Unveiling the Tapestry of Rice Market in Bangladesh

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Abstract

Market integration serves as an important measure of market efficiency, particularly in relation to pricing efficiency. This paper investigates the nature and extent of market integration in Bangladesh by analyzing the most recent weekly rice market price data from six district markets between May 2020 and June 2023. The findings reveal that the wholesale rice price series are non-stationary at their levels but become stationary after first differencing. A vector error correction model (VECM) is employed following the Johansen-Juselius procedure to assess the co-integrating relationships between the district markets. The negative and statistically significant error correction terms for the Barishal, Chattogram, and Sylhet districts suggest that short-run price adjustments converge toward long-term equilibrium. The results of the VECM indicate a long-term equilibrium relationship between the Dhaka rice market and those in Barishal, Chattogram, Dinajpur, and Khulna. However, in the short run, the estimated coefficients suggest only weak price transmission between district markets within the same week.

Keywords

Rice Market Dynamics

Spatial Transmission of Price

Bangladeshi Rice Economics

Rice Market Connectivity

Bangladeshi Agricultural Markets

1. Introduction

Agricultural price policy is profoundly shaped by the extent of market integration, which has long captured the attention of global researchers. Pan and Li (2020) explain that market integration is deemed perfect when the price difference of a homogenous commodity across two separated markets equals, at most, the transaction costs, allowing for the free spread of goods and information between them. This concept is vital for comprehending market efficiency, particularly through the lens of diverse price correlations (Deb et al., 2023). Spatial market integration stands as a critical metric for market efficiency, as it facilitates improved resource allocation, lowers social costs, and boosts social welfare. Conversely, spatial market fragmentation harms market development, increases society's deadweight loss, and reduces economic efficiency (Pan and Li, 2020). A cohesive cluster of integrated markets should be the ultimate goal for establishing a unified pricing system.

The study of market integration has consistently attracted attention from governments and academics worldwide. Using an error correction model, Ozturk (2023) assessed the co-integration of Turkey's grain market with global grain markets and discovered that Turkey's rice market is not co-integrated with the global rice market. Similarly, Makbul (2023) and colleagues explored the integration of Indonesia's rice markets by analyzing monthly rice prices from 33 major cities between May 2020 and June 2017. Their findings indicated that full integration was absent in many Indonesian rice markets. Baquedano and Liefert (2020) examined price co-integration between urban consumer markets in developing countries and global agricultural commodity markets. Their analysis, based on over 60 country/commodity combinations, revealed that consumer markets in developing nations are indeed co-integrated with global markets.

In their study, Moser et al. (2009) explored market integration in Madagascar, identifying crime rates, remoteness, and lack of information as major impediments to market integration at the sub-regional level. Onumah et al. (2022), through their investigation of rice price volatility in Ghana using monthly price data from 2013 to 2020, found evidence of co-integration between the world and Ghanaian rice markets. Svanidze and Götz (2020) discovered that Russia's wheat market was segmented due to high trade costs, impeding the market's ability to function as an efficient spatial system. Zhou et al. (2000) applied co-integration techniques to analyze Southern China's rice markets, revealing a significant lack of integration caused by inadequate transportation, government intervention, and limited grain availability for arbitrage. Furthermore, Iregui and Otero (2017) utilized consumer price index data from 13 Colombian cities to demonstrate that unprocessed food products exhibited higher market integration compared to processed goods and other tradable commodities.

In developing economies like Bangladesh, the degree and nature of market integration play a pivotal role, especially in decentralized food markets spread across vast geographies (Prince et al., 2023). Several studies have delved into Bangladesh's rice market integration, but findings have been inconsistent. Goletti et al. (1995) asserted that Bangladesh's rice market integration was moderate, while Dawson and Dey (2002) found the market to be perfectly integrated. Hossain and Verbeke (2010), employing a vector error correction approach, demonstrated that Bangladesh's divisional rice markets were moderately integrated between 2004 and 2006. Deb et al. (2023) studied price transmission along Bangladesh's vertical rice supply chain, concluding that wholesale and retail prices are co-integrated in the long run.

