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FOOD PRICE VOLATILITY:
A Comparative Analysis among Major Cities of Pakistan[a]

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Abstract

The purpose of this study is to measure the food price volatility for sixteen food commodities [beef, chicken, pulse mash, pulse moong, pulse masoor, rice iri, wheat, tomato, potato, onion, ginger, garlic, milk, egg, sugar and tea] for fourteen main cities of Pakistan [Bahawalpur, Faisalabad, Hyderabad, Islamabad, Karachi, Khuzdar, Lahore, Multan, Peshawar, Quetta, Rawalpindi, Sargodha, Sialkot and Sukkur]. Furthermore, to provide comparative analyses of volatilities among different cities GARCH (1,1), I GARCH (1,1) and standard deviation techniques are employed on the monthly food price data for the period July 2002 to June 2016 collected from various issues of Pakistan Bureau of Statistics for fourteen cities. The results elaborate that volatility is exist in the series of food prices with strong heterogeneity among cities. It is suggested that the government should develop a mechanism to keep a check on the variation in prices and design separate policies for each city according to the volatility in the prices of food commodities in that city.

Keywords: Food Prices, Volatility, GARCH, IGARCH, Standard Deviation.
JEL Classification: P51, Q18.

I. Introduction

International food prices doubled during the period 2007-08. This sharp rise in the prices of food commodities named as 'International Food Crisis' [Headey (2014)]. The FAO index[1] of food prices went up by 27 per cent in 2007-08. The prices of major staple food commodities especially wheat and rice increased by 121 and 76 per cent respectively. Similarly dairy prices rose by 90 per cent and maize prices rose by 80 per cent. This food crisis affected most of the developing countries; Pakistan was one of them. The issue of high food prices became more severe when food inflation reached 26.6 per cent in the year 2008-09 - breaking the record of the past 23 years. In 2010, Pakistan faced massive floods and in 2011, heavy rains that reduced the production of

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[1] The FAO (Food and Agriculture Organization) index of food price is a trade weighted Laspeyres index of worldwide quotation of the prices of fifty five food items given in US dollar.

wheat, furthermore, raising the wheat prices as well as prices of perishable food commodities. In 2012 there was again an increase in the international price of wheat which has further increased the domestic prices. During the period July-April 2014-15 food inflation declines because of the reduction in prices of various food commodities especially wheat, chicken, rice, potatoes and eggs, etc. The above state of prices depicts the volatile nature of food prices.

Volatility or uncertainty in food prices has always been a matter of concern for policy makers and economists because of its implications on the economy both at macro and micro levels. It is the cost of unpredictable food prices which hampers the actual mechanism of the pricing system. In addition, it leads to allocative inefficiencies by creating a loss for both consumers as well as producers. Volatility in the prices of staple food commodities creates more adverse impacts than the volatility in the prices of other agricultural products, as the staple food are a fundamental part of the income of poor producers (farmers) and expenditure of poor consumers. Mostly poor consumers spend a large share of their income on staple foods and these crops are extensively planted at a low cost; hence, it also harms the producers as well. The most severe impact of volatile food prices is on the welfare of a household.

The dire consequences of volatility on household welfare are through its reduction in the purchasing power of household which persistently threatens the survival, food security, livelihood, nutritional status, of poor. These consequences are severe especially for children and threaten their health by raising the probability of contagious diseases. To accomplish the basic nutritional requirement, households cut down their expenditures on the education of children that raise child labour. Various studies reveal that children bear both the physical and mental cost of volatility. Given the adverse impact of volatility on household well being, it is considered necessary to evaluate the pattern of food price volatility - the current state of prices, i.e. the period of high and low prices.

To accomplish the task, numerous studies assessing the volatility in food prices were reviewed. Extensive literature exists internationally regarding the assessment of volatility in the prices of different agricultural commodities. Literature often concludes that the prices of food commodities are highly volatile. Recently, in case of Pakistan, Ismail, et al. (2017) assessed the volatile nature of food commodities using ARCH and GARCH model - for the economy as whole and concluded that prices are highly volatile and the volatility is significantly affected by the prices of crude oil, urea and also due to exchange rate and interest rate.

The review exhibits that there still exist gaps regarding the assessment of volatility in the prices of food commodities. As said earlier, the volatile nature is only assessed for the economy as a whole; however, the volatility may substantially differ across the region and specifically across cities. The cities differ in terms of population and physical structure – affecting the demand and supply of staple food. Given the heterogeneous nature of cities in Pakistan, this study aims to observe the volatility in the monthly prices of major food commodities for different cities of Pakistan. The study focuses on the prices of sixteen food commodities: beef, chicken, pulse mash, pulse moong, pulse masoor, rice, wheat, tomato, potato, onion, ginger, garlic, milk, egg, sugar and tea in fourteen main cities of Pakistan: Bahawalpur, Faisalabad, Hyderabad, Islamabad, Karachi, Khuzdar, Lahore, Multan, Peshawar, Quetta, Rawalpindi, Sargodha, Sialkot and Sukkur. The cities are selected on the basis of two criterions. Firstly, the city is listed in the Pakistan Bureau of Statistics list of major cities secondly the availability of data. However, the selection of food commodities is based on the household expenditure share – commodities selected accounts major proportion of the household expenditure [HIES 2015-16]. Moreover, these commodities are also a part of SPI basket, which is sensitive to price change.

