1$) utilizing the Transformed Grubel-Lloyd Index (TGLI) (Dalum, Laursen et al. 1998, Hoang 2019).

2.2.2 Trend analysis of AIIT

A linear trend model has been applied to distinguish between deterministic trend and random fluctuations in the GLI time series for each commodity in the present data panel (Hoang 2019). A significant trade divergence is evident from the magnitude and direction of the regression coefficient. Significance has been considered for a 10% threshold. A summary of the extreme commodities temporal integration and structural reversal has been presented in Table 3. A specific group of commodities exhibited a significant long-term upward integration trend, with $\gamma_g > 0$. This group presents extremely upward deterministic trends and contains mostly processed and semi-processed products such as processed fish (code 1604), dried vegetables (code 0712), flours and meals (code 1208) with

significant $\gamma_g = 0.0493$, 0.0414 and 0.0455, respectively. Moreover, upward structural growth is also suggested by the flour and meals of oilseeds (Code 1208), which transitioned from the lowest category (GLI=0.0963) to the strong intra-industry group (GLI=0.9041) during the study period. On the other hand, a group of traditional commodities presented reverse trends toward inter-industry trade (Hoang 2019). These include Birds' eggs" (code 0407) and Dried leguminous vegetables (Code 0713), which exhibit negative and significant regression coefficients with values $\gamma_g = -0.0250$ and -0.028 accordingly. Another group of commodities presented insignificant γ_g values, including Wheat and meslin" (Code 1001) and "Whey" (Code 0404). This group exhibited very persistent patterns of neither upward nor downward integration.

Table 3: Time-Series Trend Analysis of GLI Indicators (Selected Extremes)

Commodity Code	Description	γ_g	P-value	R^2	Structural Trajectory
1604	Prepared or preserved fish	0.0493	< 0.01	0.7193	Increasing IIT
1208	Flours and meals of oil seeds	0.0455	< 0.01	0.6873	Increasing IIT
0712	Dried vegetables, whole, cut, sliced	0.0414	< 0.01	0.6940	Increasing IIT
1106	Flour and meal of leguminous vegetables	0.0337	0.0143	0.2901	Increasing IIT
0401	Milk and cream, not concentrated	-0.0238	0.0044	0.3553	Decreasing IIT

Commodity Code	Description	γ_g	P-value	R^2	Structural Trajectory
0407	Birds' eggs, in shell, fresh/preserved	-0.0250	0.0059	0.3363	Decreasing IIT
1905	Bread, pastry, cakes, biscuits	-0.0272	0.0029	0.3967	Decreasing IIT
0713	Dried leguminous vegetables, shelled	-0.0280	0.0010	0.4439	Decreasing IIT

Note: The γ_g parameter isolates the deterministic integration trend over the 21-year period. A positive coefficient indicates secular integration, while a negative coefficient indicates structural reversion to inter-industry trade, evaluated at $p < 0.10$ (Hoang 2019).

2.2.3 Mobility and Stability Analysis of AIIT

Markov transition analysis provides a clear picture of trade dynamics, specifically highlighting the stability and mobility of IIT as it moves between different classes or categories over time. Markov transition analysis (MTA) results indicate whether Pakistan's AIIT is dynamic (with frequent changes in trade patterns) or stable (with consistent trade patterns).

One-step Markov transition Matrix is computed to measure the stochastic evolution of Pakistani agricultural commodities in our dataset (Proudman and Redding 2002, Hoang 2019). Year-on-year probability of commodity transitions in 4 predefined classes is presented in Table 4. Diagonal values of the matrix capture structural stickiness. We observe the greatest persistence in commodities being trapped in a strong inter-industry group, with an 83.58% probability. A sharp decline in the persistence of strongly integrated commodities has been observed from 38.14% for strong AIIT to 36.73% for weak AIIT and 36.16% for weak inter-industry trade. These

probabilities reveal the presence of “LOW IIT TRAP” in Pakistan's agricultural sector, where commodities that are not integrated face many complications in structural advancement.

