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Price Volatility Transmission in the Feeder Markets of Basmati Rice in Pakistan

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A B S T R A C T

Basmati rice is an important crop that is widely consumed in Pakistan as well as a source of foreign exchange due to its high demand in the world market. It has some unique characteristics which makes it differentiated from other types of rice. The northeast region of Punjab is the main basmati rice producing area where Gujranwala is the most significant and the central market transporting basmati rice to the local and international markets. With the minimal government interference, the market forces determine the price ending into price volatility and its spread into the local and international markets. The interconnection of markets through price linkages is important tool to mitigate the adverse impacts of price volatility. To analyze this, five feeder markets including Gujranwala, Sialkot, Gujrat, M. B. Din and Lalamusa were selected. The analysis was conducted through MGARCH-BEKK bivariate analysis with a time series data of monthly average price returns from a period of January 2015 till June 2022 to determine the dynamic conditional correlations between these markets. The finding revealed that Gujranwala holds significant influence in the basmati rice-producing area, impacting other markets. The findings further disclosed that higher shocks in Gujranwala significantly impacted Sialkot's, Gujrat's and M.B. Din's volatility while it was insignificant in the market of Lalamusa only. The study demonstrated that the volatility of feeder markets in Pakistan is interconnected, which can provide policymakers, investors, and researchers with a valuable insight for further exploration.

Keywords: Basmati, Rice, Price Volatility Transmission, MGARCH-BEKK, Feeder Markets.

INTRODUCTION

Prices in the food and agricultural sectors are crucial indicators that reflect the delicate equilibrium between supply and demand, meteorological conditions, geopolitical changes, and market speculation. Changes in agricultural commodity prices directly influence the expenses related to food production, thus influencing the availability and cost of food for consumers globally. Understanding and monitoring these prices are crucial for policymakers, producers, and consumers as they provide significant insights into the factors influencing global food security, economic stability, and social well-being. In an efficient commodity market, prices accurately reflect information about factors such as production levels, inventories, global demand, and geopolitical events that can impact supply chains. Efficient markets facilitate price discovery that helps the decisions made by buyers and sellers based on prevalent market conditions. (Kriesberg, 1972; Rao, 2017; Baffes & Nagle, 2022).

Price volatility refers to sudden and significant price changes within a market over time, posing a continuous challenge for planning and decision-making. Various factors can trigger it, including the delicate equilibrium between supply and demand, geopolitical changes, weather, technological progress, and market speculation. Price volatility affects all market participants, including producers, consumers, investors, and policymakers. Producers face uncertainty in determining output levels and investment choices due to shifting pricing, while consumers face swings in product and service costs, affecting their purchasing and shopping behaviours. Understanding and controlling price fluctuations is essential for navigating the intricacies of contemporary marketplaces. It plays a crucial role in maintaining the resilience and

sustainability of the overall economic system, affecting producers, consumers, investors, and policymakers. (FAO et al., 2012; Serra & Zilberman, 2013; Assefa et al., 2015; Pan & Zheng, 2023).

Rice is an important crop as it is one of the important food supplies, a raw material to other industries, its climate suitability to agro climatic zone in different countries and relatively larger area under cultivation and production. Rice is mainly produced and consumed in Asia. Mostly rice is consumed in those countries where it is produced. That's why the world rice market is very thin as almost 8 percent of rice production is traded in the world rice market. Rice has a special status in WTO negotiations because most poor regions are directly or indirectly interlinked with this crop. The world rice market is highly stratified and heterogeneous in nature (Gnanamanickam, 2009; IRRI, 2015; Khairulbahri, 2021).