The food price volatility is measured using both sophisticated and commonly applied techniques; (i) Generalized Autoregressive Conditional Heteroscedasticity GARCH (1,1) and Integrated GARCH (1,1) Model and simple (ii) standard deviation technique - to make a comparative analysis of food price volatilities for different cities of Pakistan. This study lengthens the literature by estimating the volatility in the prices of different food commodities for major cities of Pakistan. The assessment may help policy makers in designing suitable policies such as price control mechanism given the heterogeneity among cities. This research is limited to the assessment of food price volatility only, the factors causing the food price volatility though important to examine but remain unanswered. This is because of the absence of information on factors influencing the pricing system at the city level.

This paper is organized as follows: Section II provides literature review, Section III explains data sources and methodology. Section IV provides empirical analysis while Section V presents conclusion and policy implications.

II. Literature Review

Numerous studies exist on the assessment of food price volatility. The literature becomes extensive after the global food price shock in 2007-08. The review is hence focused on literature exploring the food price volatility since world food price shocks. Specifically, this study discusses the literature regarding issues related to the measurement of volatility i.e. make an assessment of studies based on ARCH/GARCH model. In this regard, Grove and Alemu (2007) analyzed the daily price data of sunflower seed, soybean prices, white maize, wheat and yellow maize prices for South Africa. Based on ARCH-LM test they found that in wheat and soybean there is no time varying volatility while for other crops they applied GARCH methodology to calculate the conditional volatility and concluded that risk-averse producers crop wheat and sunflower seeds rather than soya bean, white and yellow maize.

Apergis and Rezitis (2011) derived the volatility in relative prices of food (as a proxy of producer prices) for Greece by means of GARCH methodology. They examined the monthly data of prices from 1985 to 2007 and concluded that there is a short term deviation in food prices or volatility in food prices, which means more uncertainty regarding future prices. Consequently it affects the consumers as well as producers.

Sukati (2013) investigated the volatility in the monthly prices of maize for the period of February 1998 - September 2013 in Swaziland. He used ARCH/GARCH techniques to model the volatility and found that price volatility of maize respond strongly to market dynamics[2] but not persistent. Minot (2013) examined the monthly data of staple food prices in Africa as well as the prices of international grains from January 1980 to March 2011 and determined the food price volatility in Africa using GARCH (p, q) model. He found that the high volatility during 2007-2010 did not increase African food price volatility and the price volatility in tradable food is less than the price volatility in non tradable food in key cities as compared to other cities.

Kelkay and Yohannes (2014) determined the volatility in the price of pulses (pea and beans) for the period of December 2011 to June 2012 in Ethiopia. They modeled the volatility using GARCH regression models and concluded that volatility is spilled over from one period to another period. Hasanov and Shitan (2014) examined the monthly data of palm oil prices from January 1980 to December 2011 to model the volatility using symmetric GARCH and different asymmetric models - GJR-GARCH, EGARCH, FIEGARCH and APGARCH models. They found very slight asymmetric effects in the return prices of palm oil while symmetric effects are strong.

Balanay (2015) in his study, collected the data of prices and supply levels for duck eggs from 1990-2009 and estimated price volatility of duck eggs and supply response in Philippine using ARCH and ARDL model respectively. He also collected data for prices of beef, pork, crude oil and yellow corn used in the estimation of supply response and found short run time-varying price volatility in the market of duck eggs. His results suggested a high level of risk and uncertainty in the duck eggs market that should be monitored to save the market from future threats.

Ismail, et al. (2017) used the monthly price data from April 1983 - April 2013 of barley, rice tea, beef, wheat, lamb poultry, rapeseed oil, sugar, sunflower oil, soybean oil, cotton crude oil, urea and also the monthly data of exchange rate and interest rate. Base on GARCH family regression model, he concluded that the impact of interest rate is passed on poultry and beef prices. While the exchange rate influenced the prices of wheat, urea prices affected the prices of rice and sugar and crude oil volatility influenced the volatility of wheat.

Overall studies conducted on the assessment of food price volatility have mainly relied on ARCH/GARCH technique and concluded that uncertainties are higher in food prices. In Pakistan, the research also identified the factors influencing volatility in food prices using GARCH family regression model. There is no significant research which is identified to model food price volatility across cities in Pakistan.

[2] Factors that influence volatility in maize prices, e.g., import price of maize as Swaziland import maize from South Africa, international oil prices that used in the production of maize and its transport to different markets.

III. Data Sources and Methodology

1. Data Sources

The paper uses monthly data on food prices for sixteen food commodities[3] namely; beef, chicken, pulse mash, pulse moong, pulse masoor, rice iri, wheat, tomato, potato, onion, ginger, garlic, milk, egg, sugar and tea, from July 2002 to June 2016 for 14 large cities. The cities included in our analysis are Bahawalpur, Faisalabad, Hyderabad, Islamabad, Karachi, Khuzdar, Lahore, Multan, Peshawar, Quetta, Rawalpindi, Sargodha, Sialkot and Sukkur. The data is gathered from various issues of Monthly Statistical Bulletin published by the Pakistan Bureau of Statistics.

2. Methodology

Based on the literature, to make an assessment of the volatile nature of food prices in large cities of Pakistan, this study has also employed Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, introduced by Bollerslev (1986), an extended form of ARCH (Autoregressive Conditional Heteroscedasticity) model, introduced by Engle in 1982. GARCH model is considered appropriate to measure the food price volatility because it assumes that previous volatility and shocks exist in a city market may affect the present volatility in food prices – conditional volatility. GARCH model assumes that there is an existence of continuously changing conditional volatility with the passage of time in food prices. In General, Equation for GARCH (*p*, *q*) model is shown below.

$$\delta_t^2 = \gamma + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \delta_{t-j}^2 \quad (1)$$

where, $p > 0$, $q > 0$, $\alpha_i \geq 0$, $\beta_j \geq 0$ and $\alpha_i + \beta_j < 1$. p represents the lagged terms of the squared error terms while q are terms of lagged conditional variances, δ_t^2 is the conditional variance of error term, δ_{t-j}^2 represents the variances of the previous time period and ε_{t-i}^2 is the squared error terms of the previous time period, $\alpha_i s$ are ARCH parameters and $\beta_j s$ are GARCH parameters.

