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Price Volatility of Food and Agricultural Commodities: A Case Study of Pakistan

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Rapid price increase in food/agricultural commodities has gained attention after the “Price Spike” in 2007-2008. Again the same trend was observed in 2010 due to which it increases concern about the volatility in commodity prices. This study aims to investigate the factor affecting volatility of selected food and agricultural commodities. Monthly data from April 1983 to April 2013 is taken for analysis. GARCH (1, 1), GJR (1, 1) and EGARCH (1, 1) models are estimated for all the variables using normal and Student-t distribution. The results conclude that the mean and the volatility effect of exchange rate and interest rate are transmitted across all the selected commodities. Volatility in the price of fertilizer is only transmitted on the volatility of sunflower oil. Later, analysis shows that past price has significant impact on current prices for all the commodities except for soybean oil, sunflower oil and cotton.

Key words: Food and agricultural commodities, Price volatility, Exchange rate, interest rate, fertilizer, GARCH models

JEL: Q22, Q110, C220

1. Introduction

The prices of major food and agricultural commodities have risen dramatically since the end of 2006 to middle of 2008 both internationally and domestically. These prices of food and agricultural commodities were characterized by price volatility and presented serious challenges to market participants such as consumer, producers and investors. They have affected growth at the macroeconomic level of the

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developing countries more than developed economies. (Aizenman & Marion, 1993; Ramey & Ramey, 1995). Moreover, the large food and agricultural commodity price swings has negative effect on balance of payments, imports and exports, government budget, inflation, and poverty (Roache, 2010).

The observed variability in global food and agriculture commodity prices over the period 2006-2009, comprising the 2006-2008 price spike has revived the debate about the causes and consequences of such sharp and pronounced price variations. In a number of studies, economists such as Abbot *et al.* (2008), Mitchell (2008), Cooke and Robles (2009) and Gilbert and Morgan (2010a) have discussed the factors behind the global ‘price spike’ of 2008. These involved changes in supply and demand factors. On the demand side, the fast economic growth in Asian economies and particularly in China was emphasized. On the supply side, the underinvestment in agriculture as well as low commodity inventory levels of recent years were mentioned as contributory factors. Other macroeconomic and financial factors were considered to influence food and agricultural commodity price volatility includes: changes in oil prices, changes in the world money supply, and changes in the value of the dollar. Other factors which were also quoted include climate change, trade policies, the feedback between price expectation and market responses and speculation in futures and options trading in food and agriculture commodity markets (Mitchell, 2008; Cooke & Robles, 2009; Gilbert & Morgan, 2010a).

In case of Pakistan, food and agricultural price index have shown volatility during the period of 2006-2008 and the price of almost every food and agricultural commodity has risen to a historical high over the past few years (Hye, Malik, & Mashkoor, 2010; Hye & Siddiqui, 2010). The prices of the main food staples like wheat, maize and rice have increased sharply. The prices of meat, fruits, vegetables, oils and ghee also have risen sharply with a double increase in the prices of butter and milk (Hye & Siddiqui, 2010). According to FAO-OECD (2011), volatility in food and agriculture commodity prices in developing countries like Pakistan are caused by high energy costs, high oil prices and weather conditions. Other factors like exchange rates, interest rates and fertilizer prices are also considered for causing fluctuations in food and agricultural commodity prices (Mushtaq et al. 2011 and Hye et al., 2010).

This paper focuses on sources of food and agriculture commodity price volatility in Pakistan. It investigates whether the key macroeconomic factors can explain variations of the shocks that drive the evolution of food and agriculture commodity prices by using GARCH models.

The structure of the paper is as follows: Section 2 presents the empirical review. Section 3 presents model specification and methodology. Section 4 shows data and preliminary analysis. Section 5 reports estimated GARCH models. Section 6 provides a conclusion.

2. Empirical Review

In empirical literature, many studies have discussed sources of food and agricultural commodity price volatility.

Increase in agricultural input prices, namely fertilizer and crude oil increases the expenditures of producers, which ultimately raises the prices of agricultural outputs (Herrmann, 2009). High cost of domestic food production is due to the high cost of inputs, especially fertilizer and transportation cost. It will shift a large number of farmers with high potential agricultural crops to high global food prices that generate more revenue. Due to which the necessary food and agricultural items will be ignored and producers will only harvest the crops that generate maximum revenue. Baffes (2007) have found significant effect of crude oil or diesel on agricultural commodities. Balcombe and Rapsomanikis (2008) have found significant transmission of the volatility of oil and fertilizer prices to agriculture commodities. Abbott et al., (2008) have found set of macroeconomic factors including petroleum prices, exchange rate variations, and aggregate demand measured by the GDP and trade of a country, that causes all food prices to change together in the same general pattern. Harri and Hudson (2009), Gardebroek and Hernandez (2012) and Trujillo-Barrera et al. (2012) have found the impact of oil prices on corn. Onour and Sergi (2011), Du et al. (2011) and Nazliogluet et al. (2012) have found a price transmission between oil and corn and oil and wheat. OECD (2009) reports have indicated a strong association between oil price volatility and price volatility of agriculture commodity markets. Hatchet-Bourdon (2011) has observed a correlation between crude oil price volatility and agriculture commodity market price volatility. Han & Nayga (2012) has analyzed the association between the volatilities of grain and oil prices.