Rice occupies 3rd position in terms of area and production after wheat and cotton in Pakistan. Two major types of rice are produced in Pakistan i.e. basmati and non-basmati. Basmati rice has some unique quality characteristics such as strong aroma, slender and long kernel, gelatinization *etc.* which generates its higher demand in the country and rest of the world. In Pakistan, it is mainly grown in northeast region of Punjab province. In addition to basmati rice, Pakistan also produces other varieties known as non-basmati rice which is mainly grown in the Sind province. Basmati rice has gained attraction amongst rice growers and traders due to its demand and higher prices (almost double compared to non-basmati rice) in the local and export markets. Most of the area in Punjab province is suited for the cultivation of basmati rice and farmers prefer to grow basmati rice varieties though the trend in the international market is different and in favour of non-basmati rice varieties (Taniguchi & Ali, 2018, Akhter & Haider, 2020; Saeed et al, 2020).

Given the unique characteristics and higher demand for basmati rice, both domestically and internationally, its price patterns differ significantly from those of non-basmati rice. The premium quality and strong consumer preference for basmati rice result in consistently higher prices, often nearly double compared to non-basmati varieties. These price trends are driven by factors such as consumer demand, export potential, and the crop's limited growing region within Pakistan, particularly in the northeast of Punjab. However, despite its economic value, basmati rice prices are not immune to fluctuations. These fluctuations are influenced by both local conditions, such as yield variations, and global factors like competition from other rice-producing countries and changes in trade policies.

Price volatility in the basmati rice market is a critical issue for all stakeholders, from farmers to traders and consumers. The fluctuations in prices are influenced by numerous factors, including supply chain disruptions, changes in export demand, shifts in international trade policies, and climatic variability. As basmati rice is predominantly grown in a specific region, any regional disturbances, such as extreme weather events or water shortages, can result in significant price instability. Additionally, given the international appeal of basmati rice, global market forces and competition from other rice-exporting countries contribute to volatility in both the local and international markets. Understanding these price movements is essential for managing market risks and ensuring the stability of basmati rice prices in Pakistan.

Limited literature is available on price volatility in Pakistan. One of the studies related to Pakistan, Ismail et al. (2017) analyzed the price volatility of major agricultural commodities in Pakistan, including rice. The study identified the significant determinants of price volatility in selected food commodities. The results confirmed that the exchange and interest rates were the main determinants transmitted to all commodities. It also highlighted that past commodities' prices impacted prevailing prices. In addition, Ahmad et al. (2017) investigated the trends in the volatility of major rice markets in Pakistan, measured the spatial difference volatility among major wholesale markets in Pakistan, and compared it with international rice markets. The study's results indicated the presence of spatial differences in volatility and had a positive association with volatility among significant rice markets in Pakistan. These results reflected those markets had a difference in market forces, the flow of information, and market infrastructure, leading to susceptibility to various risks. Similar results were found in Zehra and Fatima (2019), in which they measured the food price volatility of major food commodities in Pakistan. The study found the presence of volatility in food prices having substantial heterogeneity in significant markets in Pakistan. The study recommended that governments intervene to control the variation of prices among major

cities, and policy should be developed for each city separately. The available literature has some gaps i.e the specific analysis of basmati rice particularly for feeder markets and the price volatility transmission.

While basmati rice remains a valuable crop in Pakistan due to its quality, demand, and higher prices, it is also highly susceptible to price volatility. This price volatility not only affects the local markets but also has broader implications for international trade. In particular, the transmission of price fluctuations across various feeder markets within Pakistan remains underexplored. This study seeks to address the gap by analyzing the patterns of volatility transmission in the basmati rice market, offering insights that are critical for policy development and market stability. This section is followed by methodology and results and discussion. The last section carries the conclusion and implications of this study.

METHODOLOGY

Monthly time series data on price returns from the selected markets were collected for the period from January 2015 to June 2022. The selection of data was on the basis of the availability from multiple sources. Gujranwala, Sialkot, Gujrat, Mandi Bahauddin, and Lalamusa were selected as feeder markets. These all markets related to the production of basmati rice in Punjab. Gujranwala is the central hub for basmati rice production, and the regional headquarters was selected as the base market. The prices return of these markets were used to estimate the volatility transmission.