Rice, Bangladesh's staple food, constitutes two-thirds of the nation's caloric intake and provides half of its protein requirements (Sayeed & Yunus, 2023). The country's climate and topography are ideal for rice cultivation, with three major growing seasons: Aus, Aman, and Boro. All districts engage in rice production, with Dhaka serving as the primary trading hub. Dhaka's markets, filled with rice mills and traders, form the core of Bangladesh's rice commerce, while Chattogram, a major port city, acts as the gateway for rice exports and imports. Other significant rice-producing regions include Dinajpur and Sylhet, which are known for high-quality rice varieties, as well as Khulna and Barishal in the southern part of the country.

Hossain and Verbeke (2010) found that Dhaka's rice market exhibits unidirectional causality with Khulna and Barishal, and bi-directional causality with Chattogram. Boro, the most dominant rice crop, is cultivated on small family farms, primarily during May and June (Sayeed & Yunus, 2023). Agricultural production in Bangladesh is influenced by a range of external factors, such as weather variability, which directly affects output and pricing (Prince, 2017). Inflation and trade openness also impact the competitiveness of agricultural exports, including rice (Younus & Prince, 2017). Exchange rate fluctuations further complicate food price dynamics by affecting the cost of imports and exports, while high debt levels exert downward pressure on disposable income.

In Bangladesh, where many individuals engage in the gig economy, income instability exacerbates challenges in maintaining consistent demand for staple foods like rice (Prince, 2021). Inflationary pressures further erode purchasing power, particularly for low-income households. Trade openness, tariffs, and exchange rate volatility add layers of complexity to the supply chain, affecting local rice prices and market integration (Prince & Faruq, 2015).

A key objective of Bangladesh's strategic food policy is to ensure sustainable food security for its population (Prince, 2017). However, the rice market is fragmented, with regional and social divides affecting rice pricing. The public procurement system operates as a separate value chain, paying premiums for paddy rice distributed through government programs. Despite the fragmented market, private traders, millers, and wholesalers dominate the value chain, contributing to significant price discrepancies between farm and retail levels (Rahman et al., 2023). Over the past three decades, Bangladesh has witnessed remarkable progress in rice production (Prince et al., 2022), with the industry accounting for 70 percent of agricultural GDP and providing the primary income for over 48 percent of the rural population (Sayeed & Yunus, 2023). Bangladesh ranks as the third-largest rice market globally, with a per capita consumption rate of 144.5 kg, contributing to 67.5 percent of daily caloric intake (Yunus et al., 2020; FAO, 2021). The country produced and consumed 34.6 and 35.8 million metric tons of rice, respectively, between 2023 and 2021 (United States Department of Agriculture, 2021).

This study makes a significant contribution by evaluating Bangladesh's rice market integration using the latest weekly wholesale price data from 2020 to 2023. Goletti et al. (1995) highlighted several factors influencing market integration, including transportation, communication, credit, and storage facilities, along with price stabilization policies and trade restrictions. Since these factors evolve, it is critical to assess market integration using current data. This study, leveraging the most recent data, provides valuable insights into the current state of spatial integration in Bangladesh’s rice market and offers actionable policy recommendations.

2. Methodology

2.1. Data

In this study, weekly wholesale rice price data were meticulously collected for six key districts in Bangladesh: Dhaka, Chattogram, Sylhet, Barishal, Khulna, and Dinajpur. The data spanned the period from May 2020 to June 2023, sourced directly from the Department of Agricultural Marketing, under the Government of the People's Republic of Bangladesh. Each district contributed 320 observations, with rice prices uniformly recorded in terms of Tk/kg. The entirety of the data analysis was executed using the sophisticated statistical software E-Views, ensuring rigorous and comprehensive examination of the dataset.