Balcombe (2009) has considered volatility in exchange rate as an important factor that causes volatility in agricultural prices. All the commodities that are internationally traded, including agricultural commodities and food items are influenced by the exchange rate. Devaluation of the local currency with respect to the currency of trading partner affects prices at which commodities are sold and eventually influences the profits of the producer. Volatility in exchange rate affects the prices and ultimately decreases the returns. Mushtaq *et al.* (2011) have shown the existence of a long run effect of exchange rates on wheat prices. Frank & Garcia (2010) have concluded that the agricultural commodity markets are more dependent on exchange rate volatility and crude oil price volatility. Ott (2010) has found that volatility in exchange rates and crude oil prices causes volatility in agricultural commodity prices. Similar analysis has done by Campiche *et al.* (2007) and Yu, Bessler and Fuller (2006) for corn, sorghum, palm oil, vegetable oil, sugar and soybean. They have concluded that shocks caused by volatility in exchange rates affect the prices of some commodities more than the other.

Calvo (2008) has found that agricultural commodity prices are affected by a small change in interest rates that played a significant role during the price boom in 2006-2008. Frankel (2006) has argued that high real interest rates are the cause of high real commodity prices. He has concluded that there was considerable impact of monetary policy on commodity prices. Interest rates can affect food prices, particularly if market players anticipate interest rate volatility to continue (Frankel, 2006). Roache (2010) has indicated the factors that cause low frequency volatility in spot prices of food commodities includes the interest rate with other factors. Miguez and Michelena (2011) have analyzed the key aspect like inflation, inventories, exchange rates, interest rate, income growth, weather and speculations affect the agriculture commodity price volatility.

3. Model Specification and Methodology

In order to study sources of food and agriculture commodity price volatility in Pakistan, the family of GARCH models is used. These are GARCH models are specified as follows:
Mean equation

$$\mathrm{r}_t = c + \sum_{p=1}^{l} \delta_p \mathrm{r}_{t-p} + \sum_{q=1}^{m} \gamma_q \varepsilon_{t-q} + \psi_1 u_{INT,t} + \psi_2 u_{U,t} + \psi_3 u_{EX,t} + \psi_4 u_{CROIL,t} + \varepsilon_t \quad (3.1)$$

Variance equations

GARCH (1, 1)

$$\sigma_t^2 = \omega_0 + \alpha_1 \varepsilon_{t-1}{}^2 + \beta_1 \sigma_{t-1} + \psi_1 u_{INT,t}^2 + \psi_2 u_{U,t}^2 + \psi_3 u_{EX,t}^2 + \psi_4 u_{CROIL,t}^2 \quad (3.2)$$

GJR-GARCH (1, 1)

$$\sigma_t^2 = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \gamma_1 \varepsilon_{t-1}^2 I_{[\varepsilon_{t-1}<0]} + \beta_1 \sigma_{t-1}^2 + \psi_1 u_{INT,t}^2 + \psi_2 u_{U,t}^2 + \psi_3 u_{EX,t}^2 + \psi_4 u_{CROIL,t}^2 \quad (3.3)$$

EGARCH (1, 1)

$$\log \sigma_t^2 = \omega_0 + \beta_1 \log \sigma_{t-1} + \alpha_1 [\theta \mathrm{V}_{t-1} + \gamma_1 \{|\mathrm{V}_{t-1}| - \mathrm{E}|\mathrm{V}_{t-1}|\}] + \psi_1 u_{INT,t}^2 + \psi_2 u_{U,t}^2 + \psi_3 u_{EX,t}^2 + \psi_4 u_{CROIL,t}^2 \quad 3.4)$$

Where r_t represents the price return series, $u_{INT,t}$, $u_{U,t}$, $u_{EX,t}$ and $u_{CROIL,t}$ are the residuals of interest rate, urea, exchange rate and crude oil respectively. Whereas, in variance equation residual squares of interest rate, urea, exchange rate and crude oil are represented by $u_{INT}^2, u_U^2, u_{EX}^2$ and u_{CROIL}^2 respectively.

This study used ARMA (p, q) model for the identification of the appropriate lag length for conditional mean and variance specifications. Maximum log likelihood estimation with standard error based on a least square process is employed. Gaussian and student “t” distribution is used to get the best fitted model. For the estimation of parameters BFGS-BOUNDS is applied. This method is efficient for unconstrained optimization as followed by Broyden (1970). BFGS converges for an optimum quadratic Taylor expansion. After finding appropriate lag length of the return series residuals and residual squares of all the series are saved. Secondly, the LM - ARCH test is applied to analyze the presence of ARCH effect in the residuals of each series. Set of diagnostic tests are applied to check the best fitted lag length for the GARCH models, based on the information criterion (Akaike criteria, Shibata criteria, Schwartz Bayesian criteria and Hannan-Quinn criteria), that is to be minimized. The best fitted ARMA model is the one for which GARCH model is converging towards the normal distribution. Q-statistics and Q^2-statistics of Ljung-Box-Pierce test is applied to check the correlation and the volatility clustering. Following Tse (2002) to observe conditional heteroskedasticity Residual Based Diagnostic (RBD) test is also applied. Conditional mean and conditional variance is also saved for the volatility modelling of the food and agricultural series under observation.