The general approach for estimating the price volatility is multivariate generalized autoregressive conditional heteroskedasticity (MGARCH). For volatility transmission, a parametrization based on Babba, Engle, Kraft and Kroner (BEKK) model of Engle and Kroner (1995) is used having the following equation:

$$H_t = CC' + A'\mu_{t-1}\mu'_{t-1}A + B' H_{t-1}B \qquad \text{(a)}$$

In this model, H_t represents the previously defined conditional variance matrix. It captures how the volatility of the time series might change over time. The constant parameters are incorporated by the lower triangular matrix C. Next, we have a 2x2 matrix A, which includes coefficients for the ARCH terms. These terms capture how the impact of past shocks (innovations or errors) in the current and other variables affect the current volatility. Similarly, the 2x2 matrix B represents the GARCH terms. These coefficients show how past volatilities (both its own past volatility and the volatility of other variables) influence the current volatility.

The MGARCH-BEKK model is widely used for volatility analysis due to its ability to effectively capture the dynamic relationships and interactions between multiple time series. This model reduces the number of parameters to be estimated, making it computationally feasible and manageable even with large datasets. Additionally, it allows for the modeling of dynamic conditional correlations, which are essential for understanding how correlations between markets evolve over time. Overall, its robust empirical performance and straightforward economic interpretation make MGARCH-BEKK a preferred choice for analyzing and forecasting market volatilities (Caporin, & McAleer,2014).

RESULTS AND DISCUSSION

The MGARCH-BEKK bivariate analysis was employed to examine the dynamic conditional correlations among the basmati rice prices in the selected feeder markets: Gujranwala, Sialkot, Gujrat, Mandi Bahauddin, and Lalamusa. These markets are all situated within the basmati rice production area, and Gujranwala was designated as the base market due to its prominence as the region's central basmati rice market. Monthly price returns were taken for the analysis. The price return series of all the markets is presented in Figure 1, which highlights the price trends in these markets. All the price returns fluctuate over time and trend toward mean value.

The Table 1 presents descriptive statistics for Basmati rice price returns in five selected feeder markets: Gujranwala, Gujrat, Sialkot, Mandi Bahauddin, and Lalamusa. These statistics provide insights into each market's distributional characteristics and variability of price returns. The mean values of all the price returns are positive, which shows a positive trend, which means all the returns indicate an overall increase. The median returns, representing the middle value of the dataset, indicate a balanced distribution of returns. The maximum and minimum returns illustrate the price fluctuations experienced within each market. The standard deviation quantifies the dispersion of price returns around the mean, with higher values indicating greater volatility.