2.2. Econometric Model

To address the challenges posed by similar trends and non-stationarity in food prices observed in bivariate price correlation models, this research will employ advanced time series methodologies. Time series approaches are crucial for analyzing the degree of market integration, seasonality, and both short- and long-term integration concerns (Ravallion, 1986). When estimating market integration, it is imperative to determine whether each price series is stationary or non-stationary, as this significantly reduces the risk of spurious regression and facilitates the selection of an optimal model. If the price series are integrated of order one, denoted as I(1), it becomes possible to test the null hypothesis of no co-integration against the alternative hypothesis of the presence of one or more co-integrating vectors using the maximum likelihood estimation procedure developed by Johansen (1988). Subsequently, a Vector Error Correction Model (VECM) will be applied to assess the degree, speed, and pattern of district-wise rice price transmission in both the short and long run, based on Johansen's co-integration results. The optimal lag length for the variables in the model will be determined using various information criteria, such as the Final Prediction Error (FPE), Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC), and Schwarz Bayesian Information Criterion (SBIC) (Brooks, 2008).

2.2.1. Stationarity Test

A time series must be stationary in order to be used in regression analysis, as non-stationary time series might result in illegitimate and spurious associations. A stationary series is one whose mean, variance, and autocorrelation are independent of time, or rather demonstrate stable mean and variance, and have an autocorrelation that is stable across time. Two tests such as Phillips-Perron (PP) test and the Augmented Dickey-Fuller (ADF) test will be used to examine the variables' stationarity.

ADF analyzed the alternate hypothesis of stationarity condition against the null hypothesis of non-stationarity, where the stationarity condition in the pertinent series is established by the rejection of null hypothesis. The ADF entails estimating equation (1) as follows:

$$\Delta Y_t = \beta_1 + \beta_2 + \delta y_{t-1} + \sum_{i=1}^{m} \alpha_1 \, \Delta y_{t-1} + \varepsilon_t \qquad \text{……….. (1)}$$

Here Y_t is the relevant price series, β_1 & β_2 are the coefficients or parameters of the equation to be estimated, ε_t is a pure white nose term that is independently and identically distributed as a normal distribution with zero mean and constant variance and presumed to be homoscedastic.

Another test, the PP Test is a non-parametric test to detect serial correlation in the series. According to Ng and Perron (1995), PP test statistic can be seen of as Dickey-Fuller statistics because they have been proven by applying Newey-West (1994) heteroscedasticity to serial correlation and also an estimate of the covariance matrix that is consistent with autocorrelation. The PP statistics have the similar asymptotic distribution as the ADF t-statistic and normalized bias statistics under the null hypothesis that $\delta = 0$. Another benefit of PP over ADF is that, in PP there is no need to define a lag length for the test regression (Ng and Perron, 1995). In order to determine the order of integration, which indicates whether or not price series are integrated of the same order, both ADF and PP test identify the order of difference at which the series becomes stationary. Prior to performing the stationarity test, it is crucial to perform graphical analysis that consists of visualizing data in query on a graph as Gujarati and Sangetha (2010) observed that it is usually good to plot the time series under analysis before continuing the formal unit root test since such plots provide a preliminary indication of the anticipated nature of the time series. It should be noted that before conducting the analysis, all the rice price series have been transformed into the natural logged form.

2.2.2. Co-integration and VECM Framework

The existence of a constant relationship across prices in several locations is the focus of co-integration analysis. Different series are considered to be co-integrated if there is a long run linear link between them (Engle & Granger, 1987). The credibility of the study findings is increased by co-integration, which enables a method of handling time series that prevent incorrect results. Johansen's (1988) method provides a reliable way to examine the long run relationship between stationary pricing variables and also allowed for the testing of various co-integrating vectors. In this approach, to ascertain the quantity of co-integrating vectors in a co-integration regression, it creates test statistic known as the likelihood ratio (LR) test, which is maximum eigenvalue test and trace test. Trace test tests the null hypothesis of r co-integrating vectors, where r = 0, 1, 2….n-1, it is computed as

$$LRtr\left(\frac{r}{n}\right) = -T\sum_{i=r+1}^{n}\log(1-\lambda) \quad \ldots\ldots\ldots (2)$$

Here, $LRtr\left(\frac{r}{n}\right)$ represents the likelihood ratio test statistic for testing the null hypothesis that the eigenvalues (λ) of the matrix are less than or equal to a specified value $\left(\frac{r}{n}\right)$, T denotes the number of observations.