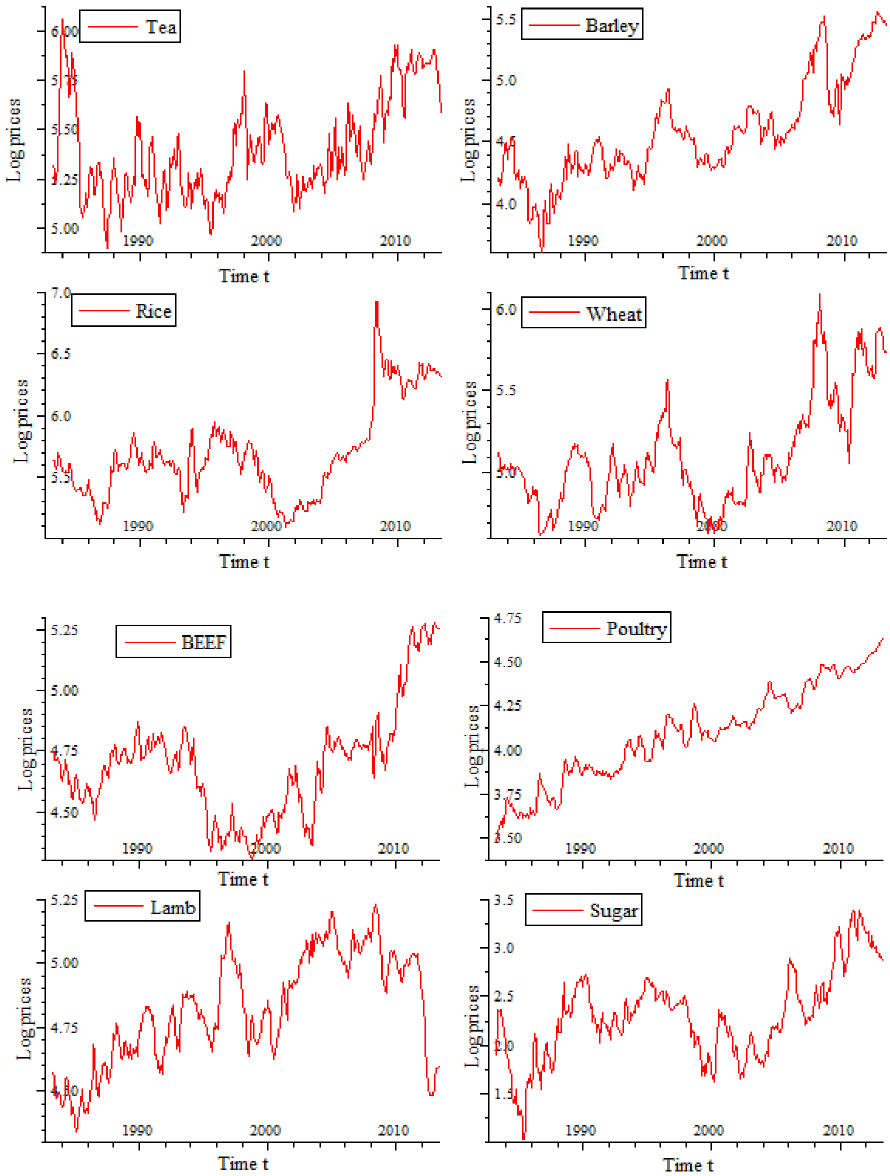
4. Data and Preliminary Analysis

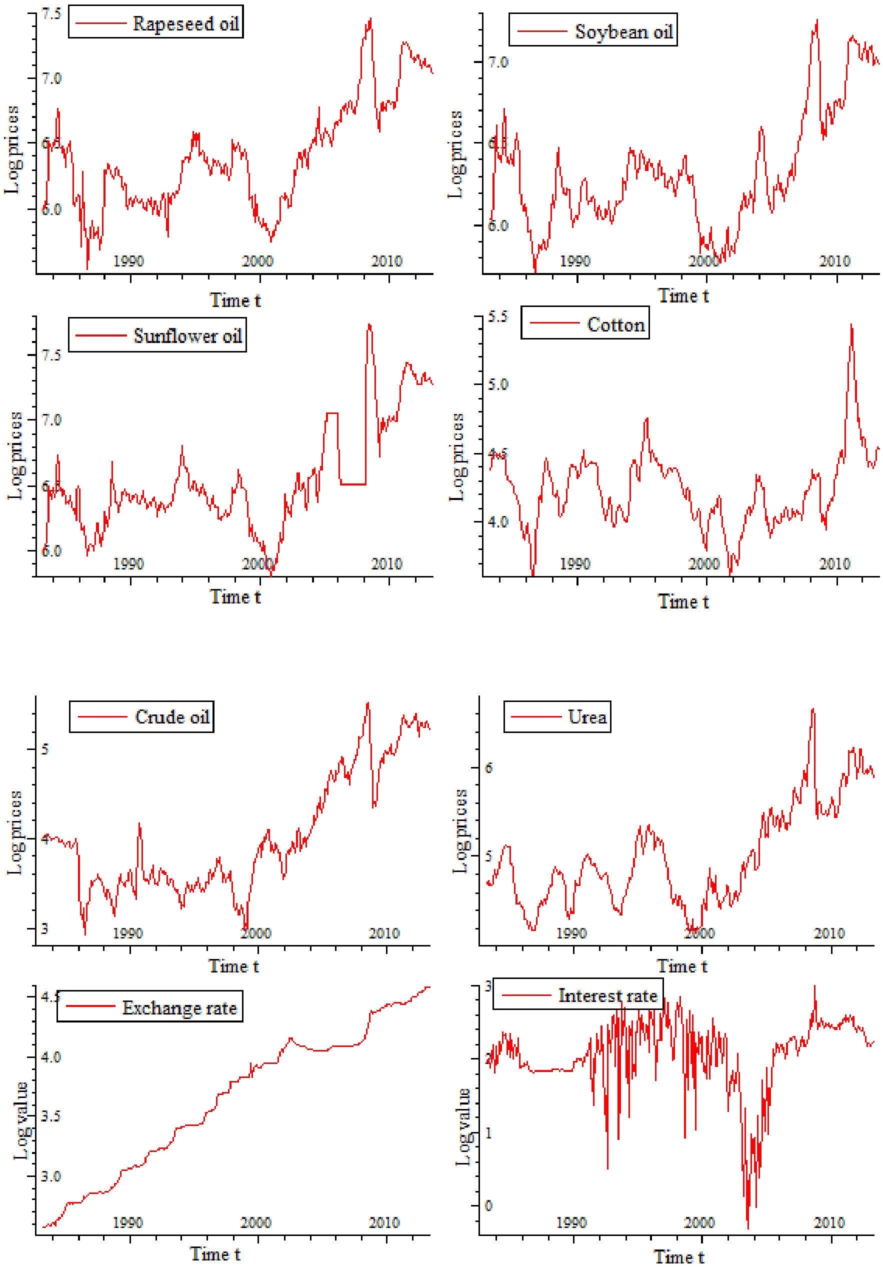
In this study monthly data from April 1983 till April 2013 of selected food and agricultural commodities for Pakistan is used for analysis. The data is taken from the IMF, World Bank, IFS and State Bank of Pakistan. Monthly data on all the commodities are measured in US dollar. Price data of tea, barley, rice, wheat, beef, poultry, lamb, sugar, rapeseed oil, soybean oil, sunflower oil and cotton are taken. Whereas, data on the price of crude oil, price of urea, exchange rate and interest rate is also considered to investigate sources of food and agricultural prices. For the analysis of the behavior of price series returns are calculated by taking the first difference of the logarithm of monthly prices for each commodity:

Figures 4.1 show plots of monthly price series of beef, lamb, poultry, rice, wheat, sugar, tea, rapeseed oil, soybean oil, sunflower oil, cotton, barley, crude oil, urea, exchange rate and interest rate. They reveal general upward trend for the selected period.

Figure 4.1: Monthly Price Series of Food and Agricultural Commodities and Key Factors

The Monthly price series at logarithmic level showing a general upward trend.

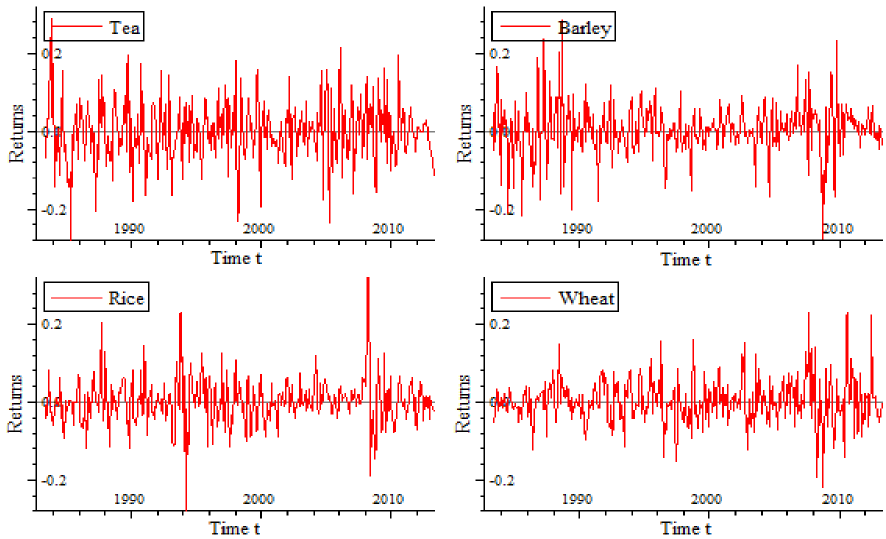


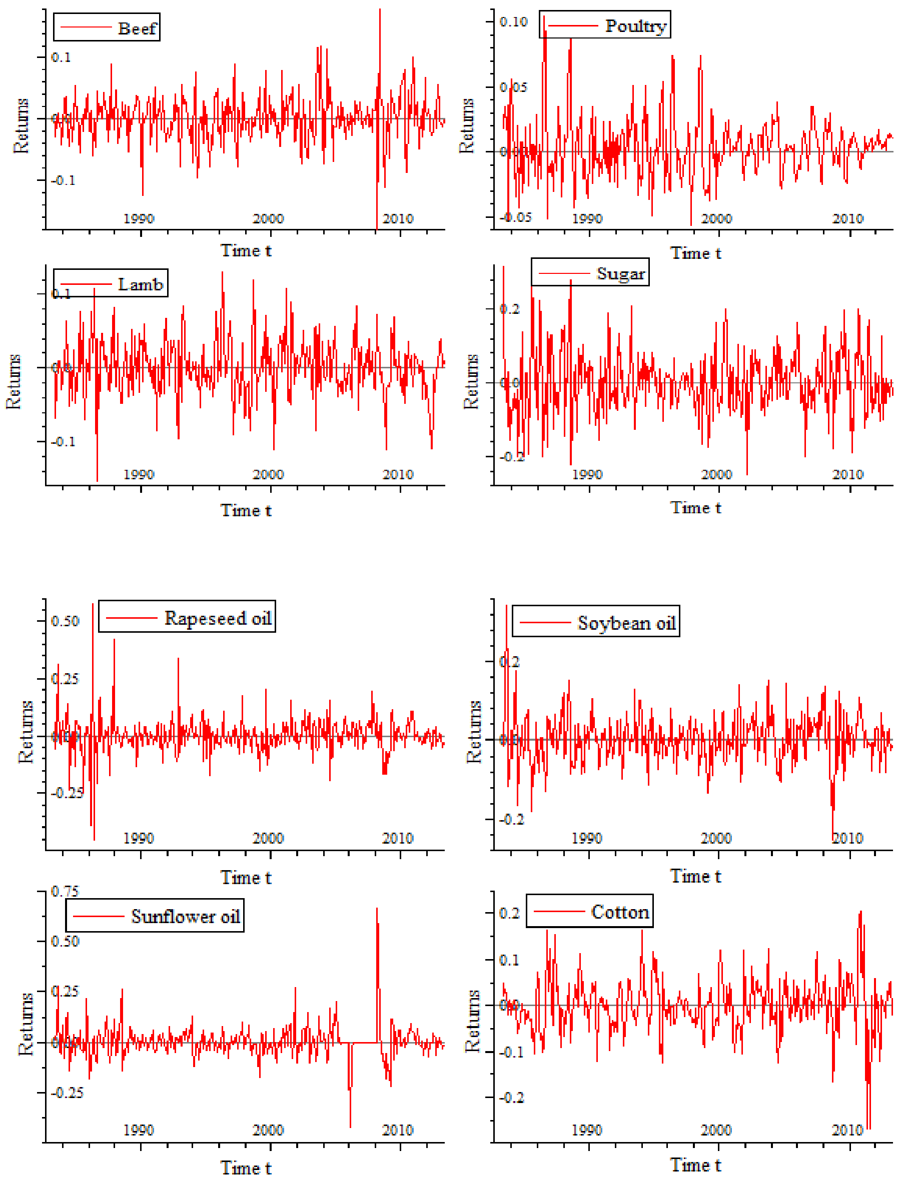


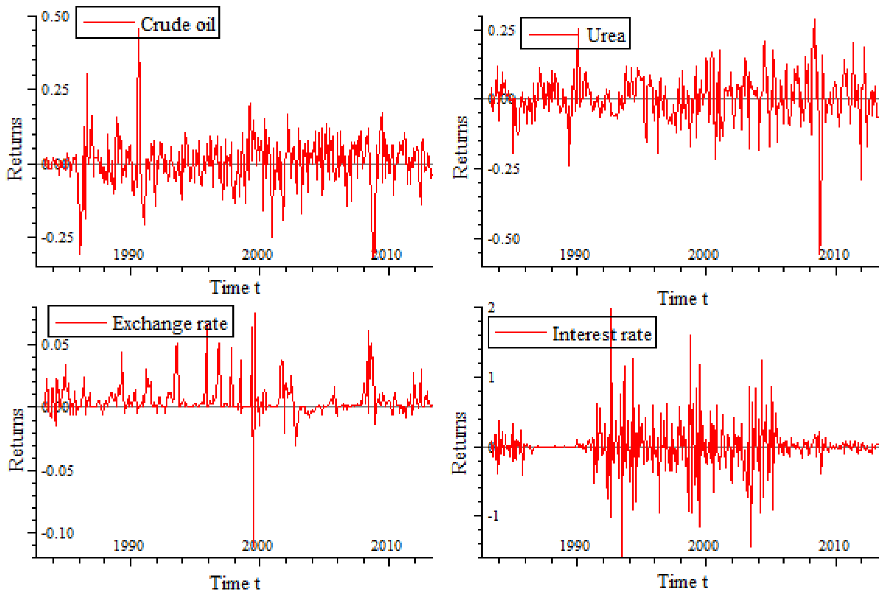
The plots of monthly return series are shown in figure 4.2. These clearly show the time varying volatility and do not show any fix pattern. All the return series shows high fluctuation and slowly return back to their means. It is clearly shown that the variance of a return series of prices is not fixed over time. The volatility clustering is exhibited in a return series showing periods of high and low volatilities, indicating ARCH effect.

Figure 4.2: Return Series of Food and Agricultural Commodities and Key Factors

The return series shows no definite pattern, and are reverting towards the mean. These exhibit volatility clustering.