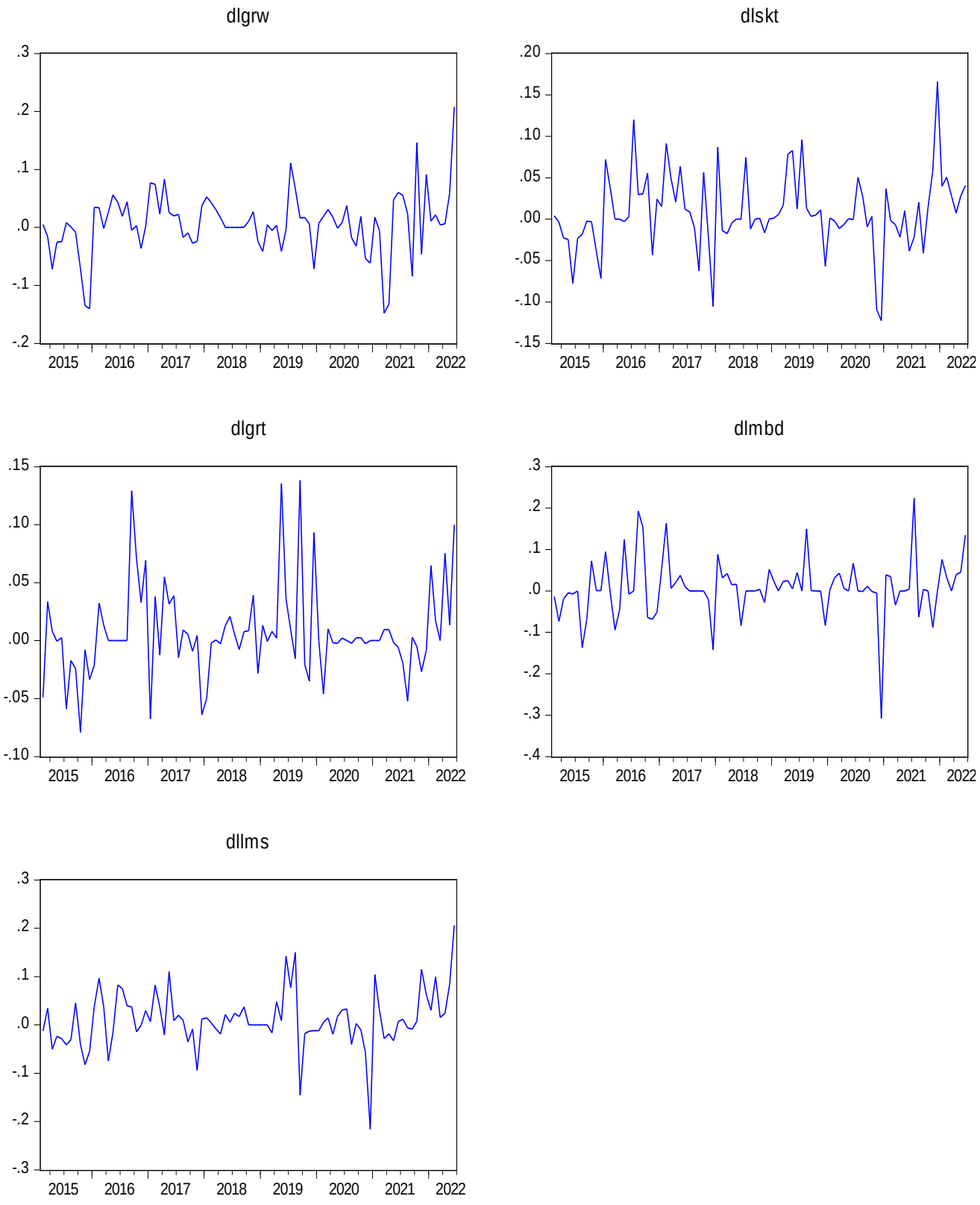

Figure 1. Monthly Price Returns of Basmati Rice of Selected Feeder Markets.

Mandi Bahauddin stands out with the highest standard deviation, reflecting heightened volatility compared to other markets. Skewness and kurtosis offer further insights into the shape of the return distributions. The Jarque-Bera test assesses the normality of the return distributions, with low p- values indicating significant deviations from normality. The pairwise results between Gujranwala and other markets of the MGARCH-BEKK analysis are elaborated on in Table 2.

Table 1. Descriptive Statistics of Feeder Markets.

	DLGRW	DLSKT	DLGRT	DLLMS	DLMBD
Mean	0.0063	0.0081	0.0070	0.0105	0.0083
Median	0.0062	0.0014	0.0000	0.0066	0.0000
Maximum	0.2079	0.1660	0.1383	0.2060	0.2239
Minimum	-0.1480	-0.1226	-0.0790	-0.2160	-0.3079
Std. Dev.	0.0546	0.0461	0.0397	0.0585	0.0707
Skewness	-0.0361	0.1754	1.1308	-0.0586	-0.3972
Kurtosis	5.6834	4.7537	5.4714	6.1338	7.7407
Jarque-Bera	26.7209	11.8612	41.6174	36.4687	85.6825
Probability	0.0000	0.0027	0.0000	0.0000	0.0000
Sum	0.5569	0.7184	0.6197	0.9360	0.7345
Sum Sq. Dev.	0.2619	0.1872	0.1386	0.3012	0.4400
Observations	89	89	89	89	89

