



Market Integration and Spatial Price Transmission among the Pakistani and Central Asian Wheat Flour Markets

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Abstract: We investigated the extent of the wheat flour market integration among Central and South Asian countries from 2006 to 2023. We employed the Vector Error Correction Model (VECM) combined with Granger causality tests to determine the degree of integration, the underlying short-run adjustments, and the direction of causality. The results of the study confirmed the existence of long-run co-integration among the wheat flour markets. We also found that Pakistan and Afghanistan significantly responded to price shocks of each other. Furthermore, Kazakhstan, being the major supplier of wheat flour in the Central Asian countries, did not seem to be affecting the prices of wheat flour in other countries. It shows that the markets of Afghanistan and Pakistan are more efficient than the Central Asian markets. There is a need to improve the efficiency of wheat flour markets in Central Asia. From the market efficiency and food security perspectives, this study has suggestions for policymakers. The increased integration between the central and South Asian markets would stabilize the food prices in the region. Moreover, spatial integration among the central and South Asian countries could increase to a greater extent with the infrastructure development. This study contributes to the existing literature by addressing the wheat flour price transmission in the central and south Asian countries for the first time. The application of cointegration and VECM models helps to understand the long-run equilibrium relationship and short-run adjustment in the wheat flour prices and enables us to shed some light on the policies to improve the efficiency of wheat flour markets of central and south Asian countries.

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Introduction

Pakistan is one of the world's leading wheat producers. Wheat is used as a major staple food in Pakistan and the Central Asian countries. The shortage in wheat supply in these markets causes instability in wheat prices and the prices of other wheat byproducts. A lesser yield of wheat causes an increase in the prices of wheat and wheat flour in the market. On the other hand, a higher output of wheat causes a decrease in the prices of wheat and wheat flour in the market. Thus, the situation of food security has been questionable in thickly populated countries. The prevalence of food insecurity and low market efficiency in developing countries has been less debated in recent years. The central and South Asian region has not received attention due to a lack of trade routes. However, the recent major infrastructure developments, with the objective of increasing connectivity between these countries, could enhance the interconnection between the markets. Despite the strategic importance of wheat as a major commodity and recent infrastructure developments aimed at enhancing trade connectivity, the extent of wheat flour market integration remains underexplored. There is a pressing need to investigate the degree of market integration and price transmission dynamics among these countries to inform policies that enhance market efficiency, stabilize food prices, and improve food security.

This study focuses on the connectedness of the wheat flour markets of South and Central Asia. Wheat is the primary food and caloric intake up to 50% in the Central and South Asian countries (Svanidze, Götz, Djuric, & Glaubien, 2019b). Wheat flour covers most of the budget for the poor sections of the community. In accordance with an estimate, a household spends 13% of its monthly expenditure on wheat flour. Thus, the price changes in such a commodity can have a major impact on consumer welfare. The Central Asian countries including Afghanistan, are net importers of wheat except Kazakhstan (Halimi, Abbott, & McNamara, 2015)

The South Asian countries like India and Pakistan are not only self-sufficient in producing wheat but also export the wheat whenever in abundance. In case of lesser yield, Pakistan has to import it from other countries, including Ukraine, Russia, Bulgaria, Romania, and Brazil. In 2021, Pakistan imported The South Asian countries like India and Pakistan are not only self-sufficient

The South Asian countries like India and Pakistan are not only self-sufficient in producing wheat but also export the wheat whenever in abundance. In case of lesser yield, Pakistan has to import it from other countries, including Ukraine, Russia, Bulgaria, Romania, and Brazil. In 2021, Pakistan imported wheat of 594, 185, 107, 50.1, 17.2 (Million USD) respectively from these countries (Pakistan, 2023). The stability in food prices has economic benefits and costs. In poor countries, stable food prices improve the well-being of the poor, food security and economic growth. However, volatility in the prices of wheat is a common phenomenon (Jam Ghulam Murtaza Sahito, 2015). The stability in the domestic food market can be attained at the cost of the government bearing the difference in the price of the world and domestic market, reduced opportunities for the arbitrageurs, and a disruption in the international market if the domestic market is too large (Dawe & Peter Timmer, 2012). Wheat market efficiency and price stability are a challenge for all countries in the South and Central Asian region. The governments are involved in food price stabilization in South Asia in order to improve food security (Cummings, 2012; Dawe & Peter Timmer, 2012). However, the Central Asian markets are less stable due to the lack of government policies and infrastructure (Svanidze, Götz, Djuric, & Glauben, 2019a). Transportation and storage facilities are essential for the well-functioning of agricultural markets. Due to the lack of these facilities, agricultural commodity prices are low in the areas of production and high in areas of consumption. Similarly, if global commodity prices go up, local agricultural commodity prices do not follow an upward trend. While the global prices go down, the local prices also go down quickly (Abbott & Borot de Battisti, 2011).

Price transmission refers to the influence of one market on the prices of other markets. Price transmission is measured in terms of the price transmission elasticity (i-e), one unit change in prices of one market affecting the prices of other markets (Minot, 2011). In a market setting, competing forces determine the equilibrium prices of the commodities. It is possible to conduct a price transmission analysis if the products are homogeneous, while it is quite difficult in the case of heterogeneous products. A clear understanding of an industry, geographical aspects, government policies, and suitable econometric techniques is necessary for the price transmission analysis (Lence, Moschini, & Santeramo, 2018).

The food markets of the developed countries are well connected with the world markets through the price mechanism. However, the markets in developing countries show less connectedness with world markets. The central and south Asian countries are a part of the Eurasian wheat belt, having significant wheat production as well as food security issues. These countries have similarities in terms of the consumption of wheat flour in their daily diet. Their borders are connected from Pakistan (east) to Kazakhstan (west). Along these lines, information about the relationship between markets will help policymakers in defining the policy framework towards efficient markets and food security. By keeping in view, the significance and potential of these markets, the governments of these countries can take rational decisions for the mutual benefit of all participating countries to improve the infrastructure to avoid difficulties in trading and wheat supply against the increasing demand for food. Despite extensive debate on the price transmission in the literature, there is a need to revisit the market integration among the Central and South Asian countries.