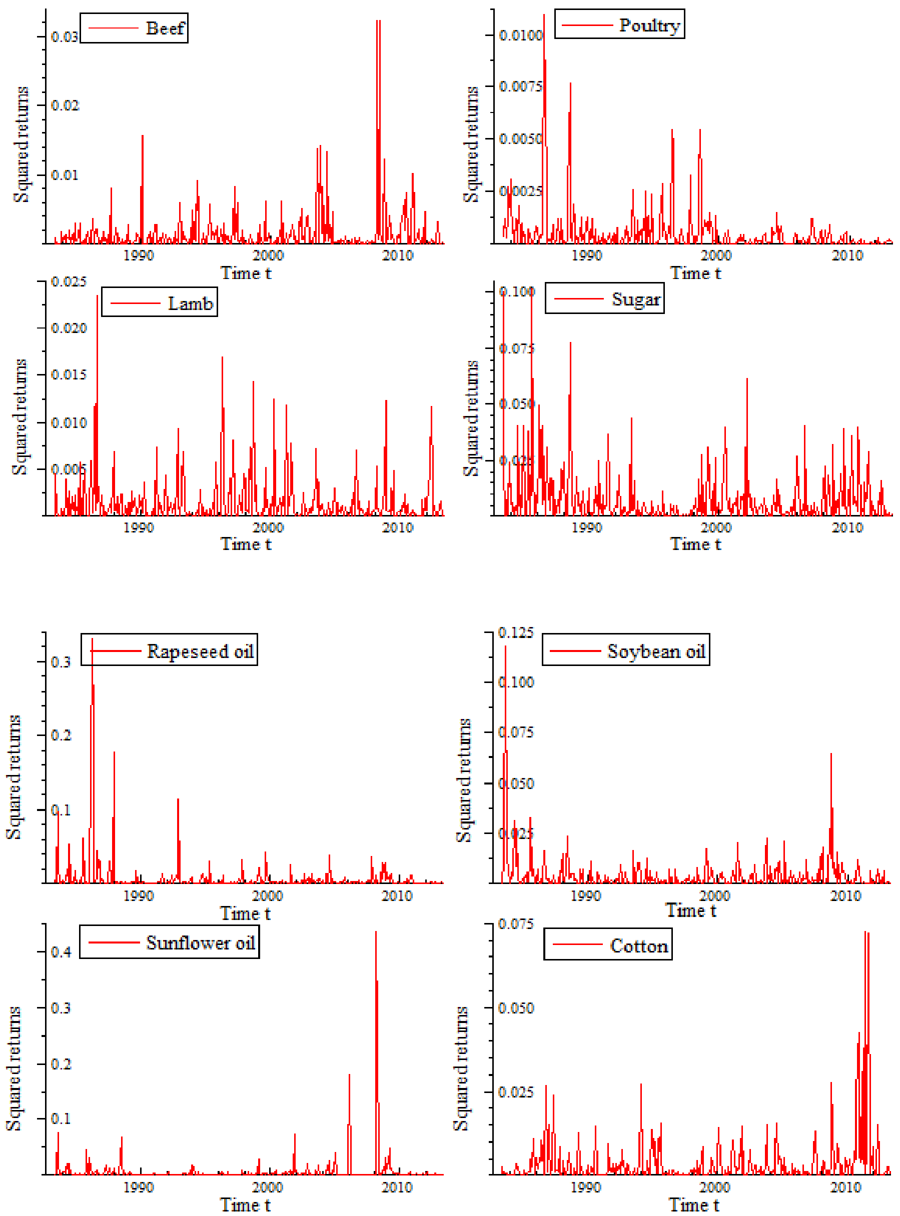

Beef
Poultry
Lamb
Sugar
Rapeseed oil
Soybean oil
Sunflower oil
Cotton
Returns
Time t
1990
2000
2010

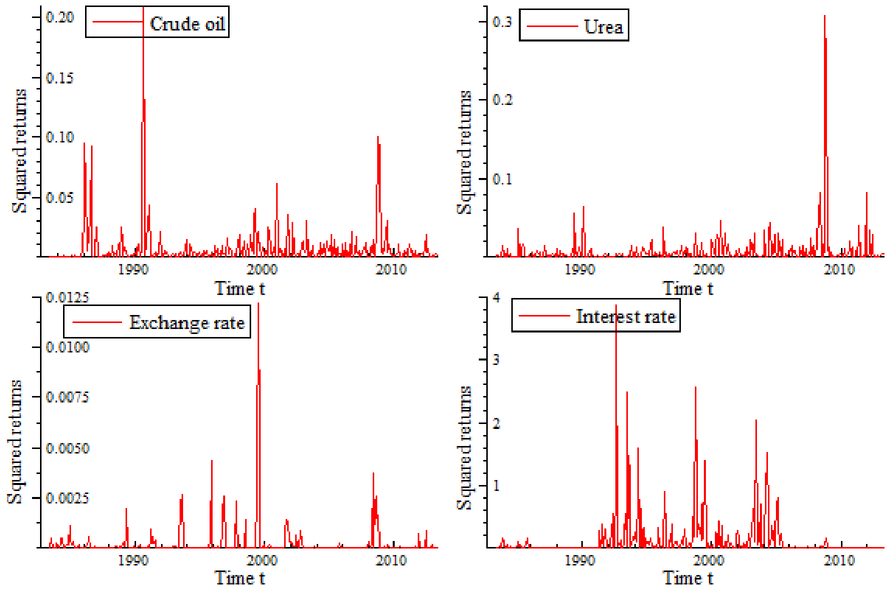


In figure 4.3, squared returns indicate variations in volatility. Brief periods of high volatility are more visible from the squared returns taken as a measure of volatility. Higher order serial correlation is observed through the plots of squared returns.

Figure 4.3: Squared Return Series of Food and Agricultural Commodities and Key Factors

The squared return series shows the periods of high and low volatility





Summary statistics of price return series (r_{it}) is shown in Table 4.2. All the series are characterized with excess kurtosis and skewness, which is the feature of high frequency data. A series is said to be normally distributed if the value of its skewness is close to zero. Rice, wheat, beef, poultry, sugar, rapeseed oil, soybean oil, sunflower oil, exchange rate and interest rate are positively skewed[5] and significant at 1% (see. Table 4.2). Whereas, tea, barley, lambs, cotton, crude oil and urea are negatively skewed[6] and statistically significant. Non normality of data distribution is clearly indicated for all the series. Secondly, the value of excess kurtosis[7] in Table 4.2 helps to analyze the peak of the return price series distribution. The series of rice, beef, rapeseed oil, sunflower oil, crude oil, urea, exchange rate and interest rate have indicated high kurtosis. Higher values of kurtosis indicate that the data distribution of these series is leptokurtic[8]. It also indicates that there is a high probability of having extreme values in the distribution. The high value

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[5] $Skewness = \frac{E[(y-u)^3]}{\sigma^3}$. When the value of skewness is positive and greater than zero, it is positively skewed with a tail longer at right end.