The first column presents the coefficients of Sialkot and Gujranwala markets. A (1,1) and A (2,2) are positive and significant, indicating that past squared errors (shocks) in both Gujranwala and Sialkot positively impact their current volatility. This implies that more significant shocks in the past tend to lead higher volatility. A (1,2) is positive and significant, suggesting that past squared errors in Gujranwala directly impact the volatility in Sialkot. A (2,1) is negative and significant, suggesting that past squared errors in Sialkot have a negative impact on Gujranwal's current volatility, indicating a dampening effect. The B parameter describes the spillover effect of past variance on current volatility. B (1,2) is positive and highly significant, indicating that past conditional variance in Gujranwala has a robust positive spillover effect on Sialkot's current volatility. All other B parameters are insignificant, suggesting the minimal impact of past conditional covariances.

Similarly, the model's estimated coefficients for the monthly price difference of basmati rice between Gujranwala and Gujrat are in the next column. A (1,1) is positive and significant. At the same time, A (2,2) is negative and significant, suggesting that larger shocks in Gujrat lead to higher volatility in the present. In contrast, negative coefficients indicate a dampening effect, with shocks in Gujrat decreasing future volatility. The model also shows a strong positive spillover effect from past covariances between Gujranwala and Gujrat, as B (1,2) is significant and positive while B (2,1) is significant and negative reveals that past volatility in Gujrat has negative impact on current volatility in Gujranwala.

The relationship between Gujranwala and Lalamusa also presented similar results. Gujranwala's ARCH parameter A (1,1) is insignificant, suggesting a minimal impact of past squared errors on its current volatility. However, both markets have strong positive and significant parameters A (1,2) and A (2,1), with shocks in Gujranwala and Lalamusa significantly impacting current volatility. The highly significant B (1,1) indicates a robust positive spillover effect on Gujranwala's current volatility from past covariances, and B (2,2) indicates a negative spillover effect on the volatility of Lalamusa. This can be interpreted as the past conditional variance amplifying the current volatility in Gujranwala, while past conditional variance can lead to lower volatility in Lalamusa. In addition, B (1,2) and B (2,1) are both highly significant but the B (1,2) is positive while B (2,1) is negative referred as the past volatility in Gujranwala market cause to elevate the volatility in Lalamusa and vice versa.

Table 2. Bivariate GARCH-BEKK estimate.

Coefficients	Sialkot	Gujrat	Lalamusa	M.B. Din
C(1,1)	0.0415***	-0.0037	0.0016	0.0108
	(0.0000)	(0.7407)	(0.8201)	(0.3189)
C(2,1)	0.0049	0.0149***	0.0222***	0.0618***
	(0.5676)	(0.0063)	(0.0006)	(0.0000)
C(2,2)	-0.0000	0.0000	0.0000	-0.0000
	(1.0000)	(0.9999)	(1.0000)	(1.0000)
A(1,1)	0.7765***	0.6256***	0.1342	0.8245***
	(0.0000)	(0.0000)	(0.1650)	(0.0000)
A(1,2)	0.3183**	0.1257	0.9067***	0.6997
	(0.0153)	(0.1792)	(0.0000)	(0.1456)
A(2,1)	-0.3340*	0.3327***	0.3166***	-0.2424**
	(0.0581)	(0.0009)	(0.0005)	(0.0304)
A(2,2)	-0.5149***	-0.2198***	0.2958**	0.1341
	(0.0008)	(0.0091)	(0.0192)	(0.5019)
B(1,1)	0.2023	0.1895	1.0098***	0.6290***
	(0.3693)	(0.0619)	(0.0000)	(0.0012)
B(1,2)	0.7683***	0.6913***	0.3703***	-0.0523
	(0.0000)	(0.0000)	(0.0090)	(0.8434)
B(2,1)	-0.0063	-0.9802***	-0.2187***	-0.4640***
	(0.9791)	(0.0000)	(0.0000)	(0.0000)
B(2,2)	-0.0495	0.2083	-0.4792***	0.1478
	(0.8688)	(0.1286)	(0.0027)	(0.4371)

Note: *, **, and *** presents significance level 10%, 5% and 1%.

