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Dynamics of Food Prices in Pakistan: GARCH Approach

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ABSTRACT

Aim of the Study: The purpose of the research is to provide in-depth findings on the dynamics of food prices by computing the volatility in fifteen food commodities for fourteen major cities of Pakistan for the period June 2002 to July 2021. The research identified the commodities with high and low price volatility and also identified the periods in which the volatility in food prices was high and low over the period.

Methodology: Volatility in food prices is computed using standard deviation and the GARCH approach Bollerslev (1986).

Findings: Based on standard deviation, it is found that beef, chicken, egg, sugar and all vegetables are highly volatile over the given period as compared to other commodities. Further, it is elaborated from GARCH results that, in the Cereal and Pulses group, Milk and Tea for most of the cities; both the residual effects and past variance are responsible for the current volatility. While in log return prices of Sugar, Eggs and commodities exist in the vegetable group, the main reason for volatility in most of the cities is only the external factors.

Conclusion: The study would help the policymakers to stabilize the food prices. It is recommended that the government should formulate a system by making investment to monitor the market prices of highly volatile food commodities (beef, chicken, egg, sugar and vegetables) in each city. It would help to stabilize the food prices.

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1. INTRODUCTION

Globalization has amplified the economic integration of the economically integrated world and the interdependence of developed and developing countries for a variety of products. It is clear that global commodity prices have experienced rising and volatile dynamics over the past two decades. International food prices almost doubled between 2007 and 2008, rising by up to 27%, according to the Food and Agriculture Organization (FAO) index. Like other developing countries, Pakistan has been affected by the international food price crisis. Food inflation between 2008 and 2009, increased by 23.13% compared to 17.65% in 2007, breaking the highest level in 23 years. During 2005 and 2008, wheat prices rose 106%, while price changes for other staple foods ranged from 20% to 120%. These high wheat prices also cause an increase in the prices of vegetables, meat, oil and milk (Awan, et.al, 2015).

Furthermore, in 2010 and 2011, Pakistan faced the challenge of heavy floods, which reduced wheat production that further raised not only the price of wheat but also the prices of some perishable goods. In 2012, local food prices were also inflated because of the extraordinary upsurge in the global prices of wheat, soybean, and corn. However, in 2014-15 (July-April), there was a decrease in food inflation due to the decline in the prices of several food commodities, particularly the prices of potatoes, wheat, eggs, rice etc. declined. Furthermore, the decline in food inflation was also because of the reduction in oil (fuel) prices. Once again, in 2016, food price inflation showed a rising trend as the prices of, sugar, wheat, pulse (mash) and meat, increased by 3.9, 2.6, 8.5, and 1.3 per cent, respectively. In 2018-19, global food inflation did not increase too much, which further decreased the inflationary pressure and Pakistan's food inflation was recorded at only 1.8 per cent. This reduction in food inflation further reduced the overall inflation in Pakistan (Economic Survey of Pakistan, 2018-19).

In 2020, food inflation increased to 10.4 per cent due to supply disruption, seasonal changes, and an increase in transportation costs. Furthermore, reliance on imported items due to COVID-19 was also one of the reasons. In April 2021, food inflation increased to 15.7 per cent due to a massive increase in chicken, tomatoes, eggs, milk, sugar, and wheat prices. However, the prices of onion, mung, and masur decreased. The given dynamics of food prices refer to its volatile pattern that is identified in several studies through volatility approach. Realizing the importance of the issue, the current study determine the dynamics of fifteen major food commodities; beef, chicken, rice, wheat, mash, mung, masur, tomato, potato, garlic, onion, sugar, tea, milk, and eggs over the years in Pakistan. The study will help the policymakers to design policies to control the variation and increase in food prices.

Following the introduction in Section 1, the paper is organized as follows. Section 2 detailed the literature based on volatility in food prices using GARCH approach. Section 3 explains the data sources and methodology. Section 4 discusses the findings. Section 5 gives the conclusions and the policy recommendations.