This study begins to estimate the conditional volatility by GARCH (1,1) model in the price series of each commodity for each city. GARCH (1,1) condition is sufficient as it shows a parsimonious illustration of conditional variance, which sufficiently fits most of the high frequency time series [Bollerslev (1987) and Engle (1993)]. The equations for conditional mean and variance are as follows:

$$lrp_{mnt} = c + a\, lrp_{mn(t-1)} + \varepsilon_{mnt} \quad (2)$$

[3] Units for the food commodities that are given in Table A-1 (Appendix).

$$\delta^2_{mnt} = \gamma + \alpha\, \varepsilon^2_{mn(t-1)} + \beta\delta^2_{mn(t-1)} \tag{3}$$

where, *lrp* represents log return[4] price, *m* represents m^{th} food commodity, *n* represents n^{th} city.

The study pursues Integrated GARCH (1,1) model in the cases where the GARCH (1,1) model is not satisfied. IGARCH model has a property of "persistent variance" which means "current information remains important for the forecasts of the conditional variances for all horizons" [Engle and Bollerslev (1986)]. IGARCH (1, 1) is described by the following equation.

$$\delta^2_{mnt} = \gamma + \alpha\varepsilon^2_{mn(t-1)} + \beta\delta^2_{mn(t-1)} \tag{4}$$

where $\alpha + \beta = 1$

The study assumes that these models can capture the conditional variance. With the help of GARCH (1,1) and IGARCH (1,1) models, the study generates a series of volatility for food prices. It verifies the validity of the application of GARCH and IGARCH model by testing the heteroscedasticity in the prices of all food commodities for each city. For this purpose ARCH-LM test is applied. The null hypothesis for ARCH LM test is no ARCH effect means the residuals are Homoscedastic indicating the volatility remains constant over time, or residuals do not vary over time [Alemu, et al. (2007)]. If the p-value is less than 0.05, it recommends rejecting the null hypothesis of no ARCH effect and accepting the alternative hypothesis of the presence of ARCH effect in the residual series. This rejection of the null hypothesis allows this study to apply GARCH (1,1) and IGARCH (1,1) models. In case of those food commodities where ARCH effect is not found, a simple standard deviation[5] technique is applied to measure the volatilities.

IV. Empirical Analysis

This section is based on the estimation of GARCH and IGARCH model. However, before estimating the GARCH model, some preliminary test such as unit root and ARCH-LM test are applied. Unit Root test is performed by employing Augmented Dickey Fuller (ADF) test on the log return price series for all the mentioned food commodities in each city. It is observed that the log return price series of commodities do

[4] Log Return = $ln \frac{P_t}{P_{t-1}}$ where , p_t is the monthly price for period *t* and p_{t-1} is monthly price for period *t-1*.

[5] $\sigma = \sqrt{\frac{\Sigma (p_{mn} - \bar{p}_{mn})^2}{N}}$

where p_{mn} represents the each value of the m^{th} commodity price for n^{th} city in the monthly data of 2002-2016 while $\bar{p}_{mn}$ is the mean of the m^{th} commodity price series for n^{th} city for the given time period.

not have any sign of unit root and are stationary at level[6]. This may be because all the series are in log return form. Furthermore, to identify the presence of short term time varying volatility in the log return prices of commodities for each city ARCH-LM test is performed. Results are reported in Table 1. The results reveal the presence of ARCH effect or the presence of time-varying volatility in the log return prices of beef, rice, wheat, garlic, ginger, sugar and tea in all cities of Pakistan with p-value less than 0.05. The volatility is also time varying for the log return prices of pulse mash, pulse masoor, pulse moong, milk and egg for most of the cities of Pakistan except in Islamabad (for pulse mash), Sukkur (for Pulse masoor), Khuzdar (for pulse moong), Quetta (for milk), Peshawar and Khuzdar (for egg), Karachi and Multan (for potato), Bahawalpur, Hyderabad, Karachi and Sukkur (for tomato) and, Faisalabad, Karachi, Lahore and Sialkot (for onion). However, the log return prices of chicken have no time-varying volatility in most of the cities; it is clear from the ARCH LM test that chicken prices have short term time-varying volatility only in six cities out of fourteen cities namely; Faisalabad, Khuzdar, Lahore, Sargodha, Sialkot and Sukkur. This further highlights the presence of heterogeneity across cities in Pakistan – validating the argument that volatility should be measured across cities.

Finally, based on of ARCH-LM test study identified those log return price series which have ARCH effect. This further confirms the use of GARCH (1,1) and IGARCH (1,1)[7] methodology for measuring the volatility in the prices of selected food commodities.

1. Results of GARCH (1,1) Model

This section presents the results of GARCH (1,1) model estimated for the log return price series for the period 2002-2016 of sixteen food commodities in fourteen cities of Pakistan. To make the analysis easy, the study distributes the sixteen food commodities into five different groups.[8]

Table 2 reveals the results of Meat group, for beef, the ARCH and GARCH coefficients are significant in most of the cities showing the existence of time-varying volatility in log return prices. The volatility is responded strongly by residual effects and also due to the existence of past variance in return prices, showing that the volatility is persistent and takes long time to come to an end. On the other hand, for chicken prices, only ARCH coefficient is significant explaining volatility in chicken prices is due to residual effects. Residual effects might be because of the successive changes in the supply and demand for meat during the period under consideration. Increase in the

[6] Results will provide on request.