The relationship between Gujranwala and M.B. Din is also examined, with A (1,1) being highly significant and exhibiting a strong effect of its shock on current volatility. Shocks in Gujranwala tend to have a lasting impact on its future volatility. The negative and significant A (2,1) B (2,1) indicate a negative impact of M.B. Din's past shocks and past volatility on Gujranwala's current volatility. Summing up the results from the analysis, it can be concluded that Gujranwala is the most influential market in the basmati rice production region. It has a substantial impact on the volatility of other markets. For example, shocks in Gujranwala and past conditional variance in Gujranwala are the reason for volatility in Sialkot, while the reciprocal impact is minimal. A similar pattern is derived from the analysis of other selected markets.

There are very limited studies regarding the volatility transmission, more specifically on basmati rice in feeder markets, so the results are not comparable. But the studies like Ismail et al. (2017), Ahmad et al. (2017) and Zehra and Fatima (2019) where they measure the price volatility on other rice market have the similar finding.

Lastly, Figure 2 presents the conditional correlation, which also helps to understand the relationship dynamics between Gujranwala and other selected markets. The correlation between Gujranwala and Sialkot indicates a moderate positive link between the price changes of Basmati, which means that when prices go up or down in one market, there's a tendency for the other. A similar pattern was observed in the other market pairs.