2. LITERATURE REVIEW

This section presents a concise review of the research available on food price volatility at the national and international levels. After the international crisis of food prices in 2007-08 the literature got more extensive. In this respect, Jordaan et al. (2007) determined that the daily prices of soybean and wheat were not volatile, while the daily prices of other crops, for instance, white and yellow maize and sunflower, were volatile. Similarly, Apergis and Rezitis (2011) analysed the monthly price data of food prices, for the 1985–2007 period. They concluded that the relative prices of food in Greece were volatile and had greater uncertainty about the prices in future, which further negatively impacted both consumers and producers. Sukati (2013) also worked on the identification of volatility in monthly maize monthly prices in Swaziland. Using monthly data from February 1998 to September 2013, he found elaborated that volatility in maize prices was not persistent but strongly affected by market dynamics. Minot (2014) determined the volatility in the prices of staple food for the January 1980–March 2011 period. The author asserted that the high volatility in international food prices from 2007 to 2010 did not accelerate volatility in African prices of staple foods. The author also stated that the 14 volatility in tradable food products was smaller than the volatility in non-tradable food products, especially in the main cities. Additionally, Kelkay and Yohannes (2014) found that in Ethiopia from December 2011 to June 2012, volatility in the prices of peas and beans had a spillover effect from one time period to another. Balanay (2015) found that in the Philippines, there was a short-term time-varying volatility in the prices of duck eggs from 1990 to 2009. Furthermore, the author recommended that as the market of duck eggs is highly uncertain, there is a need for regular monitoring to protect the market from threats in future. In another study, Kuhe (2019) utilised monthly time series data on Commodity Food Price Index from January 1991 to January 2017 and found that price volatility was quite persistent and mean reverting, indicating that past volatility was important in forecasting future volatility. Furthermore, Zehra and Fatima (2020) assessed the volatility in sixteen food commodities for the monthly data from 2002 to 2016 for fourteen cities in Pakistan. They found that in most of the commodities (in various cities) the volatility was because of the past variance

and residual effects. However, for a few commodities (in different cities), the volatility was only due to residual effects. The study also found that there existed heterogeneity among cities with differences in the intensity of volatility.

3. DATA SOURCES AND METHODOLOGY

This section provides the data sources and describes the methodological approach that is adopted for accomplishing the objective of the study.

3.1. Data Sources

The study employs monthly data of food prices for fifteen food commodities that are a part of the CPI basket, namely, beef, chicken, pulses (mash, mung, masur), rice (IRRI), wheat, tomato, potato, onion, garlic, milk, egg, sugar, and tea for 14 large cities of Pakistan. Cities included in this analysis are Bahawalpur, Faisalabad, Hyderabad, Islamabad, Karachi, Khuzdar, Lahore, Multan, Peshawar, Quetta, Rawalpindi, Sargodha, Sialkot, and Sukkur. Cities are selected based on the definition of a big city by the Pakistan Bureau of Statistics. Monthly data is gathered from July 2002 to July 2021, from various issues of the Monthly Statistical Bulletin published by the Pakistan Bureau of Statistics. In this way, a total of about 48,090 observations are included in this study

3.2. Methodology

To assess the dynamics of food prices using volatility approach two methods are used. One is standard deviation and the second is ARCH/GARCH and IGARCH Models.

a) Standard Deviation

In this method, the standard deviation of log return prices (growth rates) is measured to identify the periods of high and low volatility for each food commodity. The categorisation is based on the median value of the annual standard deviation. The years in which the standard deviation is above or equal to the median value are called high volatile periods represented by "1", while the years in which the standard deviation value is below the median value are called low volatile periods represented by "0". Furthermore, the method also helps to identify the commodities with high and low volatility. The categorisation is based on the median value of standard deviation for the commodities. Over the July 2002–July 2021 period, the commodities with a standard deviation of more than or equal to the median value are referred to as highly volatile commodities and are represented by "1". On the other hand, others are less volatile and are represented by "0". The method assumes constant variance of error terms.

b) ARCH/ GARCH/ IGARCH Models

Based on the literature, this paper also employs ARCH/GARCH models to assess the volatility in food prices in Pakistan. To model the time series data it is supposed that the residual has constant variance (homoscedasticity), but actually, the variance of the residual is not constant and heteroscedasticity arises in various time series data. This shows that the assumption of homoskedasticity in the residual variance is not valid. Engle (1982) presented the autoregressive conditional heteroskedasticity (ARCH) models, used to analyse the time series data in the presence of heteroscedasticity. The equation for the ARCH (p) model to determine the variance is given below:

$$\boldsymbol{\delta_t^2 = \gamma + \sum_{m=1}^{p} \alpha_m \, \varepsilon_{t-m}^2} \qquad \mathbf{1}$$

Where δ^2_t is the error term's conditional variance, $\varepsilon^2_{t\text{-}m}$ is the squared error term in the preceding period, and α_ms are ARCH parameters**.** In this model the error terms are considered to have a distinctive size or variance and the variance of the present error term depends on the squares of the preceding error terms.

The GARCH model which was introduced by Bollerslev (1986) is the extension of ARCH model, introduced by Engle in 1982. The GARCH Model principally generalizes ARCH model into an autoregressive moving average model. The Equation for the GARCH model is shown below.

$$\boldsymbol{\delta_t^2 = \gamma + \sum_{m=1}^{p} \alpha_m \ \varepsilon_{t-m}^2 + \sum_{n=1}^{q} \beta_n \ \delta_{t-n}^2} \quad \mathbf{2}$$

Where δ^2_{t-n} are variances in the previous period, β_ns are GARCH parameters and $0<\alpha_m<1$, $0<\beta_n<1$, and $\alpha_m + \beta_n<1$ fulfill the GARCH conditions.