[6] Series with a longer tail on left side, with a value less than zero is defined as negatively skewed.

[7] $Excess\ Kurtosis = \frac{E[(y-u)^3]}{\sigma^3} - 3\ \ or\ Fisher\ Kurtosis$

$where, y\ indicates\ the\ observation\ with\ mean\ u\ and\ \sigma\ shows\ standar\ deviation$

[8] Leptokurtic is sharper than normal distribution with a heaver tail.

of the excess kurtosis further indicates that the data show a heavier tail than the normal distribution.

Table 4.2: Descriptive statistics for returns (r_t) of series

	Minimum	Mean	Maximum	Standard deviation	Skewness	Excess Kurtosis	Jurque-Bera
Tea	-0.2799	0.0007	0.2897	0.0783	-0.0186	0.9828	14.5100
Barley	-0.2742	0.0035	0.2832	0.0691	-0.1182	2.4806	93.1380
Rice	-0.2813	0.0019	0.41169	0.06239	1.20220	8.60850	1198.30000
Wheat	-0.21926	0.00170	0.22946	0.05868	0.41652	2.41980	98.23900
Beef	-0.17966	0.00141	0.17943	0.03707	0.03114	3.28900	162.32000
Poultry	-0.05707	0.00318	0.10461	0.02225	0.66366	2.17920	97.66100
Lamb	-0.15305	0.00008	0.13036	0.03807	-0.00314	1.20010	21.60400
Sugar	-0.24741	0.00270	0.31845	0.08796	0.27599	0.67892	11.48400
Rapeseed Oil	-0.45438	0.00287	0.57580	0.08355	0.63882	11.52600	2017.30000
Soybean Oil	-0.25344	0.00265	0.34303	0.06142	0.28698	2.94960	135.44000
Sunflower Oil	-0.42206	0.00358	0.66076	0.07941	2.14150	19.38700	5913.20000
Cotton	-0.26908	0.00040	0.20561	0.05829	-0.08248	2.89900	126.47000
Crude oil	-0.31678	0.00335	0.45803	0.08452	-0.13954	3.66900	203.09000
Urea	-0.55492	0.00328	0.28625	0.08797	-1.15920	7.11960	840.96000
Exchange Rate	-0.11032	0.00562	0.07488	0.01426	0.24835	15.95900	3824.20000
Interest Rate	-1.57860	0.00070	1.96640	0.35878	0.42856	6.17260	582.53000
Critical value Jurque-Bera	1%	5%	10%				
	9.21	5.99	4.61				

Whereas, tea, barley, wheat, poultry, lambs, sugar, soybean oil and cotton shows a value less than 3 for kurtosis. A value lower than 3 shows that there is less probability of extreme values and these series are platykurtically distributed[9]. It implies that the distributions of return series are not normal.

In Jarque Bera test (JB) the null hypothesis under consideration is that the series are normally distributed. The null hypothesis of normality of JB statistics are rejected for all return series as the calculated value in Table 4.2 is greater than the critical value of 1%, 5%, and 10% level of significance suggesting that all the distributions of a return series are non-normal.

[9] Platykurtic distribution is flatter than normal distribution.

Overall descriptive statistics show that the distributions of price return series are skewed, leptokurtic and platykurtic. It concludes that the price return series of Pakistani market show non normal distribution which is the main characteristic of the data set of most of the emerging markets (Choudry, 1996).

KPSS test at a level and at the first difference with constant for unit root for the stationarity of the return series is used. The results of unit root tests are shown in Table 4.3. All series are non-stationary at the level as the calculated values are greater than the critical values at 1%, 5%, and 10% level of significance. At first differenced return series of rice, wheat, beef, poultry, sugar, rapeseed oil, soybean oil, sunflower oil, exchange rate, tea, barley, lamb, cotton, crude oil, urea and interest rate are stationary at 1% level of significance.

Table 4.3: Unit root test

Kwiatkowski–Phillips–Schmidt–Shin (KPSS)				
	Log Level		Log First Difference	
	with constant	with constant and trend	with constant	with constant and trend
Tea	4.9944	1.65987	0.01962	0.0164259
Barley	11.2406	1.72147	0.0593445	0.0216872
Rice	7.21935	2.03134	0.0930032	0.0357157
Wheat	7.93214	1.82813	0.107774	0.0282508
Beef	5.76777	3.00973	0.23447	0.0377548
Poultry	16.6182	1.17962	0.0369913	0.0338716
Lamb	9.6491	1.03139	0.149932	0.0574777
Sugar	6.41088	1.78359	0.0410028	0.0375264
Rapeseed Oil	9.83891	2.18872	0.0450457	0.0327789
Soybean Oil	7.47396	2.34956	0.0705844	0.0376475
Sunflower Oil	8.2425	1.96624	0.0373904	0.0302492
Cotton	1.32349	1.01585	0.0684311	0.0357745
Crude oil	11.761	3.28156	0.168624	0.0272404
Urea	9.10884	1.97848	0.0681359	0.031068
Exchange Rate	17.2971	1.83328	0.167393	0.0740553
Interest Rate	1.66404	0.79407	0.00872	0.00850
critical value	1%	5%	10%	
with constant	0.739	0.463	0.347	
with constant and trend	0.216	0.146	0.119	
Note: All series are non-stationary at level and are stationary at first difference at 1% critical value				

In order to test conditional heteroskedasticiy, Lagrange Multiplier test and the Ljung-Box test are employed on return series of rice, wheat, beef, poultry, sugar, rapeseed oil, soybean oil, sunflower oil, exchange rate, tea, barley, lamb, cotton, crude oil, urea and interest rate and .macroeconomic factors. The Ljung-Box–Pierce Q-statistics and Q2-statistics are significant, showing there is serial correlation in residuals and square residuals. The LM test shows strong evidence that the squared residuals exhibit an ARCH effect. These results, support for the estimation of a conditional heteroscedasticity model for food and agriculture commodity prices.