Despite the extensive literature on price transmission and market integration in global agricultural markets, there is a notable lack of comprehensive studies focusing on the combination of wheat flour markets of Central and South Asian countries, particularly Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, and Kazakhstan. Previous research has primarily examined global or regional wheat markets in isolation, with limited attention to the interconnectedness of these specific countries, which share geographic proximity and significant wheat consumption patterns. Moreover, while some studies have explored long-run market relationships, there is a scarcity of research that simultaneously investigates both long-run and short-run price transmission dynamics in this region using advanced econometric techniques like the Vector Error Correction Model (VECM) and Granger causality tests.

This study addresses these gaps by analyzing the extent of market connectedness and price transmission among the wheat flour markets of the selected countries over the period of 2006–2023, providing new insights into their long-run equilibrium relationships, short-run adjustments, and policy implications for improving market efficiency and food security.

This study aims to analyze the wholesale prices of wheat in wheat-consuming countries from the central and south Asian region. These countries include Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, and Kazakhstan. The price has

been collected over the period of 2006 -2023. The selection of countries was based on wheat consumption and the geographical location adjacent to Pakistan, where there is the potential for developing the wheat trade between the countries. The study has focused on the volatility of the selected countries' wheat prices as well as their integration with the Pakistani wheat market. Cointegration and the VECM models have been used to achieve the study's objective. Furthermore, more dynamic models like TVP-VAR are used due to the limited availability of data.

The main objective of this study is to analyze the integration among wheat flour markets through price transmission by using monthly wheat flour price data of the Central and South Asian countries from 2006 to 2023. By using graphical and descriptive statistics, different dynamics of the wheat prices would be exhibited. Moreover, Johansen co-integration, VECM, and Granger Causality test specifies the integration (long-term relationship and adjustment towards equilibrium) among wheat flour prices of selected countries of the central and south Asian region. The results of this study would demonstrate whether the selected markets have a long-term relationship with each other. More specifically, the study has the following specific objectives:

- i) To examine the extent of market connectedness and price transmission among wheat flour markets, particularly in Pakistan, Afghanistan, Tajikistan, Kazakhstan, and Kyrgyzstan, focusing on long-run dynamics.
- ii) To examine the extent of market connectedness and price transmission among wheat flour markets in Pakistan, Afghanistan, Tajikistan, Kazakhstan, and Kyrgyzstan, focusing on short-run dynamics.

The remaining parts of the paper are: The second section reviews the previous works completed by other authors. The third section describes the variables, sources of data, and methodology. The fourth section elaborates on the results. The last section entails the conclusion and policy recommendations.

Theoretical Framework, and Literature Review

Theoretical Framework of the Study

The flour market integration in Central and South Asian countries has utmost economic importance due to the fact that it is an important food and trading commodity (Svanidze et al., 2019a). Market integration is defined as the ability of different markets to integrate by transmitting price (price transmission) signals and other resources. Such integration is imperative for achieving greater efficiency in resource allocation, facilitating food security,

and greater stability of economic conditions in the region (Baulch, 1997; Enke, 1951). The theory of Market integration is based on the Law of One Price (LOOP), which states that prices of identical goods should be the same across geographical regions if traded in the same currency and in the absence of trade barriers and other transaction costs (Goldberg & Verboven, 2005; Samuelson, 1952). The law of one price also governs the relationship of the markets in which price transmission occurs from one market to another (Fackler & Goodwin, 2001). However, Factors like exchange rate risk, international boundaries, tariffs, and other institutional factors prevent the law of one price (LOP) from taking place (Zhang, Brown, Dong, & Waldron, 2017). In the absence of the law of one price, the differences in the price level make spatial arbitrage possible (Clements, Si, & Vo, 2023; Friesz & Lin, 2025). The possibility of arbitrage is considered an inefficiency of markets. However, the arbitrage process equalizes the prices between markets and restores the equilibrium through the price transmission process (Taylor, 2001). The concept of asymmetric price transmission (APT) demonstrates how price increases propagate more rapidly than decreases due to market imperfections (Ravallion, 1986). In agricultural and staple food markets of developing regions, the asymmetric price transmission is evident, where the upward shocks are faster and the downward change in price is slower (Harshana & Ratnasiri, 2023; T N et al., 2024). Such uneven movement of price is also called the Rocket and Feather phenomenon (Arida, Masbar, Majid, & Indra, 2023; Tappata, 2009).

Literature Review

Studies on food prices have focused on two types of price transmission. The first type is the vertical price transmission, which focuses on price at a different level from the price of the producer (farm price) to the price of the consumer (wholesale price) (Cramon-Taubadel, 1998). The second type is spatial price transmission, which focuses on the price relations among geographically separated markets (Lence et al., 2018; Jam Gulam Murtaza Sahito, 2017; Zakari, Ying, & Song, 2014). The spatially integrated markets transmit the prices through the demand or supply. The change in demand or supply, which is transferred from one region to another region, changes the prices accordingly. For example, in strongly integrated markets, a harvest shortfall would increase the price while an excess of the harvest would decrease the price at regional levels (Goodwin & Piggott, 2001; Svanidze et

al., 2019a). Nevertheless, in weakly integrated markets, the decreases in price levels due to the high level of the harvest would prevail because these markets have restrictions on exporting the commodities (Jamora & von Cramon-Taubadel, 2016). The asymmetric price transmission entails that the (Meyer & von Cramon-Taubadel, 2004), in which different types of asymmetric price transmission and the methods to analyze the price transmission have been identified.