The above model is termed the GARCH (p, q) model where, p is the lagged terms of the squared error terms and q is the lagged terms of conditional variances.

In the GARCH model, α captures the impact of random deviations in the preceding period on δ_t^2, and β captures the impact of past variance on current variance. This study begins with the estimation of conditional volatility by using ARCH (1) and GARCH (1, 1) models. The study uses IGARCH (1,1) model in the cases where the sum of ARCH and GARCH parameters is equal to 1. The ARCH (1), GARCH (1, 1) and IGARCH (1,1) conditions shown through equations 3, 4 and 5 respectively, are appropriate as they display a parsimonious illustration of conditional variance that adequately fits most of the high-frequency time series data [(Bollerslev (1987) and Engle (1993)].

$$\boldsymbol{\delta_t^2 = \gamma + \alpha \ \varepsilon_{(t-1)}^2} \quad \mathbf{3}$$

$$\boldsymbol{\delta_t^2 = \gamma + \alpha \varepsilon_{(t-1)}^2 + \beta \delta_{(t-1)}^2} \quad \mathbf{4}$$

$$\boldsymbol{\delta_t^2 = \gamma + \alpha \ \varepsilon_{(t-1)}^2 + \beta \delta_{(t-1)}^2} \quad \mathbf{5}$$

The justification for applying ARCH/GARCH and IGARCH models for the assessment of volatility is checked by the ARCH-LM test. The test is used to identify the presence of heteroscedasticity in the price series of each food commodity for every city. The null hypothesis of the ARCH-LM test is no ARCH effect, which means that the residuals are homoscedastic, i.e., volatility remains the same over 28 the period (Jordaan, et al., 2007). A p-value smaller than 0.05 means the null hypothesis of no ARCH effect in the residuals is rejected. This rejection of the null hypothesis means that GARCH (1,1) and IGARCH (1,1) models can be used.

4. FINDINGDS AND DISCUSSION

This section explains the results of dynamics in food prices through standard deviation and GARCH Approach.

a) Standard Deviation

The periods of high and low volatility for each commodity are presented in Table 1. The table shows that during the period of accelerated global food prices, i.e., 2002- 2008, in Pakistan the food prices of beef, chicken, egg, tomato, and sugar were highly volatile as compared to other commodities. Furthermore, 2008-09 was highly volatile for egg, milk, onion, tomato, potato, mash, masoor, rice, wheat, and tea. Unsurprisingly, in 2008-09 the food inflation record of the previous 23 years was broken as inflation reached 23.13 per cent. In the next year, almost all food commodities remained volatile except tomatoes and tea. It is evident from the results that during the years 2014-2015 and 2015-16, the volatility in most of the food commodity prices was low as there was a decline in the fuel prices in 2014-15. Additionally, in 2020, due to COVID-19, all the food commodities, except onion, were highly volatile. Table 2 shows

that the prices of beef, chicken, egg, sugar, and all vegetables were highly volatile over the given period, while milk, tea and rice, wheat, and all three pulses were comparatively less volatile.

Table 1: *Commodity Wise High and Low Volatility Periods*

Year	Beef	Chicken	Egg	Milk	Garlic	Onion	Potato	Tomato	Pulse Mash	Pulse Masoor	Pulse Moong	Rice IRI	Wheat	Sugar	Tea
2002-03	1	0	1	0	1	0	0	0	0	0	0	1	0	0	1
2003-04	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0
2004-05	1	1	1	0	1	1	1	1	0	0	0	0	1	1	0
2005-06	1	1	1	1	0	0	0	1	1	0	1	0	0	1	1
2006-07	0	1	1	0	1	1	1	1	0	1	1	1	0	0	0
2007-08	0	1	1	1	0	0	0	1	0	1	1	1	1	0	0
2008-09	0	0	1	1	0	1	1	1	1	1	0	1	1	0	1
2009-10	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0
2010-11	1	0	0	1	0	1	1	0	0	0	0	0	0	1	0
2011-12	0	0	0	1	1	1	0	0	1	1	1	1	1	1	0
2012-13	0	0	0	0	1	1	0	0	0	0	0	0	1	0	1
2013-14	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
2014-15	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0
2015-16	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
2016-17	1	0	0	0	1	0	1	1	1	1	1	0	0	1	1
2017-18	0	0	0	0	0	1	0	0	1	1	1	0	0	0	1
2018-19	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1
2019-20	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1
2020-21	1	1	1	1	1	0	0	1	0	0	1	0	1	1	0
Median	2.6	14.4	14.4	2.8	13.5	24.8	21.9	42	4.8	4.2	5.2	3.4	4.4	5.6	4.3