A structural reversion, rather than integration, has been observed from the off-diagonal probabilities. The probability of transition from strong inter-industry trade to strong intra-industry is just 3.92% in a single year. While reversion from strong intra-industry trade to weak inter-industry trade is quite high (23.31%). Regressing from weak inter-industry trade toward lower trade has a probability of 35.31. This indicates very temporary and brittle instances of trade integration.

Shorrocks Mobility Index (M) (Shorrocks 1978) is used to present this structural volatility in a single numerical value by using the trace of the transition matrix across 4 classes. A higher level of transition is noticed with an index value of $M=0.6846$ ($0 < M < 1$). A comparison of this index with the transition matrix reveals downward mobility rather than an upward integration trend.

Table 4: One-Step Markov Transition Probability Matrix for Agricultural IIT (2003–2023)

	Strong Inter-Industry (0.00–0.25)	Weak Inter-Industry (0.26–0.50)	Weak Intra-Industry (0.51–0.75)	Strong Intra-Industry (0.76–1.00)
Strong Inter-Industry (0.00–0.25)	83.58%	9.31%	3.19%	3.92%
Weak Inter-Industry (0.26–0.50)	35.31%	36.16%	18.08%	10.45%
Weak Intra-Industry (0.51–0.75)	11.43%	26.53%	36.73%	25.31%

	Strong Inter-Industry (0.00–0.25)	Weak Inter-Industry (0.26–0.50)	Weak Intra-Industry (0.51–0.75)	Strong Intra-Industry (0.76–1.00)
Strong Intra-Industry (0.76–1.00)	23.31%	15.25%	23.31%	38.14%

Note: The main diagonal elements represent structural stickiness, while off-diagonal elements indicate stochastic mobility between integration states (Hoang 2019).

source: Author's calculation based on the database UN Comtrade, 2024.

2.2.4 Piecewise regression analysis

Pakistan AIIT has been significantly influenced by major economic events over the past two decades. For empirical testing, piecewise regression has been estimated for three main economic events: the financial crisis of 2008, the China-Pakistan Economic Corridor (CPEC) of 2015, and the COVID-19 pandemic of 2020.

Financial Crisis – 2008

Significant structural breaks were induced by the GFC 2008 at both the raw commodities and processed-products levels. Specifically, trend reversal from disintegration to integration was observed for several export categories. A pre-shock divergent trend with $\gamma_1 = -0.0573$ was observed for "Dates, figs, pineapples, and mangoes in comparison of positive significant post-shock convergence trend with $\gamma_2 = 0.0647$. One other example of positive transition from pre-shock divergence ($\gamma_1 = -0.1700$) to post-shock convergence with ($\gamma_2 = 0.1709$) has been observed for "Dried leguminous vegetables" (Code0713). A reverse trend from integration to disintegration has been noticed for "Fruit juices" (Code 2009) with ($\gamma_1 = 0.0982$) falling to a significant negative value of the regression coefficient ($\gamma_2 = -0.1297$) due to crises.

China-Pakistan Economic Corridor (CPEC) – 2015

The CPEC (One Belt One Road) is a very important initiative for Pakistani trade, as it will leave a significant impact on the economy of Pakistan (Zhao, Sun et al. 2022). Pakistan had great trade potential for China and other Central Asian countries to increase exports of its grain and

perishable crops through CPEC (Shahzad, Razzaq et al. 2019).

Integration increased for some processed agricultural products with the commencement of infrastructure and trade projects under CPEC in 2015. One such example is "Vegetables, fruit, nuts prepared or preserved by vinegar" (Code 2001), which has been shifted to post-integration with significant value $\gamma_2 = 0.018$ from pre marginally disintegration class with ($\gamma_1 = -0.0032$). Overall, there was no uniform benefit for all agricultural products integration regression has been observed for some products such as "Cereal straw and husks" (Code 1213) reversed from integration to disintegration with $\gamma_2 = -0.0741$. The results indicate that the events generate breakpoints in intra-industry trade. CPEC, as a major regional initiative, plays an important role in enhancing Pakistan's agricultural collaboration and agricultural exports.