[7] I GARCH (1,1) Methodology is applied in those cases where GARCH (1,1) model is not satisfied.

[8] 1. Meat group: beef and chicken, 2. Cereal and Pulses group: Pulse Mash, Pulse Masoor, Pulse Moong, Rice IRI and Wheat, 3.Vegetable group: Tomato, Potato, Onion, Ginger, Garlic, 4. Dairy: Milk and Egg, 5. Sugar and Tea.

TABLE 1

ARCH- LM TEST

City	P-Value							
	Beef	Chicken	Pulse Mash	Pulse Masoor	Pulse Moong	Rice IRI	Wheat	Tomato
Bahawalpur	0.0034	0.9*	0.012	0	0	0.0004	0	0.2*
Faisalabad	0.0001	0.0009	0.0075	0	0.024	0.0001	0.001	0.006
Hyderabad	0.0088	0.07*	0	0	0	0.0007	0.03	0.8*
Islamabad	0.0075	0.169*	0.4492*	0	0.0011	0	0.0007	0
Karachi	0	0.78*	0.02	0.0012	0.005	0.0003	0	0.38*
Khuzdar	0	0.0004	0.0002	0	0.7*	0	0	0.6
Lahore	0.0002	0	0	0.0001	0	0.002	0	0.0001
Multan	0	0.34*	0	0	0	0	0.017	0.0017
Peshawar	0.003	0.4*	0.012	0.0014	0	0.0001	0	0.03
Quetta	0	0.405*	0	0.0355	0.0003	0	0	0
Rawalpindi	0.0001	0.24*	0.002	0.02	0.0001	0.0001	0	0
Sargodha	0.0034	0	0.0125	0.0159	0.0001	0.024	0.0004	0.0005
Sialkot	0.0004	0	0.001	0	0	0	0	0.04
Sukkur	0.0093	0	0	0.8*	0.0015	0.0121	0.013	0.6*
City	Potato	Onion	Garlic	Ginger	Milk	Egg	Sugar	Tea
Bahawalpur	0	0	0.015	0	0.006	0.003	0.0001	0
Faisalabad	0.02	0.35*	0	0.014	0	0.0076	0.0002	0.012
Hyderabad	0	0	0	0.0001	0.0069	0.0008	0.0003	0.004
Islamabad	0.0001	0	0	0	0	0.0008	0.0002	0.0007
Karachi	0.345*	0.17*	0.0004	0	0	0.04	0.0004	0.0023
Khuzdar	0.03	0	0.0003	0.0003	0	0.169*	0.02	0.03
Lahore	0.02	0.7*	0	0.0002	0	0.0002	0.01	0.0062
Multan	0.33*	0.0004	0	0.0014	0.0017	0.0004	0	0.016
Peshawar	0.0002	0	0.013	0.0001	0	0.96*	0.02	0
Quetta	0.008	0	0.02	0.0007	0.17*	0.003	0.0005	0.018
Rawalpindi	0.0004	0	0	0	0	0.0002	0.0001	0.002
Sargodha	0	0	0	0.0001	0	0.004	0.02	0.006
Sialkot	0.0018	0.65*	0	0.0001	0	0.0037	0.0014	0.0012
Sukkur	0	0.017	0.015	0.0011	0.0002	0.018	0	0.02

Source: Authors' estimation.*p-values are greater than 0.05 showing acceptance of null hypotheses means volatility is not time varying and so on.

TABLE 2

GARCH (1,1) Results for Meat Group

City	Beef			Chicken		
	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur	0.17*	0.76*	0.95			
Faisalabad	0.70*	0.11	0.82	0.33**	0.04	0.37
Hyderabad	0.13**	0.78*	0.91			
Islamabad	0.24*	0.66*	0.91			
Karachi	2.044*	0.11**	2.15			
Khuzdar	0.48*	0.31*	0.8	0.62*	0.12	0.74
Lahore	0.81*	0.29*	1.21	0.19**	0.06	0.25
Multan	0.23**	0.42*	0.66			
Peshawar	0.16*	0.83*	1			
Quetta	0.56*	0.25*	0.82			
Rawalpindi	0.18*	0.77*	0.96			
Sargodha	0.18	-0.09	0.09	0.44**	0.06	0.49
Sialkot	0.2	-0.08	0.12	0.44**	0.18	0.62
Sukkur	0.12*	0.81*	0.94	0.25**	0.44	0.69

Source: Authors' estimation. *, **represents significant at 1% and 5% respectively.

price of animal feed may also be the reason for the increase in chicken prices products. The cities where conditions of GARCH model are not satisfied, for instance where the sum of both coefficients is greater than 1[9] and GARCH coefficient is negative,[10] IGARCH model is used which fulfill its necessary condition, i.e., $\alpha + \beta = 1$, showing that the shocks have a permanent impact on the volatility in prices for these cities. Results are shown in Table A-2 (Appendix).