Source: *Author's calculation "Medians are mentioned in percentages"*

Table 2: *High and Low Volatile Commodities*

Commodities	High and Low
Beef	1
Chicken	1
Egg	1
Milk	0
Garlic	1
Onion	1
Potato	1
Tomato	1
Pulse Mash	0
Pulse Masoor	0
Pulse Moong	0
Rice IRI	0
Wheat	0
Sugar	1
Tea	0
Median (in %)	8.5

Source: *Author's calculation*

b) ARCH/ GARCH Model

Before estimating ARCH/ GARCH and IGARCH models, unit root and ARCH-LM tests were applied. Based on Augmented Dickey-Fuller (ADF) test the log return price series of all food commodities were stationary at the level for each city. ARCH-LM test was performed to identify the existence of short-run time-varying volatility in the log return prices of food commodities for each city. Table 3 shows that for most of the cities, the ARCH effect was present in the log return price series of all food commodities

except for few cities. Finally, the ARCH-LM test shows that the log return price series had an ARCH effect. The test endorses the application of ARCH (1)/GARCH (1,1) and IGARCH (1,1) methodology for assessing the volatility in the price series of selected food commodities.

Table 3: *ARCH-LM TEST*

City	**P-Value**							
	Beef	**Chicken**	**Egg**	**Milk**	**Garlic**	**Onion**	**Potato**	**Tomato**
Bahawalpur	0.0062	0	0.0003	0	0.333*	0	0	0.31*
Faisalabad	0.0031	0.0001	0	0	0	0	0	0
Hyderabad	0	0	0	0	0	0.006	0	0
Islamabad	0	0.12*	0	0	0	0	0.0018	0
Karachi	0	0	0	0	0	0	0.056*	0
Khuzdar	0.0864*	0.0017	0	0.39*	0	0	0	0
Lahore	0.017	0	0.047	0	0	0.7*	0.001	0
Multan	0	0.0008	0	0	0.028	0	0.8*	0.0071
Peshawar	0	0.0043	0	0	0	0.0001	0	0
Quetta	0.86*	0	0	0	0	0	0	0
Rawalpindi	0	0	0	0	0	0	0.0001	0
Sargodha	0	0	0	0	0.001	0	0.0003	0
Sialkot	0	0	0.045	0	0.0003	0.48*	0.0001	0
Sukkur	0.186*	0.0003	0	0	0	0	0.0002	0.45*

City	**P-Value**						
	Pulse Mash	**Pulse Masoor**	**Pulse Moong**	**Wheat**	**Rice IRI**	**Tea**	**Sugar**
Bahawalpur	0	0.88*	0.38*	0	0	0	0.022
Faisalabad	0	0	0.008	0.007	0	0	0.0005
Hyderabad	0	0	0.29*	0.013	0	0	0
Islamabad	0	0	0.007	0	0	0	0.33*
Karachi	0	0.27*	0.0006	0	0	0	0
Khuzdar	0.9*	0	0.0027	0	0.61*	0	0
Lahore	0.32*	0.88*	0	0	0.033	0	0
Multan	0	0.22*	0	0.019	0	0	0
Peshawar	0	0.002	0	0	0	0.22*	0.021
Quetta	0	0.015	0	0	0	0	0.116*
Rawalpindi	0	0.035	0	0	0	0	0
Sargodha	0	0	0	0.12*	0	0	0.012
Sialkot	0	0.0001	0.77*	0	0.2*	0	0.0035
Sukkur	0	0.004	0	0	0.0035	0	0

Source: Authors' calculations. *a p-value greater than 0.05 shows the acceptance of null hypotheses implying that the volatility is not time varying and so on

Results of ARCH (1) Model

This section highlights the results of ARCH model, applied on the series which have ARCH effect. Table 4 explains the results of ARCH (1) model applied on the log return price series of food commodities. It is seen that the ARCH coefficient is significant for all the commodities, showing that the short term time varying volatility in the return prices of all the above commodities is influenced by some external factors, which may cause extra supply in some period whereas a deficient supply in the next period.

Table 4: *ARCH (1) Results*

City	P-Value							
	Beef	**Chicken**	**Egg**	**Milk**	**Garlic**	**Onion**	**Potato**	**Tomato**
Bahawalpur	0.12**	0.31*	0.55*	0.40*		0.41*	0.80*	
Faisalabad	0.24*	0.30**	0.47*	0.21*	0.19*	0.36*	0.27*	0.35*
Hyderabad	0.20**	0.27**	0.48*	0.42*	0.79*	0.19**	0.16**	0.34**
Islamabad	0.35*		0.46*	0.21*	0.88*	0.50*	0.28**	0.51*
Karachi	0.32*	0.31*	0.55*	0.22*	0.66*	0.27*		0.35*
Khuzdar		0.14**	0.42*		0.60*	0.11*	0.30**	0.30**
Lahore	0.44*	0.16*	0.53*	0.98*	0.24*		0.20**	0.42*
Multan	0.18**	0.31**	0.56*	0.48*	0.24**	0.31*		0.51*
Peshawar	0.61*	0.25**	0.45*	0.36*	0.39*	0.22**	0.13*	0.44*
Quetta		0.90*	0.35*	0.55*	0.03*	0.37*	0.11*	0.50*
Rawalpindi	0.70*	0.19**	0.13**	0.13*	0.26*	0.38**	0.29*	0.30*
Sargodha	0.22*	0.33*	0.50*	0.24**	0.22*	0.30**	0.24*	0.55*
Sialkot	0.24*	0.30**	0.18*	0.20*	0.23*		0.29**	0.50*
Sukkur		0.26**	0.51*	0.42*	0.24**	0.47*	0.25*	