COVID-19 pandemic – 2020

COVID 19 disrupted the supply chains but accelerated two-way trade but speed up trade linkages for some products. An unusual upward shock has been identified in the "Flours and meals of oil seeds" (Code 1208). There was already existing a positive integration with ($\gamma_1 = 0.0350$), however, this bilateral trade accelerated significantly with value $\gamma_2 = 0.1451$ resulting in abrupt post-integration with ($\gamma_1 + \gamma_2 = 0.1801$). Products that are perishable and need significant capital assets faced severe weakness, such as "Milk and cream, concentrated" (Code 0402), which evolved in post-disintegration with $\gamma_2 = -0.1399$ from an integrated value of ($\gamma_1 = 0.0200$). This highlights the fragile nature of dairy supply chains during COVID 19.

Table 5: Piecewise Regression Estimates for Major Macroeconomic Shocks (Selected Sectors)

Exogenous Shock	Commodity Code	Commodity Description	Pre-Shock Trend (γ_1)	Shock Differential (γ_2)	Post-Shock Trend ($\gamma_1 + \gamma_2$)	P-value	Structural Interpretation
2008 GFC	0804	Dates, figs, pineapples, mangoes	-0.0573	0.0647	0.0074	< 0.01	Disintegration to Integration
2008 GFC	0713	Dried leguminous vegetables	-0.1700	0.1709	0.0009	< 0.01	Disintegration to Integration
2008 GFC	2009	Fruit juices, unfermented	0.0982	-0.1297	-0.0314	< 0.01	Integration to Disintegration
2015 CPEC	2001	Vegetables, fruit, prepared by vinegar	-0.0032	0.0188	0.0156	< 0.01	Disintegration to Integration
2015 CPEC	1213	Cereal straw and husks	0.0264	-0.0741	-0.0477	< 0.01	Integration to Disintegration
2020 COVID	1208	Flours and meals of oil seeds	0.0350	0.1451	0.1801	< 0.05	Shock acceleration
2020 COVID	0402	Milk and cream, concentrated	0.0200	-0.1399	-0.1199	< 0.05	Integration to Disintegration

Note: Evaluated at $p < 0.10$. A statistically significant γ_2 confirms a structural break (Hoang 2019).

3 Discussion

A clear and significant macroeconomic paradox has been witnessed by examining the agricultural trade patterns between 2003-2023. The regression analysis results reveal simultaneous convergence and divergence, although the static indicators show a stagnant trade trend, consistent with the trade overlap assumption (Grubel and Lloyd 1975). This finding supports dispersion and polarization in agricultural distribution, while integration is growing for initially less competitive products (Dalum, Laursen et al. 1998). Consequently, Local structural integration restricted the agricultural sector in in LOW IIT TRAP" (Hoang 2019). A low level of integration is not enough to offset the irresistible one-way trade dominance of major staples, which is commanding the fundamental structure and is necessary for understanding structural weakness in the South Asian agricultural system.

Dynamic analysis has further uncovered the macroeconomic contradiction of simultaneous convergence and divergence in Pakistan's

agricultural sector. 83.58% probability value in strong interindustry trade, provided by one step Markov transition matrix, points out substantial structural inertia (Proudman and Redding 2002). However, moderate mobility has been identified by using the scalar mobility index (Shorrocks 1978). Off-diagonal probabilities in the transition matrix reveal unequal chances of downward shifts and non-persistent integration. The chances of a backward transition to strong inter-industry trade on an annual basis are very high for commodities with higher integration. This indicates the fragile nature of developing integration and competitiveness in global

Time series trend analysis for individual products, rather than analyzing the deterministic trend, highlights the significant role of value addition and product differentiation in avoiding the LOW IIT TRAP (Hoang 2019). Numerical analysis highlights the concentration of semi-processed and value-added products in strong intra-industry trade, while the main staple and raw material trade is either strictly stuck or reversed toward one-way

trade. These findings support the literature, which suggests focusing on product differentiation for higher market shares for smooth, sustainable two-way trade, while comparative cost advantages are the main point of inter-industry trade (Qasmi and Fausti 2001).