Table 3 and 4 demonstrate the results of Cereal and Pulses group. The ARCH coefficient is significant for all the commodities included in this group for each city except for rice in Karachi and Rawalpindi. The significant ARCH coefficient points out that the short run time-varying volatility in this group is highly influenced by residual effects which may be because of the excess supply in some period while a shortage of supply in the subsequent period. These successive periods of excess and shortages in food supply depend on the harvest of crops, which in turn depends on weather conditions. Ismail, et al. (2017) though in their study, highlighted that the prices of urea significantly affect

[9] Karachi, Lahore, Peshawar (beef)

[10] Sargodha and Sialkot(beef)

TABLE 3

GARCH (1,1) Results for Cereal and Pulses Group

City	Pulse Mash			Pulse Masoor		
	ARCH CO-EFFICIENT (α)	GARCH CO-EFFICENT (β)	α + β	ARCH COEF-FICIENT (α)	GARCH CO-EFFICENT (β)	α + β
Bahawalpur	0.48*	0.28	0.76	0.06**	0.82*	0.88
Faisalabad	0.19*	0.71*	0.9	0.21*	0.47*	0.69
Hyderabad	0.92*	0.18**	1	0.39*	0.70*	1.09
Islamabad				0.889*	-0	0.88
Karachi	0.37*	0.40*	0.77	0.38*	0.70*	1.08
Khuzdar	0.29**	0.24	0.53	0.40*	0.32**	0.72
Lahore	0.37**	0.34	0.72	0.23*	0.68*	0.91
Multan	0.52*	0.03	0.55	0.93*	0.09	1.02
Peshawar	0.11**	0.63*	0.74	0.33**	0.30**	0.64
Quetta	2.65*	-0.008	2.65	0.13**	0.81**	0.95
Rawalpindi	0.41*	0.62*	1.03	0.41*	0.29	0.7
Sargodha	0.18**	0.44	0.62	0.37*	0.63*	1
Sialkot	0.82*	0.27*	1.09	0.28*	0.65*	0.94
Sukkur	0.41**	0.17	0.58			
City	Pulse Moong			Rice IRI		
Bahawalpur	0.24**	0.56*	0.8	0.14*	0.79*	0.93
Faisalabad	0.41*	0.60*	1.01	0.16*	0.69*	0.85
Hyderabad	0.58*	0.19	0.78	0.31*	0.50*	0.81
Islamabad	0.34*	0.56*	0.9	0.62**	0.31*	0.93
Karachi	0.26*	0.52*	0.78	0.2	-0.04	0.24
Khuzdar				0.04*	0.89*	0.93
Lahore	0.08*	0.81*	0.89	0.68*	0.27*	0.95
Multan	0.25*	0.64*	0.89	0.39*	0.01	0.4
Peshawar	0.28*	0.57*	0.85	0.31*	0.65*	0.96
Quetta	0.61*	0.37*	0.98	0.24**	0.31**	0.55
Rawalpindi	0.61*	0.02	0.63	0.22	-0.03	0.25
Sargodha	0.63*	0.18	1.18	0.31*	0.55*	0.86
Sialkot	0.67*	0.21	0.87	0.48*	0.45*	0.93
Sukkur	0.30**	0.48*	0.79	0.56*	0.40*	0.96

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

TABLE 4

GARCH (1,1) Results for Cereal and Pulses Group

City	Wheat		
	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur	0.40*	0.01	0.41
Faisalabad	0.20*	0.56*	0.77
Hyderabad	0.38*	0.54*	0.92
Islamabad	0.28*	0.51*	0.79
Karachi	0.51*	0.43*	0.94
Khuzdar	0.60*	0.12	0.71
Lahore	0.53*	0.1	0.62
Multan	0.13*	0.68*	0.82
Peshawar	0.17*	0.70*	0.87
Quetta	0.29*	0.64*	0.94
Rawalpindi	0.15*	0.60**	0.75
Sargodha	0.34**	0.42**	0.76
Sialkot	0.55*	0.40*	0.95
Sukkur	0.35**	0.55*	0.9

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

rice prices and also the depreciation of rupee impact wheat prices. The study also found that the volatility in the return prices of commodities in this group is persistent and due to the existence of past variance in the series with significant GARCH coefficient for most of the cities. However, GARCH coefficient is insignificant for Pulse Mash (Bahawalpur, Khuzdar, Lahore, Multan, Sargodha and Sukkur) for Pulse Masoor (Multan and Rawalpindi), for Pulse Moong (Hyderabad, Rawalpindi, Sargodha and Sialkot) and for Wheat (Bahawalpur, Khuzdar and Lahore), showing current volatility does not depend on its lagged volatility. Table 3 and 4 depict that in few cases, the conditions of GARCH model are violated with negative GARCH coefficient[11] and the sum of both ARCH and GARCH coefficients is equal or greater than 1.[12] In these cases the study uses IGARCH (1,1) model. IGARCH (1,1) model satisfy all the conditions and exhibit constant impact of shocks on volatility - results are reported in Table A-2 (Appendix).

[11] For commodities: Mash, Masoor and Rice in the cities, (Quetta), (Islamabad) and (Karachi and Rawalpindi) respectively.

[12] In cities Hyderabad, Rawalpindi and Sialkot (Pulse Mash), Hyderabad, Karachi, Multan and Sargodha (Pulse Masoor), Faisalabad and Sargodha (Pulse Moong).

Table 5 and 6 demonstrate the results of vegetable group. Each commodity of the vegetable group has significant ARCH coefficient for every city. It indicates the presence of short term time-varying volatility in the log return price of each commodity with its responsive behavior towards shocks or residual effects as explained earlier, this might be because of the excess supply in some period while the shortage of supply in a subsequent period. For instance, an increase in the consumption of tomato, garlic and onion before and during the religious events like Eid-ul Azha, Moharram and Ramazan. In addition, heavy rains and floods, especially in Sindh damage the cultivation of these vegetables during the period of 2010-11. The results also reveal that the volatility in the log return prices of the commodities in this group is not dependent on its lagged volatility for the majority of cities. However, the log return prices of Tomato in Quetta and Sialkot, the log return prices of Potato in Bahawalpur, Hyderabad, Rawalpindi and Sialkot, log return prices of Onion in Rawalpindi and Sukkur, log return prices of Garlic in Faisalabad, Islamabad, Multan, Quetta, Sialkot and Sukkur and log return prices of Ginger in Bahawalpur, Hyderabad, Karachi, Khuzdar, Lahore, Peshawar and Quetta; volatility is due to both the presence of residual effects and past volatility, showing persistent behavior. The GARCH (1,1) model is satisfied in all the above cities because the coefficients are less than 1 and positive. IGARCH (1,1) model is applied where the sum of both coefficients is greater than 1.[13] Results are shown in Table A-2 (Appendix).