City	P-Value						
	Pulse Mash	**Pulse Moong**	**Pulse Masoor**	**Rice IRI**	**Wheat**	**Sugar**	**Tea**
Bahawalpur	0.14*			0.41*	0.13*	0.21*	0.45*
Faisalabad	0.18*	0.28**	0.16*	0.46*	0.28*	0.29**	0.48*
Hyderabad	0.59*		0.32*	0.58*	0.32*	0.28*	0.56*
Islamabad	0.42*	0.29*	0.22*	0.32*	0.50*		0.27*
Karachi	0.15*	0.19*		0.91*	0.33*	0.38*	0.55*
Khuzdar		0.11**	0.22*		0.53*	0.14**	0.52*
Lahore		0.34*		0.60*	0.17*	0.27*	0.42*
Multan	0.10*	0.70*		0.32*	0.30*	0.55*	0.48*
Peshawar	0.12*	0.48*	0.17**	0.82*	0.28*	0.46*	
Quetta	0.22**	0.52**	0.26*	0.22*	0.69*		0.44*
Rawalpindi	0.35*	0.53*	0.22*	0.27*	0.70*	0.32*	0.17*
Sargodha	0.16**	0.39**	1.10*	0.40*		0.29**	0.48*
Sialkot	0.30*		0.30*		0.86*	0.36*	0.54*
Sukkur	0.23*	0.40*	0.18*	0.59*	0.21**	0.27**	0.43*

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively.

Results of GARCH (1,1) Model

After the application of ARCH (1) model the study further assessed the volatility by using GARCH (1,1) model. This model helps to answer whether the existing volatility is only due to some external factors or also due to the existence of previous volatility in the food commodities. For easy analysis the research allocates the food commodities into five groups[1].

Table 5 divulges the results of Meat group. Significant ARCH and GARCH coefficients for beef, in each city explain, the volatility in log return price series is not only enormously affected by residual effects but also due to the presence of past variance in log return prices. It exhibits that the volatility in beef prices is

[1] 1. Meat Group (Beef and Chicken), 2. Dairy Group (milk and egg), 3. Vegetable Group (Garlic, Onion, Potato and Tomato), 4. Cereal and Pulses Group (Rice, Wheat, Pulse Mash, Pulse Masoor and Pulse Moong) 5. Other Group (Sugar and Tea)

persistent and takes long time to come to an end. On the other hand, for chicken prices only ARCH parameter is significant for each city though, the GARCH parameter is significant only for Khuzdar, Quetta and Sargodha. Significant ARCH coefficient and insignificant GARCH coefficient explains that, in chicken prices the presence of volatility is only due to the factors that cause changes in its supply and demand while, past variance do not effect current volatility. Cities where, conditions of GARCH model are not fulfilled like, negative GARCH coefficient, ARCH (1)[2] model is considered for volatility assessment.

Table 5: *GARCH (1,1) Results for Meat Group*

	BEEF			**CHICKEN**		
City	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**
Bahawalpur	0.104**	0.720*	0.824	0.317*	-0.056	0.261
Faisalabad	0.703*	0.047**	0.75	0.296**	0.011	0.307
Hyderabad	0.156*	0.753*	0.909	0.265**	0.037	0.302
Islamabad	0.562*	0.303*	0.866			
Karachi	0.241*	0.477*	0.718	0.304*	-0.041	0.262
Khuzdar				0.115**	0.550*	0.665
Lahore	0.504*	0.169**	0.673	0.157*	0.077	0.234
Multan	0.114*	0.629*	0.743	0.310**	0.002	0.312
Peshawar	0.514*	0.358*	0.872	0.242**	0.11	0.352
Quetta			0.358	0.093**	0.904*	0.997
Rawalpindi	0.195*	0.534*	0.728	0.192**	-0.114	0.078
Sargodha	0.165*	0.161*	0.325	0.150*	0.600**	0.75
Sialkot	0.348*	0.298*	0.646	0.285**	-0.313	-0.03
Sukkur				0.276**	0.239	0.515

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively.