Previous studies on spatial price transmission have used various econometric models in different countries. In the 1980s, correlation coefficients were the main measures of price transmission used in the studies. Later, researchers found various weaknesses in the usage of these empirical techniques (von Cramon-Taubadel, 2017). Then, the co-integration technique became prominent in the previous studies on price transmission (Ardeni, 1989; García-Germán, Bardají, & Garrido, 2016). The co-integration distinguishes spurious regression from the true regression between variables (von Cramon-Taubadel, 2017). Currently, the Vector Error Correction model (VECM) is popular (Enders & Granger, 1998), because of its relevant interpretation of the phenomena. Basically, VECM is a modified form of Vector Autoregressive (VAR) models. It re-parameterizes VAR models by including lagged values of the time series variables. The literature also mentioned some limitations of the VECM. First, the VECM has linear parameters, which are assumed same over the whole study period; therefore, it does not address breaks in the long-run equilibrium. Second, VECM deviates from one or both forms of linearity (Greb, Jamora, Mengel, Cramon-Taubadel, & Wurriehausen, 2016; Hassouneh, Cramon-Taubadel, Serra, & Gil, 2012; Meyer, 2004). The Threshold Vector Error Correction Model (TVECM) addresses the breaks present in the long-term equilibrium (Balke & Fomby, 1997). The TVECM model has different bands of adjustments. Particularly, a no-arbitrage band that encompasses the adjustment that is smaller than the transaction cost. If the change is greater than the transaction cost between the markets, then adjustments are made in other bands. TVECM is a flexible model as it has the capability of including a constant term or intercept and lag in each regime. This model has been used with modifications in many studies on price transmission analysis (Hansen & Seo, 2002; Meyer, 2004; Seo, 2006).

Moreover, literature finds that various approaches have been used to estimate the degree of market integration. The Bivariate and Multivariate Time Series

Analysis: These approaches work by analyzing past price data to determine which markets move in tandem with, or cause movement in, others. Through the use of co-integration tests, it is possible for the researchers to ascertain whether prices in various markets are integrated in the sense that they are characterized by a persistent rise in the long run (Johansen, 1988; Engle & Granger, 1987). Threshold Autoregressive (TAR) Models, which enable the end user to study nonlinearities in the relative prices of goods and services and the possibility of asymmetric adjustments (Baulch, 1997; Meyer & von Cramon-Taubadel, 2004).

The research on market integration is enriched with heterogeneous settings of the applied work from all around the world. The empirical literature consists of spatial market integration among domestic markets, among global markets, and between global and domestic markets. We found that few studies focused on the domestic wheat markets of Pakistan (Mushtaq & Abbas, 2007; Jam Ghulam Murtaza Sahito, 2015; Jam Gulam Murtaza Sahito, 2017). They have generally used nonlinear threshold models. These studies have analyzed the integration among some of the domestic markets of Pakistan. They found that the ban on the movement of wheat, the poor transportation infrastructure, and variations in the transportation cost are the major hindrances to the well-functioning of the domestic markets of Pakistan. However, markets are integrated in the long term with each other. The short-term deviations occur and are adjusted in a short period of time. The highly controlled wheat markets in Pakistan also put pressure on the government, as the efficiency of the wheat market is restricted. (Sharma, 2003) assessed wheat market integration between Asian markets (including India and Pakistan) and global benchmarks using error correction models (ECMs), revealing partial integration but significant policy distortions that delay equilibrium adjustments. In a more recent analysis, (M. Ahmed, Singla, & Singh, 2022) applied a transaction cost approach to Indian wheat markets from 2006–2016, finding asymmetric price transmission across spatially separated markets and recommending infrastructure improvements to reduce asymmetries—echoing challenges in cross-border trade with Pakistan and Afghanistan.

Studies on the Afghan wheat market found that the wheat price volatility in the Afghan wheat market is mainly affected by Kazakhstan and Pakistan. Pakistan and Kazakhstan, as the main suppliers of wheat to Afghanistan, transmit price signals in the long run; however, the domestic markets do not

respond to these signals quickly in the short run. However, the export restrictions in Pakistan have weakened the connections of its markets with Afghanistan in the long run. Moreover, the domestic markets of Afghanistan are also well connected with the central market. However, some of the regional markets may not respond quickly to the central market due to poor transportation means (Philippe Chabot & Dorosh, 2007; Ph Chabot & Tondel, 2011; Halimi et al., 2015; Najibullah Hassanzoy, Ito, Isoda, & Amekawa, 2016; N. Hassanzoy, Ito, Isoda, & Amekawa, 2017). From Central Asia, the most prominent studies on price transmission and wheat market integration are conducted by (Akramov, 2011; Bobokhonov, Pokrivcak, & Rajcaniova, 2017; Ph Chabot & Tondel, 2011; Ilyasov, Goetz, Akramov, Dorosh, & Glauben, 2015; Svanidze, Götz, Djuric, Ilyasov, & Glauben, 2016).

These studies showed that the Central Asian countries are part of the major wheat belt region of Asia with the potential to increase wheat productivity. However, these countries are net importers of wheat due to heavy domestic demand (y Paloma, Mary, Langrell, & Ciaian, 2016). These studies showed that these countries are landlocked, and the transportation costs are unregulated, which affected the wheat market integration in the region (Kourmanova et al., 2008; Svanidze et al., 2019a). Moreover, political issues and trade restrictions are also the major reasons for food insecurity in the region.

Data and Methodology

Data Collection

We selected the sample of representative wheat flour markets of Pakistan, Afghanistan, and four central Asian countries, such as Tajikistan, Kyrgyzstan, Uzbekistan, and Kazakhstan. These markets are selected on the basis of geographical importance, high intake of wheat, and availability of data, and their direct or indirect relationship with Pakistani markets. We collected monthly data of wheat flour prices from the Global Information and Early Warning System (GIEWS), for the period 2006 to 2023. These data on GIEWS database are often available for more than one city, so we have collected the data for the major market or the capital city of the respective country (Hatzenbuehler, Abbott, & Abdoulaye, 2017).