Table 7 illustrates the results of milk and egg. ARCH coefficient is significant for milk and egg in most of the cities. However, insignificant for cities: Bahawalpur and Multan (Milk) and Sukkur (Egg). The significant ARCH coefficient is an evidence of the significant influence of residual effects on volatility. It might be due to the shortage of supply in some period and excess supply in subsequent periods. For instance, government policies, expensive poultry feed and seasonal changes cause volatility in the prices of milk and egg. As in winters, the demand for eggs rises. Ismail, et al. (2017) highlighted that poultry prices are affected by interest rate. The GARCH coefficient is not significant in most of the cities showing that the volatility is not due to previous volatility. IGARCH model is applied where the sum of both coefficients is equal to or greater than 1[14] and in cases where ARCH coefficient is insignificant.

Table 8 depicts the results of Sugar and Tea. ARCH coefficient is significant for sugar and tea in all cities, showing the presence of fluctuations in the volatility with the passage of time in the short run mainly due to residual effects. For sugar, the residual effects might be government policies or high crude oil prices (used in processing). According to Ismail, et al. (2017) urea prices influenced the sugar prices. Similarly, the residual effects for tea might be the change in the import cost of tea. GARCH coefficient is insignificant for most of the cities for sugar exhibiting that the volatility is

[13] GARCH model is not satisfied in Rawalpindi (Onion), Islamabad (Garlic) and Islamabad and Sargodha (Ginger) as the sum of both coefficients is greater than 1.

[14] Faisalabad and Peshawar (Milk), Karachi, Rawalpindi, Sukkur and Lahore (Egg).

TABLE 5

GARCH (1,1) Results for Vegetable Group

City	Tomato			Potato		
	ARCH CO-EFFICIENT (α)	GARCH CO-EFFICENT (β)	α + β	ARCH CO-EFFICIENT (α)	GARCH CO-EFFICENT (β)	α + β
Bahawalpur				0.66*	0.27**	0.93
Faisalabad	0.28**	0.24	0.52	0.38*	0.22	0.6
Hyderabad				0.30*	0.37**	0.67
Islamabad	0.50*	0.02	0.53	0.44**	0.05	0.49
Karachi						
Khuzdar				0.26**	0.31	0.57
Lahore	0.33**	0.18	0.52	0.29*	0.05	0.34
Multan	0.57**	0.2	0.77			
Peshawar	0.47*	0.01	0.48	0.33**	0.37	0.7
Quetta	0.27**	0.59*	0.86	0.37**	0.3	0.67
Rawalpindi	0.20**	0.18	0.38	0.23*	0.47*	0.69
Sargodha	0.45**	0.18	0.63	0.28*	0	0.28
Sialkot	0.56*	0.38*	0.93	0.36**	0.41**	0.77
Sukkur				0.40**	0.17	0.57
City	Onion			Garlic		
Bahawalpur	0.35*	0.07	0.41	0.47**	0.12	0.59
Faisalabad				0.13**	0.53*	0.66
Hyderabad	0.46*	0.1	0.56	0.41**	0.16	0.58
Islamabad	0.58*	0.07	0.65	1.09*	0.39*	1.4
Karachi				0.27*	0.177	0.45
Khuzdar	0.19*	0.22	0.42	0.50*	0.01	0.5
Lahore				0.27*	0.08	0.34
Multan	0.29**	0.23	0.52	0.60*	0.27*	0.87
Peshawar	0.40**	0.19	0.59	0.43*	0.05	0.48
Quetta	0.20**	0.25	0.45	0.34**	0.44**	0.78
Rawalpindi	0.52**	0.56*	1.09	0.37**	0.24	0.61
Sargodha	0.21*	0.38	0.59	0.27**	0.11	0.38
Sialkot				0.60*	0.36**	0.96
Sukkur	0.14**	0.82*	0.96	0.24**	0.46**	0.7

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

TABLE 6

GARCH (1,1) Results for Vegetable Group

City	Ginger		
	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	$\alpha + \beta$
Bahawalpur	0.06*	0.85*	0.91
Faisalabad	0.46*	0.2	0.66
Hyderabad	0.33*	0.41*	0.74
Islamabad	0.92*	0.13	1.06
Karachi	0.32*	0.30*	0.63
Khuzdar	0.30*	0.57*	0.86
Lahore	0.27*	0.68*	0.95
Multan	0.25**	0.38	0.63
Peshawar	0.25**	0.55*	0.81
Quetta	0.46*	0.34**	0.79
Rawalpindi	0.52*	0.06	0.59
Sargodha	1.23*	0.23	1.46
Sialkot	0.33**	0.32	0.65
Sukkur	0.79*	0.12	0.9

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

not affected by previous volatility. However, significant for only three cities: Karachi, Quetta and Sialkot. GARCH coefficient is significant in all cities for tea prices, illustrates the volatility is also significantly influenced by past variance. For both commodities, IGARCH (1,1) model is applied where the sum of both ARCH and GARCH coefficient is equal to 1[15] or negative GARCH coefficient.[16] In these cases, IGARCH (1,1) model is the best fit and gives the best results see Table A-2 (Appendix).