The findings of Dairy group are demonstrated in Table 6. The significant ARCH coefficient for both commodities in each city is indicated that volatility is highly influenced by residual effects. That might be the change in input prices (oil prices), seasonal (winter and summer) changes which create volatility in the log return price of egg and milk. As in winter season, the demand for eggs generally rises and so on. However, GARCH coefficient is insignificant for egg prices in majority of the cities except Quetta, presenting that the volatility in most of the cities is not due to previous volatility. Though, the conditional volatility in milk prices is also due to the presence of previous volatility in majority of the cities except for Islamabad and Sargodha. All those cities where GARCH coefficient is negative the study considers ARCH model, as it is the best to assess conditional volatility. IGARCH model is used in return price series of milk for Peshawar as the sum of both ARCH and GARCH coefficients is equal to 1. IGARCH[3] model fulfils its necessary condition, i.e., $\alpha + \beta = 1$, displaying that shocks have permanent impact on volatility.

[2] For Bahawalpur, Karachi, Rawalpindi and Sialkot chicken prices ARCH(1) model is considered

[3] IGARCH Model results for all commodities are shown in Table A-1 (Appendix).

Table 6: *GARCH (1,1) Results for Dairy Group*

	EGG			MILK		
City	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur	0.561*	0.043	0.603	0.220**	0.339*	0.559
Faisalabad	0.445*	-0.163	0.281	0.155*	0.470*	0.625
Hyderabad	0.481*	0.031	0.513	0.324*	0.405*	0.729
Islamabad	0.418*	-0.19	0.227	0.215*	0.018	0.233
Karachi	0.553*	-0.02	0.533	0.158*	0.784*	0.942
Khuzdar	0.430*	-0.124	0.307			
Lahore	0.469*	0.04	0.509	0.081*	0.746*	0.827
Multan	0.556*	0.083	0.638	0.351*	0.005*	0.356
Peshawar	0.447*	-0.017	0.431	0.143*	0.847*	0.99
Quetta	0.183*	0.743*	0.926	0.769*	0.074*	0.842
Rawalpindi	0.135*	-0.055	0.08	0.124*	-0.194	-0.07
Sargodha	0.513*	0.153	0.666	0.727*	0.002	0.73
Sialkot	0.269*	0.237	0.507	0.209**	-0.02	0.189
Sukkur	0.526*	0.075	0.601	0.150**	0.600*	0.75

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively

The results of vegetable group are reported in Table 7. It is seen that, in this group ARCH parameter is significant for all commodities in their respective cities. Showing that short term time-varying volatility in prices of vegetables has responsive behaviour towards shocks or residual effects. These shocks might be the change in transportation cost, change in international prices of vegetables or change in weather condition (in 2010 and 2011 rains and floods, particularly in Sindh harm the production of these vegetables). While, past volatility in vegetable prices has no effect on current volatility for majority of the cities. However, the volatility in the log return prices of Garlic (Faisalabad, Hyderabad, Multan, Peshawar, Quetta and Sukkur), in the log return prices of Onion (Rawalpindi and Sukkur), in the log return prices of Tomato (Khuzdar) and in the log return prices of Potato (Bahawalpur); is due to both the existence of residual effects and previous volatility, showing persistent behaviour of volatility for these cities. The ARCH (1) model is considered in cases where the GARCH coefficient is negative. IGARCH (1,1) model is applied for Garlic (Sukkur) and Rawalpindi (Onion),where the summation of both coefficients is equal to or more than 1.

Table 7: *GARCH (1,1) Results for Vegetable Group*

	GARLIC			ONION		
City	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur				0.410*	0.117	0.526
Faisalabad	0.093*	0.649*	0.742	0.361*	0.19	0.551
Hyderabad	0.283*	0.628*	0.911	0.186**	0.251	0.437
Islamabad	0.545*	0.05	0.595	0.498*	0.011	0.509
Karachi	0.682*	-0.009	0.673	0.282*	0.116	0.398
Khuzdar	0.482*	0.289	0.771	0.105*	0.069	0.174
Lahore	0.319*	0.241	0.56			
Multan	0.354*	0.355*	0.709	0.317*	0.16	0.478
Peshawar	0.150*	0.600*	0.75	0.218**	0.009	0.228
Quetta	0.338*	0.416*	0.754	0.370*	0.002	0.372

Rawalpindi	0.248*	0.106	0.354	0.447*	0.636*	1.083
Sargodha	0.284*	-0.192	0.092	0.300**	0.013	0.314
Sialkot	0.256*	-0.19	0.066			
Sukkur	0.843*	0.221**	1.064	0.434*	0.405*	0.839