The maximum eigen value test tests the Ho of co-integrating vectors against the H_1 of r+I co-integrating vectors for r= 0,1,2,….n-1. This test statistic is computed as:

$$LRmax\left(\frac{r}{n}+1\right) = -Tlog(1-\lambda) \quad \ldots\ldots\ldots (3)$$

Here, n denotes the variables in the system, T represents the sample size and λ shows maximum eigenvalue. Because it explicitly treats all the variables as endogenous and soles the endogenity problem by offering an estimation procedure that does not necessitate the random selection of a variable for normalization, Johansen's approach to co-integration is now widely used to assess the degree of market integration.

The short run characteristics of the co-integrated series have been assessed and price adjustment across rice market is quantified by using a vector error correction model (VECM). Hendy and Juselius

(2000) stated that when variables are stationary at first difference and co-integrated, the application of the VECM is facilitated. In order to quantity how price deviations return to equilibrium, VECM takes into account the possibility that shocks in one market may not immediately affect others or that they may take time to travel. According to Obayelu and Salau (2010), vector error correction model considers all variable to be endogenous, restricts long run behavior to converge to co-integrating relationships, and permits short-run adjustment dynamics.

When X and Y are I(1) and co-integrated in a two variable VAR,

$$\Delta X_t = C_1 + \gamma_1 Z_{t-1} + \beta_1 \Delta X_{t-1} + \cdots + a_1 Y_{t-1} + \cdots + \varepsilon_{xt} \quad \ldots\ldots\ldots\ldots (4)$$

$$\Delta Y_t = C_2 + \gamma_2 Z_{t-1} + \gamma_1 \Delta X_{t-1} + \cdots + \delta_1 Y_{t-1} + \cdots + \varepsilon_{yt} \quad \ldots\ldots\ldots\ldots (5)$$

Here, ΔX_t denotes the first difference of the variable X at time t, $C_1$and C_2 represent the intercept terms in the respective equations, the coefficients $\gamma_1$and $\gamma_2$quantify the impact of the lagged exogenous variable Z at time t-1 on ΔX_t and ΔY_t, respectively, the coefficient $\beta_1$represent the parameter estimate for the lagged first difference of X, the coefficient a_1 denotes the parameter estimate for the lagged endogenous variable Y at time (t-1), $\delta_1$is the coefficient which represents the parameter estimate for the lagged endogenous variable Y at time (t-1) in the equation for ΔY_t, and $(\varepsilon_{xt}. \varepsilon_{yt})$ denotes bivariate white noise.

3. Results

3.1. Descriptive Statistics

Table 1 provides the descriptive statistics of the dataset utilized in this study, while Figure 1 illustrates the line graphs derived from the raw data for the six district markets under consideration. A review of Table 1 reveals that the mean wholesale rice prices across the selected districts range from Tk. 44.38 to Tk. 49.90. The highest recorded rice price was observed in Dhaka, whereas Dinajpur reported the lowest price within the observed period.

Table 1: Descriptive Statistics

Districts	Dhaka	Barishal	Chattogram	Dinajpur	Khulna	Sylhet
Mean	49.90	44.38	48.56	45.68	45.50	46.47
Maximum	56.70	51.30	55.40	51.00	52.00	54.20
Minimum	37.80	38.88	42.00	38.00	38.60	39.88
Std. Dev	4.71	2.36	3.52	2.58	2.96	3.33
Observations	260	260	260	260	260	260

Source: Authors' calculation

3.2 Unit Root Test Result

Table 2 presents the outcomes of the unit root tests conducted using both the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods. These tests were applied to each variable over the period from May 2020 to June 2023. The analysis revealed that the variables are non-stationary at their levels, and any attempt to utilize them in this form would result in spurious regression. However, all variables became stationary at their first difference, indicating they are integrated at the same level, denoted as I(1). The appropriate lag lengths for the tests were determined using information criteria such as FPE, AIC, HQIC, and SBIC (Appendix-1).