2. Assessment based on Standard Deviation

The results of ARCH –LM test demonstrate that there are some food price series for various cities that have no ARCH effect. GARCH technique is not applicable for the series where ARCH effect is not present. Hence to identify the volatility for those series, this paper uses a simple standard deviation technique. Hence, this study also

[15] Islamabad, Quetta and Khuzdar (Tea).

[16] Islamabad (Sugar).

TABLE 7

GARCH (1,1) Results for Dairy Group

City	Milk			Egg		
	ARCH CO-EFFICIENT (α)	GARCH CO-EFFICENT (β)	α + β	ARCH CO-EFFICIENT (α)	GARCH CO-EFFICENT (β)	α + β
Bahawalpur	0.194	0.031	0.23	0.48*	0.2	0.68
Faisalabad	0.82*	0.29	1.11	0.53*	0.13	0.66
Hyderabad	0.62*	0.26**	0.88	0.38**	0.37	0.75
Islamabad	0.41*	0.06	0.47	0.59*	0.11	0.7
Karachi	0.23*	0.63*	0.86	0.08**	0.91*	0.99
Khuzdar	0.35**	0.01	0.36			
Lahore	0.11**	0.64*	0.75	0.99*	0.07	1.06
Multan	0.21	-0.05	0.15	0.54*	0.24	0.78
Peshawar	1.08*	0.25*	1.33			
Quetta	0.65**	0.16	0.82	0.63*	0.3*	0.94
Rawalpindi	0.44*	0.01	0.44	1.37*	0.01	1.39
Sargodha	0.40**	0.23	0.63	0.4*	0.23	0.63
Sialkot	0.17*	0.36*	0.53	0.35**	0.31	0.66
Sukkur	0.24*	0.59	0.84	0.4	0.93	1.33

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

makes a comparative analysis of volatilities across cities on the bases of standard deviation results as it is applicable to all series. It is illustrated from standard deviation results, reported in Table A-3 (Appendix) that during the period July 2002-June 2016 the volatility in beef prices is high in Sialkot and Sargodha as compare to other cities while for chicken it is high in Lahore. The volatility is high in Karachi and Sukkur (for Pulse Mash), Islamabad (for Pulse Masoor), Karachi, Multan and Sargodha (for Pulse Moong), Bahawalpur and Rawalpindi (for Rice IRI) and Bahawalpur (for Wheat). For the vegetable group it is seen that food price volatility is high in Sargodha (for tomato), Hyderabad, Sialkot (for Potato), Khuzdar, Rawalpindi and Sargodha (for Onion), Sargodha, Islamabad (for garlic) and Sargodha (for ginger). The volatility is high in Sargodha and Faisalabad (for Milk) and Rawalpindi (for Egg). For sugar, the volatility is high in Islamabad while almost the same in other cities. Price volatility in tea prices is high in Peshawar otherwise the same in remaining cities. The heterogeneous nature of food price volatility across cities is mainly because the cities differ in terms of population and physical structure, weather conditions and have different consumption pattern - affecting demand and supply of staple food. However, Ghauri, et

TABLE 8

GARCH (1,1) Results for Sugar and Tea

City	Sugar			Tea		
	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Bahawalpur	0.39**	0.22	0.61	0.27*	0.66*	0.93
Faisalabad	0.32**	0.37	0.69	0.16*	0.73*	0.89
Hyderabad	0.42*	0.29	0.72	0.29*	0.61*	0.89
Islamabad	0.18	-0.1	0.08	0.52*	0.48*	1
Karachi	0.22*	0.61*	0.83	0.26*	0.66*	0.92
Khuzdar	0.42**	0.33	0.75	0.26*	0.74*	1
Lahore	0.24**	0.39	0.63	0.29*	0.69*	0.98
Multan	0.68*	0.2	0.87	0.26*	0.71*	0.97
Peshawar	0.33**	0.27	0.6	0.31*	0.04	0.34
Quetta	0.12*	0.84*	0.96	0.25*	0.75*	1
Rawalpindi	0.37**	0.29	0.66	0.32*	0.63*	0.95
Sargodha	0.36**	0.3	0.66	0.20*	0.73*	0.93
Sialkot	0.16*	0.79*	0.95	0.29*	0.65*	0.95
Sukkur	0.47*	0.21	0.68	0.22*	0.73*	0.95

Source: Authors' estimation. *, ** represents significant at 1% and 5% respectively.

al. (2013) argued that distance between markets involves high transportation cost that can cause difference in volatility among cities.

V. Conclusions and Policy Implications

Given the Global food price shocks, this study aims to estimate the volatility in the prices of food commodities with the help of GARCH (1,1), I GARCH (1,1) and standard deviation techniques for fourteen major cities of Pakistan. This study also compares the volatility in food prices across different cities. For the purpose, monthly price data from July 2002 to June 2016 of sixteen major food commodities is employed. Results reveal that food prices in large cities are volatile. In most of the commodities for various cities, the volatility is because of the existence of past variance and residual effects. However, in a few commodities for different cities, the volatility is only due to residual effects. The results based on standard deviation also highlight cities with high volatility in selected commodities. The results elaborate that there exist strong heterogeneity among cities with a difference in the intensity of volatility.