	POTATO			TOMATO		
City	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur	0.694*	0.239*	0.932			
Faisalabad	0.279*	0.173	0.452	0.350*	-0.086	0.264
Hyderabad	0.161**	-0.069	0.091	0.348**	-0.117	0.232
Islamabad	0.274**	-0.136	0.137	0.511*	0.053	0.564
Karachi			0	0.440*	-0.391	0.049
Khuzdar	0.298**	0.136	0.434	0.201**	0.708*	0.909
Lahore	0.236*	-0.315	-0.079	0.425*	0.036	0.461
Multan			0	0.576*	0.125	0.701
Peshawar	0.131*	0.037	0.169	0.437*	0.009	0.446
Quetta	0.109*	-0.069	0.04	0.477*	-0.146	0.331
Rawalpindi	0.287*	0.043	0.33	0.303*	0.004	0.307
Sargodha	0.233*	-0.038	0.195	0.510*	0.097	0.607
Sialkot	0.286**	0.244	0.53	0.496*	0.096	0.592
Sukkur	0.312*	-0.218	0.094			

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively

The outcomes of Cereal and Pulses group are presented Table 8 and 9**.** The ARCH parameter is significant for all commodities present in the group for the respective city. It referred that short term time varying volatility in prices of cereal and pulses is affected by residual effects that may affect the crop yield. While, the crop yield is based on different factors like weather conditions input prices etc. In 2017 Ismail, et al. accentuated in their research that urea price has significant impact on rice price while, rupee depreciation influences on wheat prices. It is noticed that volatility is persistent in the return prices of Rice IRI and Wheat in all cities as the past variance significantly affect the present variance. Similarly, in most of the cities the volatility is also persistent for Pulse Mash, Pulse Masoor and Pulse Moong except for Pulse Mash (Quetta, Sialkot and Sukkur), for Pulse Masoor (Islamabad) and for Pulse Moong (Quetta and Sargodha). The results explain that in some cases the condition of GARCH model is violated with negative GARCH coefficient[4], the study assessed the volatility of these commodities by using the ARCH model. Further, in return prices where the sum of ARCH and GARCH coefficient is equal to or more than 1 the study applies the IGARCH model[5].

[4] For Pulse Mash (Quetta, Sialkot and Sukkur), For Pulse Masoor (Islamabad)

[5] For Pulse Mash (Faisalabad, Hyderabad, Islamabad and Rawalpindi), for Pulse Masoor (Sargodha), for Rice IRI (Peshawar and Sukkur) and for Wheat (Rawalpindi)

Table 8: *GARCH (1,1) Results for Cereal and Pulses Group*

PULSE MASH				PULSE MASOOR		
City	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**
Bahawalpur	0.081*	0.821*	0.902			
Faisalabad	0.138*	0.868*	1.006	0.273*	0.519*	0.792
Hyderabad	0.660*	0.373*	1.033	0.291*	0.255*	0.546
Islamabad	0.340*	0.667*	1.007	0.212*	-0.019	0.193
Karachi	0.145*	0.401*	0.546			
Khuzdar				0.184*	0.726*	0.91
Lahore						
Multan	0.076*	0.794*	0.87			
Peshawar	0.109*	0.814*	0.924	0.069**	0.890*	0.959
Quetta	0.232*	-0.004	0.228	0.067**	0.917*	0.984
Rawalpindi	0.251*	0.767*	1.019	0.231*	0.616*	0.847
Sargodha	0.177**	0.426**	0.603	0.599*	0.506*	1.106
Sialkot	0.339*	-0.117	0.222	0.184*	0.788*	0.972
Sukkur	0.199*	-0.203	-0.004	0.376*	0.577*	0.953
PULSE MOONG				**RICE IRI**		
City	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**
Bahawalpur				0.143*	0.780*	0.923
Faisalabad	0.291*	0.681*	0.97	0.145*	0.693*	0.839
Hyderabad				0.562*	0.378*	0.94
Islamabad	0.231*	0.748*	0.98	0.174*	0.727*	0.901
Karachi	0.244*	0.584*	0.83	0.150**	0.600**	0.75
Khuzdar	0.079*	0.822*	0.90			
Lahore	0.341*	0.373*	0.71	0.702*	0.233*	0.935
Multan	0.584*	0.388*	0.97	0.239*	0.447*	0.686
Peshawar	0.478*	0.402*	0.88	0.226*	0.813*	1.038
Quetta	0.523**	0.056	0.58	0.165*	0.417*	0.581
Rawalpindi	0.575*	0.208*	0.78	0.327**	0.501*	0.828
Sargodha	0.391**	0.284	0.68	0.343*	0.449*	0.792
Sialkot						
Sukkur	0.373*	0.553*	0.93	0.139*	0.868*	1.007

Source : Author's calculation, '*'and '**' represents significant at 1%and 5% respectively