Table 2: Result of Unit Root Tests

District	Levels		First Difference		Levels		First Difference	
	ADF	P-value	ADF	P-Value	PP	P-Value	PP	P-Value
Barishal	1.24	0.99	***-10.96	0.00	-1.26	0.64	***-32.97	0.00
Chattogram	0.89	0.99	***-6.42	0.00	-0.18	0.93	***-38.46	0.00

Dhaka	-0.55	0.87	***-19.93	0.00	-0.99	0.75	***-33.80	0.00
Dinajpur	-0.14	0.94	***-5.98	0.00	-1.56	0.50	***-33.29	0.00
Khulna	0.57	0.98	***-15.96	0.00	-0.50	0.88	***-29.55	0.00
Sylhet	0.19	0.97	***-18.20	0.00	-0.34	0.91	***-23.52	0.00

Source: Authors' calculation; Note: * denotes unit root in the first difference is rejected at 1% level of significance**

3.3. Test of Co-integration

Table 3 presents the results of the Johansen and Juselius multivariate co-integration analysis. The eigenvalue test identifies two co-integrating equations, whereas the trace test reveals three. As noted by Lütkepohl et al. (2001), the power of the trace test can surpass that of the maximum eigenvalue test in certain conditions. Furthermore, a greater number of co-integrating vectors indicates a stronger interrelationship among the variables within the system (Kargbo, 2005). Collectively, these findings confirm the existence of a long-run equilibrium relationship between the variables.

Table 3: Result of the multivariate co-integration rank test

Eigen Value	**Trace Test**				**Maximum Eigen value test**			
	Null	**Trace Statistic**	**P-Value**	**Hypothesized number of cointegrating equations**	**Null**	**Max Eigen Statistic**	**P-value**	**Hypothesized number of cointegrating equations**
0.21	r=0	166.58	0.00	None*	r=0	60.26	0.00	None*
0.15	r≤1	106.32	0.00	At most one*	r=1	41.71	0.01	At most one*
0.08	r≤2	64.61	0.04	At most two*	r=2	23.36	0.39	At most two
0.07	r≤3	41.24	0.07	At most three	r=3	20.37	0.22	At most three

0.04	r≤4	20.87	0.18	At most four	r=4	12.92	0.33	At most four
0.03	r≤5	7.94	0.25	At most five	r=5	7.94	0.25	At most five

Source: Authors' calculation; Note: * denotes rejection of null hypothesis at 1% level of significance

3.4. Vector Error Correction Model

Simply being aware of market integration is insufficient, it is also crucial to understand at what degree the markets are integrated. This necessitates separating the short and long term effects or price variations occurring in one region from those occurring in another. Dynamic adjustments allow researchers to examine the speed to adjustment and the time required for prices to propagate from one market to another. The estimated results of the VECM show that in the long run there exists an equilibrium relationship between Dhaka rice markets with Barishal, Chattogram, Dinajpur and Khulna rice markets (Equation 6 & Table 5).

$$ECT_{t-1} = 1.00\, DHAKA_{t-1} + 6.28\, BARISHAL_{t-1} + 16.76\, CHATTOGRAM_{t-1} - 5.42\, DINAJPUR_{t-1} - 18.47\, KHULNA_{t-1} - 2.05\, SYLHET_{t-1} + 2.72 \quad \ldots\ldots (06)$$

The coefficients of error correction term for Barishal, Chattogram and Sylhet are negative and statistically significant indicating that there is a convergence from short run dynamics towards long run equilibrium (Table 4 and Table 5). The adjustment coefficient is 0.01 for both Barishal, Chattogram and Sylhet towards long run equilibrium in case of disequilibrium situation.

The short run dynamics of chosen variables in the study can be assessed by analyzing the significance and signs of the estimated lagged coefficients (Table 4 and Table 5). The coefficients' values suggest that there is weak transmission of price changes from one district market to another within the same week. In the short run, it is found that all the rice market is dependent significantly on its previous week's rice price. A percent increase in the Dinajpur and Sylhet's rice price is associated with 0.16 percent and 0.14 percent increase in rice price of Barishal. Chattogram's rice price is dependent significantly in the short run on the rice prices of Dhaka, Barishal, Dinajpur and Khulna. In case of Dinajpur, a percent increase in the rice price of Dhaka is linked with the decline rice price of Dinajpur by 13.62 percent. Khulna's rice price is found to be associated with the rice price of Chattaogram and Dinajpur.