Structural effects of Different microeconomic shifts have been identified by using the segmented regression technique. Different structural breaks specify the rigorous catalyst role of structural breaks in trade transitions. Trend shifts toward integrated trade patterns for some basic agricultural commodities were induced by the GFC 2008. Such shifts were mainly driven by terms-of-trade shocks and volatile fluctuations in global supply chains (Sedegah, Odhiambo et al. 2025). Integrated trade boosted processed and prepared agricultural products, mainly due to infrastructure development regarding CPEC 2015. This confirms the notion of expanded trade reliance on geographical infrastructure and connectivity (Zhao, Sun et al. 2022). An accelerated trade pattern for durable, storable basic commodities and a shift toward regressing trade in perishable products have been observed during COVID-19. This specific incident aligns with current trade evaluations that, although such situations disrupt global supply chains, trade flows eventually adjust to these disruptions, with varying resilience across product categories (Arita, Grant et al. 2022).

4 Conclusion and limitations

An empirical analysis of trade integration into global markets for the period 2003-2023 reveals structural inertia and limited integration in the agricultural sector. Although marginal acceleration in bilateral trade has been observed across different static and dynamic trade indices, the sector faces a LOW IIT TRAP (Hoang 2019). An expanded structural polarization is witnessed by the simultaneous existence of convergence and σ -divergence, which isolates very few integrated processed value-added products from a wide variety of basic staple items stuck in stagnant inter-industry trade (Dalum, Laursen et al. 1998). Irrespective of the catalyst role played by External

shocks such as the GFC 2008, CPEC 2015 and COVID-2019, the sector remains stuck in asymmetric downward regression. Smooth and sustainable bilateral trade is strictly limited to processed goods.

Only structural macroeconomic policies can lift the sector out of a low IT trap. Policymakers should shift their focus from one-way trade of raw, unprocessed agricultural products. Policies should focus on product differentiation, value addition, and technological advancements in the supply chain. For smooth, sustainable integration of differentiated products in global integrated markets, utilization of modern infrastructure and logistic systems for the lowest production cost is unavoidable (Qasmi and Fausti 2001).

Although a strong dynamic econometric framework is applied, it is important to recognize some data limitations. It is not possible to separate the horizontal AIIT or vertical AIIT patterns while using aggregate trade data (Greenaway, Hine et al. 1994). Moreover, There was a lack of total trade volumes, which limits the relative export and import unit values necessary to distinguish between quality and quantity differentiation. As a result, although this study is a valuable contribution to understanding trade dynamics, it cannot address vertical quality effects and horizontal variety growth. Using trade volumes and Firm-level microdata in future studies can overcome these limitations and provide details on quality dynamics and supply chain disruptions in Pakistan's agricultural sector.

In conclusion, based on the study's empirical findings, the following suggestions can be offered. First, encourage public and private investment in agro-based processing and technology to enhance export competitiveness, particularly in high-potential sectors such as spices and dried fruits. Second, increasing exports of high-value RCA commodities (e.g., spices, dried fruits) can strengthen the trade performance of Pakistan's agricultural sector. Third, effectively leverage the regional platform (CPEC) to enhance regional trade by strengthening logistics, cold storage, and digital trade platforms for perishable commodities such as vegetables and fruits. Furthermore, robust

trade policies and regional agreements (e.g., CPEC) should be supported to safeguard against global shocks or disruptions.

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