Model Selection

Keeping in view the research objectives of the study conducted by, and data limitations, we employed the Johansen co-integration test, the vector error correction model (VECM), and the Granger causality test. As both the approaches of Cointegration (Engle & Bollerslev, 1986; Johnson & Soenen, 2002) assume time-series data to be integrated of order one $I(1)$ or stationary (Davids, Meyer, & Westhoff, 2017). Therefore, we tested the stationarity of each series by using Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests to satisfy assumptions of the subsequent co-integration test (Zakari et al., 2014). Afterward, we employed the Johansen Cointegration test to determine the number of cointegrating vectors (r). After finding the co-integration among variables, we employed the vector error correction model¹ (VECM) to measure short-run dynamics and speed of adjustment of the long-term equilibrium. Finally, based on the results VECM, we employed the VEC Granger causality test (Granger, 1988) to determine the direction of causality among the variables of the model. The description of data, its sources, and specifications are shown in Table 1.

Table 1.

Wheat flour price data sources and description

Commodity	Country	Description	Source	Data Taken
Wheat (flour)	Pakistan	Retail	GIEWS	Peshawar
Wheat (flour)	Afghanistan	Retail	GIEWS	Kabul
Wheat (flour, first grade)	Tajikistan	Retail	GIEWS	National Average ²
Wheat (flour, first grade)	Kyrgyzstan	Retail	GIEWS	National Average
Wheat (flour, first grade)	Kazakhstan	Retail	GIEWS	National Average
GIEWS: Global Information and Early Warning System				

¹ If time series variables are stationary at level, VAR model is used. But, if variables are found to be stationary at first difference so, we choose VECM.

² National Average- Average price of different cities

Vector Error Correction Model (VECM)

The presence of a long-run relationship among variables can be verified by using the vector error correction model (VECM) (De & Koemle, 2015). A VECM is an alternative technique of vector autoregressive (VAR) models, which is used to examine the dynamics of price transmission. In VECM, the lagged values of time are used. VECM identifies the long-run relationship like the VAR model, and the short-run adjustments that correct the disequilibrium of prices. VAR equation is given as (Tsay, 2010):

$$Y_t = \mu_t + \Phi_1 y_{t-1} + \dots + \Phi_p \Delta y_{t-p} + e_t \quad (1)$$

Where y_t is a stochastic process collected in the $n \times 1$ vector, μ_t denotes the deterministic variables vector, Φ_t shows $(n \times n)$ coefficient matrices, p symbolizes the order of VAR, and e_t is an error term. A multivariate VAR transformed into VECM is given as;

$$Y_t = \mu_t + \Pi y_{t-1} + \Phi_1^* \Delta y_{t-1} + \dots + \Phi_p^* \Delta y_{t-p} + e_t \quad (2)$$

Where $\Pi = \alpha\beta' = \Phi_p - \Phi_{p-1} + \dots + \Phi_1 - I$, $\phi_j^* = \sum_{i=j+1}^p \phi_i$, and $j = 1, \dots, p-1$.

Matrix Π consists of α, β and Φ_p matrix α represents the long-term equilibrium adjustment vector, β is matrix of cointegration vectors, and Φ_p are the short-run impact matrices. The rank of Π shows number of cointegration relationships.

Johansen and Juselius (1990) suggested two test statistics that are applied for this: test trace statistics and maximum Eigen statistics. Trace statistics and the maximum Eigen statistic are given in equations (3) and (4) (Brooks, 2008; Muyatwa, 2000).

$$\lambda_{trace}(r) = -(T-p) \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i) \quad (3)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (4)$$

Where λ_{trace} is the trace statistic, λ_{max} is the maximum eigenvalue statistic, T is the sample size, and $\hat{\lambda}_i$ is the i^{th} largest canonical correlation (eigenvalue of matrix Π). In the given equations, r shows the number of cointegrating vectors, T shows the number of observations, while $\hat{\lambda}_i$ is the estimated value for the i^{th} ordered eigenvalue from the matrix (Brooks, 2008).

Empirical Results and Discussions

Descriptive Statistics

The descriptive statistics of wheat flour price series from January 2006 to April 2023 for Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, and Kazakhstan are presented in Table 2. Pakistan has the lowest mean and standard deviation values among the selected countries. The mean value of wheat flour prices for Pakistan is 0.374808, and the standard deviation value is 0.0560. This shows that in terms of dollars, Pakistan has the lowest wheat price in the selected countries and the lowest wheat price volatility. The average value of wheat flour prices for Afghanistan is 0.4477, and its standard deviation is 0.1038. The price in Afghanistan is the second lowest among the selected countries. The wheat price and the standard deviation value of wheat flour prices is the highest, 0.113746 in Kyrgyzstan as compared to other countries. The mean value of wheat flour prices for Kazakhstan is 0.456744 with the standard deviation of 0.095162. These values show that Pakistan has the lowest as well as the most stable wheat flour price among the selected countries. Similarly, Kazakhstan also has stable prices. The Jarque-Bera tests confirm the normality of the series for each country of the sample.

Table 2.