Unlike the findings of Dawson and Dey (2002), this study did not find the rice markets in Bangladesh to be perfectly integrated; rather it found that the degree of integration is moderate, which is in line with the findings of Goletti et al. (1995) and Hossain and Verbeke (2010). This suggests that the interconnection between district rice markets in Bangladesh has certain constrains. Because of this, market intervention in one district market does not immediately affect other district markets and thus, national agricultural price policy also may not be sustainable. If the markets are not properly connected, it will have negative impacts on market development, increase deadweight loss of the society, and diminish overall economic efficiency (Pan, F., & Li, C. 2020).

Table 4: Results of VECM (Equations of short run estimates)

Dhaka

$$\Delta LN\_DHAKA_t = -0.007ECT_{t-1} - 0.477\Delta LN\_DHAKA_{t-1} + 0.179\Delta LN\_BARISHAL_{t-1} - 0.158\Delta LN\_CHATTOGRAM_{t-1} + 0.160\Delta LN\_DINAJPUR_{t-1} - 0.135\Delta LN\_KHULNA_{t-1} + 0.107\Delta LN\_SYLHET_{t-1} + 0.000$$

Barishal

$$\Delta LN\_BARISHAL_t = -0.011ECT_{t-1} - 0.038\Delta LN\_DHAKA_{t-1} - 0.353\Delta LN\_BARISHAL_{t-1} - 0.016\Delta LN\_CHATTOGRAM_{t-1} + 0.161\Delta LN\_DINAJPUR_{t-1} - 0.064\Delta LN\_KHULNA_{t-1} + 0.148\Delta LN\_SYLHET_{t-1} + 0.000$$

Chattogram

$$\Delta LN\_CHATTOGRAM_t = -0.013ECT_{t-1} - 0.108\Delta LN\_DHAKA_{t-1} + 0.144\Delta LN\_BARISHAL_{t-1} - 0.295\Delta LN\_CHATTOGRAM_{t-1} + 0.154\Delta LN\_DINAJPUR_{t-1} - 0.217\Delta LN\_KHULNA_{t-1} + 0.060\Delta LN\_SYLHET_{t-1} + 0.000$$

Dinajpur

$$\Delta LN\_DINAJPUR_t = 0.011ECT_{t-1} - 0.136\Delta LN\_DHAKA_{t-1} + 0.024\Delta LN\_BARISHAL_{t-1} - 0.160\Delta LN\_CHATTOGRAM_{t-1} - 0.283\Delta LN\_DINAJPUR_{t-1} + 0.021\Delta LN\_KHULNA_{t-1} + 0.270\Delta LN\_SYLHET_{t-1} + 0.000$$

Khulna

$$\Delta LN\_KHULNA_t = 0.016ECT_{t-1} + 0.001\Delta LN\_DHAKA_{t-1} - 0.055\Delta LN\_BARISHAL_{t-1} - 0.265\Delta LN\_CHATTOGRAM_{t-1} + 0.128\Delta LN\_DINAJPUR_{t-1} - 0.381\Delta LN\_KHULNA_{t-1} + 0.092\Delta LN\_SYLHET_{t-1} + 0.000$$

Sylhet

$$\Delta LN\_DHAKA_t = -0.009ECT_{t-1} - 0.075\Delta LN\_DHAKA_{t-1} + 0.120\Delta LN\_BARISHAL_{t-1} - 0.028\Delta LN\_CHATTOGRAM_{t-1} - 0.048\Delta LN\_KHULNA_{t-1} - 0.270\Delta LN\_SYLHET_{t-1} + 0.000$$

Source: Authors' Calculation

Table 5: Result of VECM (Long-run and short run estimates)

Sample (Adjusted): 1/15/2020 to 12/19/2023

Included observations: 280 after adjustments

Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LN_DHAKA(-1)	1.00
LN_BARISHAL(-1)	**6.284327 (2.207760) [2.84668]
LN_CHATTOGRAM (-1)	**16.76057 (2.26182) [7.41022]
LN_DINAJPUR(-1)	**-5.419865 (1.50983) [-3.58971]
LN_KHULNA (-1)	**-18.46901 (2.08718) [-8.84879]
LN_SYLHET	**-2.051647 (2.04618) [-1.00267]
C	2.725127