The highly volatile nature of food prices points out towards policy formation keeping variation among commodities and heterogeneous effect of cities. For highly volatile food commodities government should develop a mechanism to keep check on the variation in prices. It is suggested that the government should design separate policies for each city according to the volatility in the prices of food commodities in that city. The government should create food reserves that can be released in periods of high prices. In the long term, government should increase agriculture sector investment that would improve the agricultural sector growth to meet the rising demand of the frequently growing population.

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APPENDICES

TABLE A-1

Units of Commodities

Commodity	Units
Beef	1 kg
Chicken	1 kg
Pulse Mash	1 kg
Pulse Masoor	1 kg
Pulse Moong	1 kg
Rice IRI	1 kg
Wheat	1 kg
Garlic	1 kg
Ginger	1 kg
Potato	1 kg
Onion	1 kg
Tomato	1 kg
Milk	1 liter
Egg	1dozen
Sugar	1 kg
Tea (Lipton Yellow Label)	200 gm.

Source: Pakistan Bureau of Statistics.

TABLE A-2

I GARCH (1,1) Results

CITY	ARCH COEFFICIENT (α)	GARCH COEFFICENT (β)	α + β
Beef			
Karachi	0.06*	0.94*	1
Lahore	0.26*	0.74*	1
Sargodha	0.25**	0.75*	1
Sialkot	0.97*	0.03*	1
Peshawar	0.15*	0.85*	1
Pulse Masoor			
Hyderabad	0.16*	0.84*	1
Islamabad	0.45*	0.55*	1
Karachi	0.21*	0.79*	0.999
Multan	0.09*	0.91*	1
Sargodha	0.07*	0.93*	1
Pulse Mash			
Hyderabad	0.37*	0.63*	1
Rawalpindi	0.25*	0.75*	1
Sialkot	0.05*	0.95*	1
Quetta	0.53*	0.47*	1
Pulse Moong			
Faisalabad	0.18*	0.82*	1
Sargodha	0.07*	0.93*	1
Rice IRI			
Karachi	0.09*	0.91*	1
Rawalpindi	0.08*	0.92*	1
Onion			
Rawalpindi	0.18*	0.82*	1
Garlic			
Islamabad	0.24*	0.76*	1
Ginger			
Islamabad	0.28*	0.72*	1
Sargodha	0.09*	0.91*	1
Milk			
Bahawalpur	0.05*	0.95*	1
Faisalabad	0.47*	0.53*	1
Multan	0.04*	0.96*	1
Peshawar	0.08*	0.92*	1
Egg			
Karachi	0.07*	0.93*	1
Lahore	0.10*	0.90*	1
Rawalpindi	0.09*	0.91*	1
Sukkur	0.06*	0.94*	1
Sugar			
Islamabad	0.08*	0.92*	1
Tea			
Islamabad	0.06*	0.94*	1
Khuzdar	0.18*	0.82*	1
Quetta	0.18*	0.82*	1

Source: Authors' estimations. *, ** represents significant at 1% and 5% respectively.

TABLE A-3

Standard Deviation Results

City	Beef	Chicken	Pulse Mash	Pulse Masoor	Pulse Moong	Rice IRI	Wheat	Tomato	Potato	Onion	Garlic	Ginger	Milk	Egg	Sugar	Tea
Bahawalpur	0.032	0.146	0.065	0.166	0.063	0.208	0.188	0.487	0.252	0.265	0.155	0.332	0.022	0.172	0.088	0.036
Faisalabad	0.141	0.169	0.156	0.119	0.137	0.123	0.123	0.43	0.255	0.27	0.211	0.219	0.138	0.174	0.101	0.069
Hyderabad	0.138	0.154	0.17	0.138	0.132	0.123	0.117	0.486	0.286	0.284	0.161	0.223	0.112	0.18	0.103	0.069
Islamabad	0.122	0.161	0.149	0.208	0.126	0.094	0.118	0.341	0.164	0.213	0.22	0.193	0.114	0.17	0.51	0.074
Karachi	0.135	0.181	0.174	0.14	0.142	0.523	0.112	0.492	0.184	0.276	0.185	0.234	0.119	0.195	0.112	0.069
Khuzdar	0.144	0.128	0.162	0.118	0.135	0.122	0.118	0.453	0.18	0.372	0.169	0.149	0.115	0.169	0.101	0.072
Lahore	0.133	0.257	0.127	0.111	0.135	0.082	0.126	0.407	0.23	0.238	0.206	0.214	0.127	0.191	0.097	0.069
Multan	0.151	0.156	0.167	0.133	0.144	0.134	0.123	0.459	0.26	0.277	0.207	0.19	0.118	0.189	0.113	0.069
Peshawar	0.133	0.152	0.152	0.115	0.148	0.106	0.11	0.434	0.168	0.253	0.179	0.168	0.107	0.171	0.098	0.089
Quetta	0.135	0.139	0.279	0.12	0.124	0.117	0.108	0.388	0.16	0.227	0.209	0.152	0.113	0.152	0.107	0.07
Rawalpind	0.154	0.181	0.157	0.118	0.142	0.269	0.139	0.38	0.197	0.358	0.158	0.192	0.123	0.304	0.099	0.069
Sargodha	0.281	0.219	0.161	0.121	0.143	0.133	0.121	0.502	0.275	0.31	0.215	0.418	0.142	0.205	0.103	0.071
Sialkot	0.281	0.169	0.148	0.112	0.12	0.111	0.115	0.435	0.262	0.258	0.172	0.186	0.109	0.17	0.099	0.069
Sukkur	0.121	0.148	0.171	0.128	0.152	0.13	0.121	0.449	0.204	0.262	0.184	0.298	0.1	0.184	0.108	0.07

Source: Authors' estimations. *, ** represents significant at 1% and 5% respectively.