Descriptive statistics of wheat flour prices

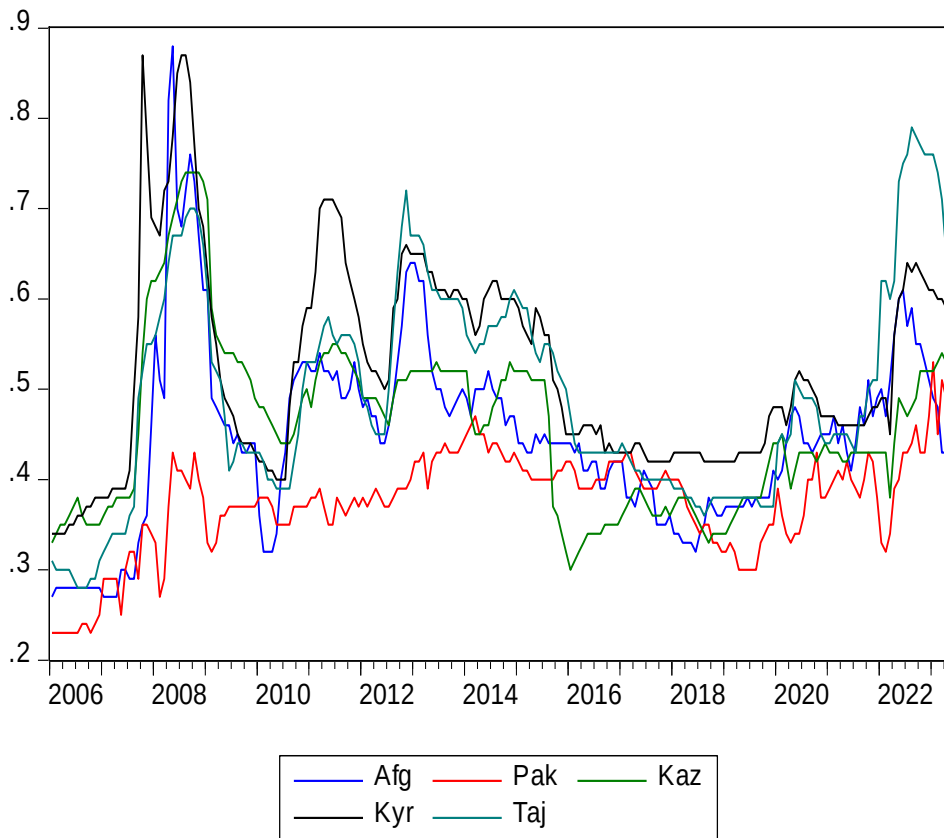
	AFG	PAK	KAZ	KYR	TAJ
Mean	0.447788	0.374808	0.457644	0.521731	0.494183
Median	0.440000	0.380000	0.450000	0.490000	0.470000
Maximum	0.880000	0.530000	0.740000	0.870000	0.790000
Minimum	0.270000	0.230000	0.300000	0.340000	0.280000
Std. Dev.	0.103820	0.056028	0.095162	0.113746	0.119820
Skewness	0.801392	-0.720486	0.847501	0.791184	0.429131
Kurtosis	4.800189	3.727362	3.765663	3.290194	2.506886
Jarque-Bera	50.34982	22.58064	29.98032	22.43023	8.491380
Probability	0.000000	0.000012	0.000000	0.000013	0.014326
Sum	93.14000	77.96000	95.19000	108.5200	102.7900
Sum Sq. Dev.	2.231183	0.649792	1.874546	2.678177	2.971861
Observations	208	208	208	208	208

Trends of Wheat Flour Prices

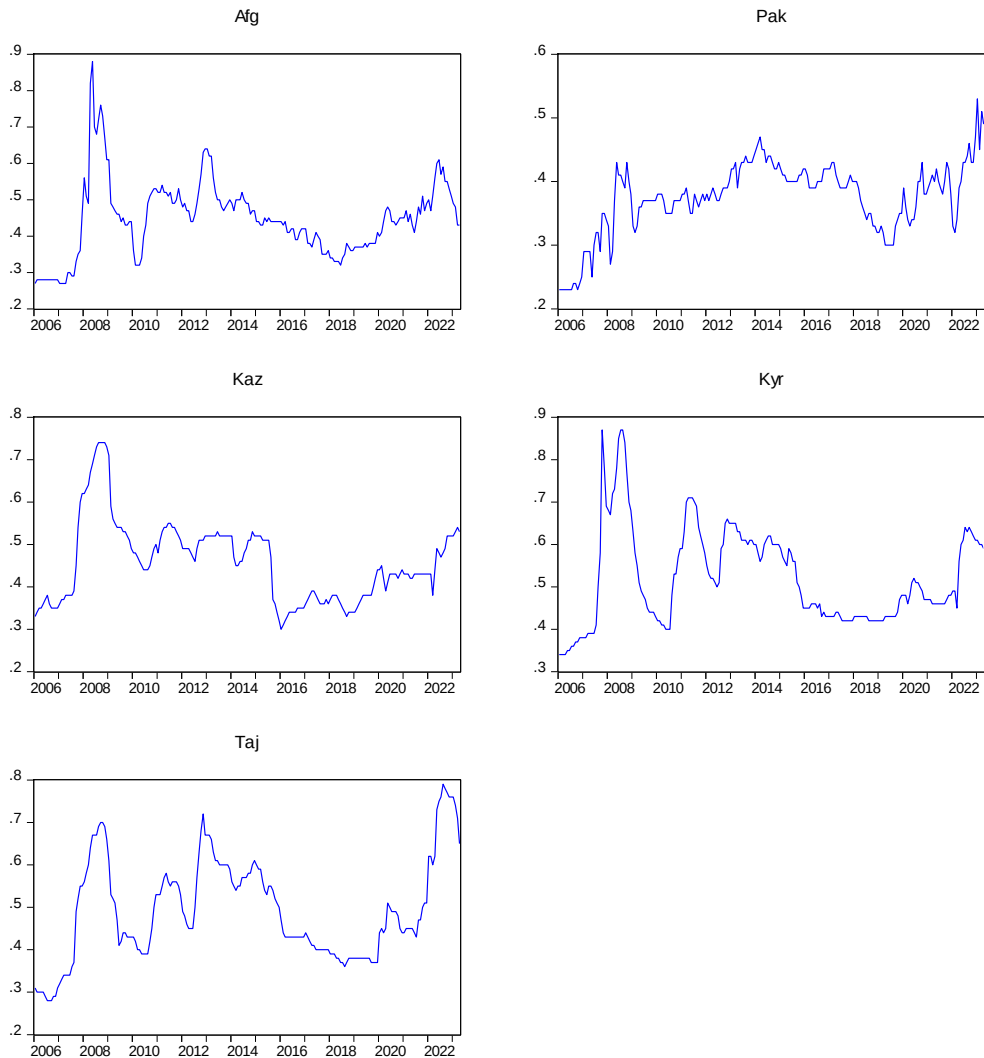
Figures 1 and 2 present the time series graph of wheat flour price series from January 2006 to April 2023 for Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, and Kazakhstan. Figure 1 exhibits the high volatility and dissimilar pattern in the years 2008-09. It is due to the food crisis of 2008. Similarly, Figure 2 shows that the volatility in the price series has decreased. The interconnection among the wheat prices of central and South Asian countries has increased during the last three years. It can be noted that countries show close price movements with each other, except Kazakhstan. Afghanistan and Pakistan show similar movement, while Tajikistan also shows a relationship with Pakistan and Kyrgyzstan. There are three main price peaks in the data (2008, 2011, and 2013), which show the hike in the price levels during these periods.