Error Correction	D(LN_DHK)	D(LN_BARISAL)	D(LN_CHTG)	D(LN_DINAJ)	D(LN_KHULNA)	D(LN_SYLHET)
CointEq1	-0.006867 (0.00570) [-1.20460]	**-0.010899 (0.00362) [-3.00796]	**-0.013302 (0.00238) [-5.58929]	**0.010763 (0.00440) [2.44367]	**0.016269 (0.00394) [4.12566]	**-0.008955 (0.00392) [-2.28610]
D(LN_DHAKA(-1))	**-0.476518 (0.06739) [-7.07099]	-0.038050 (0.04284) [-0.88825]	**-0.108034 (0.02814) [-3.83980]	**-0.136234 (0.05207) [-2.61645]	0.001042 (0.04662) [0.02234]	-0.074885 (0.04633) [-1.61632]
D(LN_BARISAL(-1))	0.179329	**-0.352892	**0.144411	0.023877	-0.054882	0.120859

	(0.10016) [1.79049]	(0.06366) [-5.54306]	(0.04181) [3.45359]	(0.07738) [0.30855]	(0.06929) [-0.79212]	(0.06886) [1.75524]
D(LN_CHATTOGRAM(-1))	-0.158208 (0.14399) [-1.09871]	-0.015630 (0.09153) [-0.17077]	**-0.295235 (0.06012) [-4.91100]	-0.159962 (0.11126) [-1.43779]	**-0.265177 (0.09961) [-2.66211]	-0.027743 (0.09899) [-0.28025]
D(LN_DINAJPUR(-1))	0.159940 (0.09126) [1.75255]	**0.160651 (0.05801) [2.76940]	**0.154533 (0.03810) [4.05587]	**-0.283230 (0.07051) [-4.01679]	**0.128468 (0.06313) [2.03493]	0.052737 (0.06274) [0.84056]
D(LN_KHULNA(-1))	-0.135378 (0.11079) [-1.22198]	-0.063646 (0.07042) [-0.90381]	**-0.216560 (0.04625) [-4.68212]	0.021335 (0.08560) [0.24925]	**-0.381388 (0.07664) [-4.97647]	-0.047407 (0.07616) [-0.62244]
D(LN_SYLHET(-1))	0.106822 (0.10885) [0.98136]	**0.148326 (0.06919) [2.14373]	0.059650 (0.04544) [1.31258]	**0.269903 (0.08410) [3.20921]	0.092041 (0.07530) [1.222321]	**-0.270227 (0.07483) [-3.61103]
C	0.000398 (0.00060) [0.662671]	0.000373 (0.00038) [0.97530]	0.000481 (0.00025) [1.31258]	0.000407 (0.00046) [0.87644]	0.000477 (0.00042) [1.14707]	0.000405 (0.00042) [0.97924]
R-Squared	0.226887	0.197397	0.373531	0.211551	0.328408	0.131498
Adj. R-squared	0.205239	0.174925	0.355990	0.189475	0.309604	0.107180
Sum sq. resids	0.023156	0.009358	0.004036	0.013824	0.011081	0.010945
S.E. equation	0.009624	0.006118	0.004018	0.007436	0.006658	0.006616
F-statistic	10.48112	8.783807	21.29457	9.582623	17.46429	5.407405
Log likelihood	835.9942	952.9892	1061.352	902.5443	931.0673	932.6700
Akaike AIC	-6.418559	7.324792	-8.165522	-6.934452	-7.155561	-7.167985
Schwarz SC	-6.308390	7.214623	-8.055353	-6.824283	-7.045392	7.057815
Mean dependent	0.000282	0.000330	0.000382	0.000309	0.000317	0.000326
S.D. dependent 0.010796		0.006735	0.005007	0.008260	0.0008013	0.007002

Determinant resid Covariance (d of adj.)	1.53E-27
Determinant resid Covariance	1.27E-27
Log Likelihood	5792.779
Akaike information criterion	44.48666
Schwarz criterion	43.74301

Number of coefficients	54

Source: Authors' calculation, Note: ** denotes 5% level of significance

4. Concluding Remarks

The term "spatial market integration" refers to the degree to which prices in geographically separated markets move in tandem and the efficiency with which price signals and information are transmitted between these markets. Studying market integration provides critical insights into the functioning of market systems and can help identify inefficiencies that may justify state intervention. A thorough understanding of market integration is essential for assessing the effectiveness of policies like market liberalization or price stabilization, as it offers a deeper perspective on how incentives are transmitted throughout the market chain. Given the importance of analyzing market integration, this study investigated the type and degree of integration in Bangladesh's rice markets by utilizing the most recent weekly wholesale price data from six regional districts.