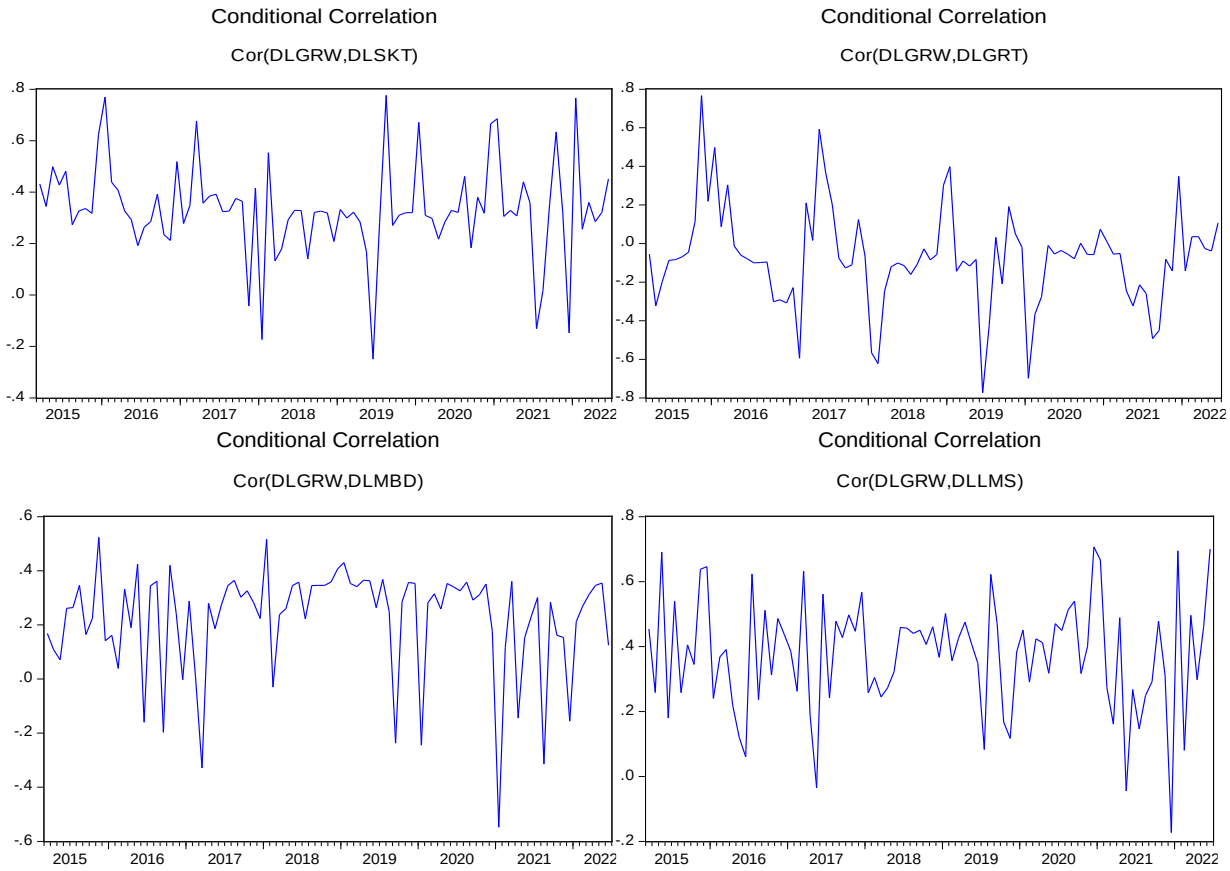

Figure 2. Conditional correlation between selected feeder markets.

CONCLUSION

This study utilized the MGARCH-BEKK bivariate model to examine the dynamic conditional correlations between basmati rice prices in five feeder markets in Pakistan: Gujranwala, Sialkot, Gujrat, Mandi Bahauddin, and Lalamusa. Gujranwala was chosen as the base market due to its significant role in the region's basmati rice trade. The analysis of monthly price returns demonstrated fluctuations in all markets, with a general upward trend. Notably, Mandi Bahauddin exhibited the highest standard deviation, indicating greater price volatility in comparison to the other markets.

The pairwise MGARCH-BEKK analysis results revealed strong interdependencies between Gujranwala and the other markets. For instance, price shocks in Gujranwala significantly influenced Sialkot's volatility, while past shocks in Sialkot had a moderating effect on Gujranwala's price fluctuations. In the case of Gujranwala and Gujrat, shocks in Gujrat led to increased volatility, but there was also a dampening influence from Gujrat on Gujranwala's future volatility. A similar dynamic was observed between Gujranwala and Lalamusa, where both markets exhibited considerable spillover effects. Gujranwala's volatility also had a lasting impact on Mandi Bahauddin, with past shocks from Mandi Bahauddin negatively affecting Gujranwala's current volatility.

In conclusion, the findings highlight Gujranwala's leading role in the basmati rice market system. Its price shocks and volatility had a considerable influence on the other feeder markets, though the reverse effect was less pronounced. Additionally, the study found moderate positive correlations between price changes in Gujranwala and the other markets, indicating a tendency for synchronized price movements across the region.

IMPLICATIONS OF THE RESULTS

- The significant spillover effects from Gujranwala to other markets indicate a high degree of price integration within the basmati rice production area. Policymakers should focus on improving infrastructure and market access in Gujranwala to ensure price stability in surrounding markets.

- Given the substantial impact of shocks in Gujranwala on other markets, implementing strategies to manage price volatility in this key region can mitigate risk across the entire area. Introducing risk management tools like market intelligence and collaborative strategies could help stabilize prices.
- Mandi Bahauddin's high volatility suggests the need for targeted interventions. Efforts such as improving market efficiency, enhancing storage facilities, or implementing stabilizing policies could help reduce excessive price fluctuations in this market.

Given Gujranwala's dominant role, it should be prioritized for investments in value chain development. Upgrading its market infrastructure, grading, and standardization systems could positively impact the entire region's price dynamics. These insights can guide policy interventions aimed at reducing volatility and promoting a more efficient and stable basmati rice market system in Pakistan.

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