Figure 1

Historical prices of wheat flour in the selected countries



Source: Author's calculations

Figure 2*Historical overview of Wheat flour price individual series**Source: Author's calculations***Unit Root Tests**

We employed three major tests for unit root, the ADF and KPSS tests, to check the stationarity of individual series. The results of ADF demonstrate that there is no unit root in all variables. The result of the KPSS test rejected the null hypothesis, indicating that there is a unit root in the series. Thus, all series were found to be non-stationary at the level. It is conventional to take the first difference of a series to make it stationary if the series is not found to be

stationary at the level. So, the tests for unit root were repeated again by taking first differences. The null hypothesis of the ADF and PP tests was rejected, and the null hypothesis of the KPSS test was accepted significantly. So, the wheat flour prices are non-stationary in level, and stationary at their first differences. The results for the unit root test (ADF) are shown in Table 3.

Table 2.

Results of the Unit root test (ADF test)

Variable	Level	First difference
Pakistan	-3.05454	-10.9064
p-value	0.0317**	0.000***
Afghanistan	-3.62692	-6.95978
p-value	0.006***	0.000***
Kazakhstan	-2.39846	-9.3389
p-value	0.1434	0.000***
Kyrgyzstan	-2.85651	-10.4145
p-value	0.0524*	0.000***
Tajikistan	-2.48397	-9.46986
p-value	0.1209	0.000***

Note: ‘***’ indicates significant at 1% level; ‘**’ indicates significant at 5% level; ‘*’ indicates significant at 10%.

Source: Author’s calculations

Lag Length Selection Criteria

Table 4 presents the results of lag length selection criteria with different methods such as Akaike information criterion (AIC), final prediction error (FPE), Hannan–Quinn information criterion (HQ), likelihood ratio (LR), and Schwarz’s criterion (SC) to determine proper lag length before applying Cointegration test to check the long-run trend in wheat prices of the sample countries. The LR, confirms six lags, while other criteria favored two lags for applying the Cointegration test.

Table 3.*Lag selection criteria*

Lag	Log L	LR	FPE	AIC	SC	HQ
0	677.0488	NA	8.30e-10	-6.720488	-6.63803	-6.68712
1	1669.486	1925.328	5.22e-14	-16.39486	-15.90011*	-16.1946
2	1727.088	108.8675	3.77e-14*	-16.7208*	-15.8138	-16.353*
3	1751.176	44.32222	3.81e-14	-16.71176	-15.3924	-16.1779
4	1773.047	39.14911	3.94e-14	-16.68047	-14.9489	-15.9797
5	1791.218	31.61854	4.23e-14	-16.61218	-14.4683	-15.7446
6	1816.402	42.56026*	4.24e-14	-16.61402	-14.0578	-15.5796
7	1838.635	36.46249	4.39e-14	-16.58635	-13.6179	-15.3851
8	1858.413	31.44694	4.67e-14	-16.53413	-13.1534	-15.166

* 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

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Unit root test results showed that all series are integrated of the same order I (d). To test the long-term relationship despite short-term fluctuations, we applied the Johansen Cointegration test using the trace statistic and maximum Eigenvalue. The null hypothesis for Pakistan-Afghanistan, Pakistan-Tajikistan, Pakistan-Kyrgyzstan, and Pakistan-Kazakhstan markets is that there is no cointegrating vector ($r = 0$). We rejected the null hypothesis of no Cointegration up to $r \leq 4$ using the trace statistic and maximum Eigenvalue, as the p-values are less than 0.05%. This shows that at least 5 cointegrating vectors are present in the data given. The series of all countries indicates that there is a long-run relationship between the price pairs. The results for the combined Cointegration test are given in Table 5.

Table 5.*Combined Cointegration Results for Wheat Markets*

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.404922	342.3447	69.81889	0.0001
At most 1 *	0.332194	236.4558	47.85613	0.0001
At most 2 *	0.300939	154.0893	29.79707	0.0001
At most 3 *	0.246898	81.05392	15.49471	0.0000
At most 4 *	0.107535	23.20877	3.841466	0.0000
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.404922	105.8890	33.87687	0.0000
At most 1 *	0.332194	82.36644	27.58434	0.0000
At most 2 *	0.300939	73.03540	21.13162	0.0000
At most 3 *	0.246898	57.84515	14.26460	0.0000
At most 4 *	0.107535	23.20877	3.841466	0.0000

Trace test indicates 5 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Vector Error Correction Model (VECM)

The existence of cointegration among the wheat price variables has been confirmed through the cointegration test. Therefore, we employed VECM to identify the long-run equilibrium relationship through the error correction term (ECT), as well as short-term adjustments through variable coefficients. Table 7 presents the estimation of VECM parameters with one co-integrating relationship, three lags, and an intercept in each equation for every country. As the VECM model considers stationary variables, all variables in our study are stationary at the first difference by taking the log differences of the variables.

The VECM shows the long-run equilibrium relationship as well as short-term adjustments from other markets. The co-integrating vector is estimated to characterize the extent of wheat flour price transmissions, and speed of adjustment parameters are determined for the disequilibrium behavior of prices, respectively. The error correction terms represent the price deviation from the estimation of the long-run co-integrating relationship. Thus, a

negative error correction term (ECT) shows the direction of the correction towards equilibrium. The coefficient values show the speed of adjustment. It shows that when there is a disturbance in the long-run equilibrium, market forces through short-term fluctuations maintain the equilibrium. The estimated results of the VECM and ECT (long-term relationship) are shown in Table 6.