The empirical findings reveal that the wholesale price series for rice are non-stationary at their levels but become stationary at first differences, necessitating the application of an error correction model (ECM). The coefficients of the error correction terms for Barishal, Chattogram, and Sylhet are negative and statistically significant, suggesting that these markets exhibit a tendency to converge toward long-run equilibrium after short-run fluctuations. The ECM results further demonstrate that, over the long term, the rice markets in Dhaka are in equilibrium with those in Barishal, Chattogram, Dinajpur, and Khulna, indicating a strong spatial connection among these regions. However, in the short run, the estimated coefficients reveal weak transmission of price changes from one district market to another within a single week, highlighting inefficiencies in the immediate adjustment process.

Based on the study's findings, several structural challenges are identified as potential impediments to short-term price transmission across district markets. These include insufficient infrastructure and inadequate transportation networks, which can hinder the smooth flow of goods and services between regions. Additionally, the lack of timely and accurate information about prices, supply, and demand conditions in different districts limits market participants' ability to respond swiftly to changing market conditions. The market power held by large traders and middlemen further exacerbates these inefficiencies, as they may exploit price disparities for profit, preventing smaller traders from competing effectively. The absence of supportive policies and weak institutional frameworks also contribute to the sluggish price transmission observed in the short run.

To address these challenges and enhance the efficiency of market integration, it is recommended that the government invest in improving infrastructure, particularly transportation and communication systems, to facilitate the movement of goods and information between districts. Developing a centralized system for real-time price monitoring and dissemination can provide market participants with the data necessary to make informed decisions. Additionally, regulatory frameworks should be strengthened to curtail the dominance of large traders and middlemen, promoting greater competition within the market. Policy interventions aimed at improving the transparency and accessibility of rice markets, such as the implementation of price stabilization mechanisms or incentives for small-scale traders, could further support the integration process.

However, further research is needed to examine the precise effects of these constraints on market integration in Bangladesh. Future studies should focus on quantifying the impact of specific factors such as infrastructure gaps, trader market power, and institutional weaknesses on price transmission dynamics. Moreover, exploring the role of external factors like global market conditions and exchange rate fluctuations could provide a more comprehensive understanding of the forces shaping market integration in Bangladesh's rice markets. By addressing these gaps, policymakers can develop targeted strategies to foster stronger and more efficient market integration, ultimately enhancing food security and economic stability in the country.

Appendix-1: Appropriate Lag Length of the Variables

Endogenous Variable: LN_BARISHAL LN_CHATTOGRAM LN_DHAKA LN_DINAJPUR LN_KHULNA LN_SYLHET

Exogenous Variable: C

Sample: 01/01/2020 to 12/19/2023

Included Observations: 280

Lag	LogL	LR	FPE	AIC	SBIC	HQIC
0	1887.115	NA	3.53e-25	-28.28323	-28.1365	-28.569
1	2703.382	252.724*	1.83e-28*	-44.40300*	-42.1356*	-41.991*
2	2807.227	335.521	1.23e-27	-42.93511	-41.3454	-40.025
3	2924.461	413.817	2.10e-27	-38.57224	-38.3910	-35.229
4	3015.332	163.923	6.52e-26	-35.00260	-34.0134	-30.225
5	3159.096	216.997	3.83e-25	-32.84781	-28.1134	-28.025

*Indicates lag order selected by the criterion

LR: Sequential modified LR Test Statistic (each test at 5% level)

FPE: Final Prediction Error

AIC: Akaike Information Criterion

SBIC: Schwarz Information Criterion

HQIC: Hannan-Quinn Information Criterion

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