Table 9: *GARCH (1,1) Results for Cereal and Pulses Group*

	WHEAT		
City	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**
Bahawalpur	0.109*	0.640*	0.749
Faisalabad	0.201*	0.683*	0.884
Hyderabad	0.318*	0.627*	0.945
Islamabad	0.453*	0.510*	0.963
Karachi	0.437*	0.540*	0.976
Khuzdar	0.322*	0.425*	0.748
Lahore	0.319*	0.532*	0.851
Multan	0.160*	0.692*	0.852
Peshawar	0.144*	0.726*	0.87
Quetta	0.279*	0.696*	0.975
Rawalpindi	0.580*	0.425*	1.005
Sargodha			
Sialkot	0.779**	0.161*	0.94
Sukkur	0.286**	0.577*	0.863

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively

Table 10 presents the GARCH results of Sugar and Tea. The results depict that for both commodities, in each city ARCH coefficient is significant, referring that volatility is strongly because of residual effects. For Sugar they might be some political factors-government policies, high input prices specifically fluctuation in crude oil prices that is used in processing. However, the factors that cause fluctuation in the tea prices are might be the international price of tea, exchange rate, oil prices, as Pakistan is the large importer of tea. The results point out that the volatility in sugar prices in all cities is not depend on the existence of previous volatility except for Karachi city. While, the significant GARCH coefficient in every city for tea prices illustrates that volatility is not only due to residual affects but also influenced by the previous variance. ARCH model is suitable for volatility assessment in series, where GARCH coefficient is negative[6].

Table 10: *GARCH (1,1) Results for Other Group*

	SUGAR			TEA		
City	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**	**ARCH COEFFICIENT (α)**	**GARCH COEFFICENT (β)**	**α + β**
Bahawalpur	0.139**	0.456	0.595	0.343*	0.615*	0.958
Faisalabad	0.288**	0.008	0.296	0.298*	0.589*	0.887
Hyderabad	0.278*	0.002	0.280	0.363*	0.573*	0.936
Islamabad				0.139*	0.698*	0.836
Karachi	0.192*	0.647*	0.838	0.379*	0.587*	0.966
Khuzdar	0.128**	0.249	0.377	0.276*	0.625*	0.902
Lahore	0.196**	0.363	0.559	0.371*	0.615*	0.987
Multan	0.542*	-0.013	0.529	0.346*	0.605*	0.951

[6] Multan, Rawalpindi, Sargodha and Sukkur for Sugar

Peshawar	0.492*	0.092	0.585			
Quetta				0.208*	0.702*	0.91
Rawalpindi	0.361*	-0.129	0.232	0.178*	0.803*	0.98
Sargodha	0.295**	-0.115	0.180	0.222*	0.702*	0.924
Sialkot	0.293**	0.152	0.446	0.359*	0.608*	0.967
Sukkur	0.254**	-0.111	0.143	0.341*	0.592*	0.933

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively

5. CONCLUSION AND POLICY IMPLICATION

For in-depth assessment of food price dynamics, and to understand the risk factor associated with the production and supply of food commodities, volatility in food prices at commodity- city level is assessed. The volatility is assessed by both the standard deviation and ARCH/GARCH and IGARCH methods. For this purpose, monthly data from July 2002 to July 2021 is collected from monthly statistical bulletin for 14 large cities of Pakistan for 15 important food commodities. Total of 48090 observations are thus employed in this study. It is identified that log return price series of all food commodities in each city are stationary at level. Through standard deviation method it is found that beef, chicken, egg, sugar and all vegetables are highly volatile over the given period as compare to other commodities. Further, the ARCH-LM test concluded that most of the food price series have short term time varying volatility in their residuals which allow the application of ARCH/ GARCH model. It is elaborated from the results that, in Cereal and Pulses group, Milk and Tea for most of the cities; both the residual effects and past variance are responsible for the current volatility. While in log return prices of Sugar, Egg and commodities exist in vegetable group, the main reason of volatility in most of the cities is only the external factors. It is recommended that the government should formulate a system by making investment to monitor the market prices of highly volatile food commodities (beef, chicken, egg, sugar and vegetables) in each city. It would help to stabilize the food prices.

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Conflict of Interest

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Table A-1: IGARCH Results for all commodities

Commodity	City	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Chicken	Quetta	0.08	0.92	1
Milk	Peshawar	0.07	0.93	1
Garlic	Sukkur	0.06	0.94	1
Onion	Rawalpindi	0.16	0.84	1
Pulse Mash	Islamabad	0.12	0.88	1
Pulse Mash	Faisalabad	0.07	0.93	1
Pulse Mash	Hyderabad	0.12	0.88	1
Pulse Mash	Rawalpindi	0.17	0.83	1
Pulse Masoor	Sargodha	0.08	0.92	1
Rice IRI	Peshawar	0.11	0.89	1
Rice IRI	Sukkur	0.07	0.93	1
Wheat	Rawalpindi	0.19	0.80	1

Source: Author's calculation, '*'and '**' represents significant at 1%and 5% respectively