Table 6.

Vector Error Correction Model (long-term relationship)

Variable	Coefficient	t-statistic	Interpretation
D(LPAK)	-1.248	-9.64	Highly significant. Pakistan adjusts strongly and quickly back to equilibrium if there's a shock.
D(KAFG)	-0.588	-3.58	Also significant. Afghanistan adjusts back, though at a slower rate than Pakistan.
D(LKAZG)	0.051	0.55	Not significant. Kazakhstan does not show significant error correction in the short run.
D(KKYR)	0.168	1.39	Not significant. Kyrgyzstan's adjustment toward long-run equilibrium is weak.
D(LTAJ)	0.030	0.29	Not significant. Tajikistan also does not adjust significantly to correct disequilibria.

As we are more interested in the long-run behavior of wheat flour markets, ECT-1 terms in the case of Pakistan and Afghanistan show a negative sign, which shows that the short-term fluctuations in other countries (independent variables) maintain the equilibrium back in these countries (dependent variables). The p-values of ECT-1 term of Pakistan and Afghanistan are significant at 5% significance level, these results show that wheat flour prices adjust towards equilibrium in these countries when there is a price change in other markets. The coefficient values of Kazakhstan, Kyrgyzstan, and Tajikistan are positive, which means that if these prices move away from the equilibrium don't return to the equilibrium position in the long run. The ECT values are interpreted briefly in Table 7.

Table 4*Vector Error Correction Model (Short-run relationship)*

Error Correction:	D(DLPAK)	D(DKAFG)	D(DLKAZG)	D(DKKYR)	D(DLTAJ)
CointEq1	-1.247986	-0.58776	0.050954	0.168237	0.03045
	-0.12944	-0.16416	-0.09241	-0.12132	-0.10429
	[-9.64148]	[-3.58031]	[0.55138]	[1.38672]	[0.29198]
D(DLPAK(-1))	0.268341	0.531232	0.031672	-0.201259	-0.004738
	-0.10129	-0.12846	-0.07231	-0.09493	-0.0816
	[2.64931]	[4.13539]	[0.43799]	[-2.11999]	[-0.05807]
D(DLPAK(-2))	0.204905	0.111056	0.035202	-0.053323	-0.051316
	-0.08053	-0.10214	-0.0575	-0.07548	-0.06488
	[2.54436]	[1.08731]	[0.61225]	[-0.70644]	[-0.79088]
D(DKAFG(-1))	0.182853	-0.463626	-0.020835	0.030395	0.056115
	-0.05048	-0.06402	-0.03604	-0.04731	-0.04067
	[3.62247]	[-7.24198]	[-0.57813]	[0.64244]	[1.37980]
D(DKAFG(-2))	0.005977	-0.435956	-0.02938	0.010359	-0.021311
	-0.05081	-0.06444	-0.03628	-0.04763	-0.04094
	[0.11762]	[-6.76480]	[-0.80987]	[0.21751]	[-0.52057]
D(DLKAZG(-1))	0.075018	0.162471	-0.47385	-0.096853	-0.038055
	-0.10808	-0.13707	-0.07716	-0.1013	-0.08708
	[0.69411]	[1.18529]	[-6.14098]	[-0.95610]	[-0.43703]

D(DLKAZG(-2))	0.053995	0.081436	-0.280399	-0.149087	-0.111344
	-0.1045	-0.13253	-0.07461	-0.09794	-0.08419
	[0.51671]	[0.61447]	[-3.75841]	[-1.52217]	[-1.32250]
D(DKKYR(-1))	-0.407454	-0.300055	0.22481	-0.375022	0.294182
	-0.09072	-0.11505	-0.06477	-0.08503	-0.07309
	[-4.49153]	[-2.60798]	[3.47110]	[-4.41069]	[4.02504]
D(DKKYR(-2))	-0.17088	-0.13162	0.081539	-0.183373	0.115104
	-0.08859	-0.11236	-0.06325	-0.08304	-0.07138
	[-1.92880]	[-1.17140]	[1.28913]	[-2.20832]	[1.61259]
D(DLTAJ(-1))	0.105034	-0.118398	0.126461	0.268085	-0.48975
	-0.08793	-0.11151	-0.06277	-0.08241	-0.07084
	[1.19458]	[-1.06174]	[2.01456]	[3.25306]	[-6.91350]
D(DLTAJ(-2))	-0.024311	-0.037425	-0.151034	-0.139215	-0.327768
	-0.0891	-0.113	-0.06361	-0.08351	-0.07178
	[-0.27286]	[-0.33119]	[-2.37432]	[-1.66705]	[-4.56599]
C	-8.13E-05	-0.00063	-0.000104	4.85E-05	-0.000535
	-0.00386	-0.0049	-0.00276	-0.00362	-0.00311

These show how past changes in each variable affect current changes in others. The long-run cointegration relation has been found in the cointegration model as well as confirmed in this model, as error correction from the long-run equilibrium. Now the other result describes how the short-run fluctuation of independent variables adjusts the dependent variables. In the results of the short-run mode, there are five independent variables, including Pakistan.

When Pakistan is taken as a dependent variable, the results show that short-run adjustments in lagged values of Pakistan, Afghanistan, and Kyrgyzstan are adjusted to regain equilibrium. In the case of Afghanistan, the flour markets of the lagged value of Pakistan, Afghanistan itself (first and second lag), and Kyrgyzstan adjusted the wheat price in the current period. The deviations in the Kazakhstan wheat price are corrected through the short-term changes in the lagged value of Kazakhstan, Kyrgyzstan, and Tajikistan. The wheat price in Kyrgyzstan is corrected by the lagged values of Kyrgyzstan itself, the lagged value of Pakistan, and Tajikistan's past values. Finally, the deviations in the wheat price of Tajikistan are affected by the lagged values of Tajikistan and Kyrgyzstan. We are interested in the relation of Pakistan wheat with other wheat markets like Afghanistan, Kazakhstan, Kyrgyzstan, and Tajikistan.

Granger's causality test

The Results VECM demonstrated that some coefficients for countries are positive, while some are negative. So, the price series changes and moves in both directions. Thus, to further understand the direction of causality, we employed the VEC Granger causality (Granger, 1988) test to identify the direction of causality between pairs of variables.

The null hypothesis for an independent variable x and dependent variable y is that: x does not Granger-cause y . As the series are cointegrated, so, Granger Causality (Granger, 1988) is an appropriate technique to find the direction of the causal relationship between variables.

The results of granger causality test for the wheat prices of different countries are shown in Table 8. The results confirmed the causality running from Pakistan to Afghanistan and vice versa for wheat flour markets in the region. Kazakhstan shows that it doesn't granger cause the wheat prices in Pakistan. However, Pakistan doesn't granger cause the wheat prices in Pakistan. Similarly, the wheat prices in Kyrgyzstan don't Granger-cause the wheat price in Pakistan. The duo of the Pakistani and Tajik markets doesn't show a significant relationship from either side. Similarly, the pair of Kazakhstan and

Afghanistan doesn't granger cause each other. Afghanistan wheat has significant relationship with the Kirghizstan wheat markets has a significant Afghanistan. Similarly, Afghanistan also has significant Granger causality on Kyrgyzstan. Tajikistan and Afghanistan wheat markets also have significant bidirectional causality.

The relationship between Kyrgyzstan and Kazakhstan shows that the Kirghizstan granger causes the wheat prices in Kazakhstan. While the inverse relation is not found between them. The relationship between Tajikistan and Kazakhstan has a unidirectional relationship between them; only Tajikistan granger causes the wheat prices in Kazakhstan, while Kazakhstan doesn't induce any change in the Tajikistani wheat markets. Lastly, Tajikistan and Kyrgyzstan have a bidirectional causal relationship between them. The apparent reason behind bidirectional causality is the existing trade relationship between immediate neighborhood countries.

Table 5.*Granger's causality test (lag = 4)*

Null Hypothesis:	Obs	F-Statistic	Prob.
DKAFG does not Granger Cause DLPAK	204	3.04132	0.0301
DLPAK does not Granger Cause DKAFG		2.87394	0.0374
DLKAZG does not Granger Cause DLPAK	204	0.88867	0.4480
DLPAK does not Granger Cause DLKAZG		2.12887	0.0978
DKKYR does not Granger Cause DLPAK	204	2.16951	0.0929
DLPAK does not Granger Cause DKKYR		1.36245	0.2555
DLTAJ does not Granger Cause DLPAK	204	1.57027	0.1979
DLPAK does not Granger Cause DLTAJ		1.56469	0.1992
DLKAZG does not Granger Cause DKAFG	204	1.05098	0.3711
DKAFG does not Granger Cause DLKAZG		1.21488	0.3055
DKKYR does not Granger Cause DKAFG**	204	4.02552	0.0083
DKAFG does not Granger Cause DKKYR		4.44550	0.0048
DLTAJ does not Granger Cause DKAFG	204	3.00170	0.0317
DKAFG does not Granger Cause DLTAJ		3.38854	0.0191
DKKYR does not Granger Cause DLKAZG	204	8.14887	0.00004
DLKAZG does not Granger Cause DKKYR		1.03116	0.3799
DLTAJ does not Granger Cause DLKAZG	204	6.65249	0.0003
DLKAZG does not Granger Cause DLTAJ		1.72183	0.1638
DLTAJ does not Granger Cause DKKYR	204	11.3625	0.0000007
DKKYR does not Granger Cause DLTAJ		14.1162	0.00000002

Conclusions and Policy Recommendations

Conclusions

The relationship of wheat flour prices is very important to the countries of South and Central Asia. Wheat is used as a staple food with varying consumption levels. In case of a shortage of wheat flour, the Central Asian countries have no other choice but to purchase from the neighboring surplus market of Kazakhstan. Similarly, Afghanistan has the most convenient option to purchase from Pakistan.

In order to understand the dynamics of wheat markets, this study investigated the wheat flour price transmission in a wheat-consuming and agriculture-based region. Previous studies have found that most of the Central Asian wheat flour market is unregulated. On the other hand, wheat flour markets in Pakistan have been highly regulated by the government, which also restricts healthy competition in the market. However, recently the government has decided to liberalize the wheat market in Pakistan (A. Ahmed, 2025; Jalil, Zulfiqar, Anwar, Iqbal, & Khan, 2020). The Results of this study showed that wheat flour markets like Afghanistan- Pakistan showed clear long-run integration.

Pakistan shows relationship with the lag values of its own, Afghanistan, and Kyrgyzstan. The Afghanistan market shows the relationship with Pakistan and Kyrgyzstan. Kazakhstan shows a relationship with Kyrgyzstan and Tajikistan. The Kyrgyzstani wheat markets have a relationship with Pakistani and Tajikistani markets. The wheat market of Tajikistan is affected by the Kyrgyzstani markets only. These results show that the neighboring countries must affect each other's wheat markets. Among the selected markets Pakistani wheat market has a unique position due to which it has a relationship with selected wheat markets except Kazakhstan. Moreover, the Results of the study showed that wheat prices in Pakistan are the most stable and the lowest wheat prices in the region. Good transportation infrastructure is indispensable for efficient transmission of prices among markets. As the developments in the transportation and trade infrastructure continue to improve with the development of the China-Pakistan Economic Corridor (CPEC). It will significantly reduce the cost and time for transportation of wheat flour from Pakistan and China to the Central Asian states. It will also improve the market conditions, welfare, and food security of people living in this region.

It is suggested that policymakers develop a policy framework towards enhancing the efficiency of food markets, which will improve the food security of the sample countries. Keeping in view the potential of Pakistani markets and infrastructure, the governments of the Central Asian countries can make mutually beneficial decisions to improve food and trade supply in the Central Asian region. Further studies can be done on the factors that can improve the interconnection of wheat flour markets in this region.

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