Table 4.4: (a) ARCH Effect Diagnostic

		ARCH TEST			Q-STATISTICS				Q-STATISTICS		
	ARCH (1-2)	**ARCH (1-5)**	**ARCH (1-10)**		**On Returns**				**On squared Returns**		
	F(2,355)	**F(5,349)**	**F(10,339)**	**Q(5)**	**Q(10)**	**Q(20)**	**Q(50)**	**Q(5)**	**Q(10)**	**Q(20)**	**Q(50)**
Tea	7.3254	4.1859	2.5666	25.7864	36.6372	62.088	151.766	20.6245	25.7626	40.8455	64.618
	(0.0008)**	(0.0010)**	(0.0053)**	(0.0000982)**	(0.0000654)**	(0.0000034)**	(0.0000)**	(0.0009536)**	(0.0040729)**	(0.0038991)**	(0.0800362)**
Barley	12.506	5.3585	3.4248	26.0272	34.2781	42.3605	105.338	35.1645	46.8204	92.4591	144.506
	(0.0000)**	(0.0001)**	(0.0003)**	(0.0000882)**	(0.0001657)**	(0.0024813)**	(0.0000080)**	(0.0000014)**	(0.0000010)**	(0.0000000)**	(0.0000000)**
Rice	35.482	15.163	7.5504	50.0978	65.8433	86.8228	144.272	86.2966	88.8900	90.6369	100.791
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000279)**
Wheat	10.056	4.1426	2.4165	26.5722	39.4901	49.3374	84.9637	25.4564	33.1676	52.4578	108.383
	(0.0001)**	(0.0011)**	(0.0087)**	(0.0000691)**	(0.0000208)**	(0.0002753)**	(0.0014841)**	(0.0001137)**	(0.0002553)**	(0.0000976)**	(0.0000034)**
Beef	14.307	7.1982	4.0405	24.5758	40.7535	64.95	95.7265	34.0669	37.1655	40.2718	65.9114
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000440)**	(0.0000125)**	(0.0000012)**	(0.0001065)**	(0.0000023)**	(0.0000530)**	(0.0046146)**	(0.0651129)**
Poultry	62.085	24.749	11.996	108.321	157.056	259.009	454.052	100.285	109.379	111.79	200.276
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**
Lamb	4.6451	2.9631	1.7237	32.3622	45.1031	55.7783	82.466	14.3221	17.382	38.0595	57.2712
	(0.0102)*	(0.0124)*	(0.0741)	(0.0000050)**	(0.0000021)**	(0.0000314)**	(0.0026129)**	(0.0136879)*	(0.0663273)	(0.0087085**)	(0.2234390)
Sugar	8.5151	4.8309	4.8067	26.3505	27.6429	37.3614	64.4607	19.0465	47.8144	58.6336	131.364
	(0.0002)**	(0.0003)**	(0.0000)**	(0.0000763)**	(0.0020587)**	(0.0105871)*	(0.0820284)	(0.0018841)**	(0.0000007)**	(0.0000116)**	(0.0000000)**

Note: p-values are shown in brackets, * shows the 5% level of significance and ** shows significance at 1%. Q-Statistics is the Ljung-Box statistics based on standardized residual and square of standardized residuals up to lag 50 with H_0: no serial correlation. LM-ARCH (n) Lagrange multiplier test for ARCH effect up to order n, its H0: series is not subject to ARCH effect.

Table 4.4: (b) ARCH Effect Diagnostic

		ARCH TEST			Q-STATISTICS				Q-STATISTICS		
	ARCH (1-2)	ARCH (1-5)	ARCH (1-10)		On Returns				On Squared Returns		
	F(2,355)	F(5,349)	F(10,339)	Q(5)	Q(10)	Q(20)	Q(50)	Q(5)	Q(10)	Q(20)	Q(50)
Rapeseed Oil	61.008	26.703	13.321	7.70880	13.0631	34.1052	54.0044	90.3753	95.5766	123.522	145.131
	(0.0000)**	(0.0000)**	(0.0000)**	(0.1730315)	(0.2201640)	(0.0254218)*	(0.3240075)	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**
Soybean Oil	8.6854	5.8310	5.5184	42.836	44.4819	48.0388	100.382	20.0956	34.4739	42.8566	58.6111
	(0.0002)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000027)**	(0.0004201)**	(0.0000312)**	(0.0011992)**	(0.0001535)**	(0.0021354)**	(0.1889040)
Sunflower Oil	33.951	14.095	6.9088	44.7221	55.7812	61.782	117.625	49.2322	49.6959	52.3056	81.0673
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000038)**	(0.0000002)**	(0.0000000)**	(0.0000003)**	(0.0001027)**	(0.0035571)**
Cotton	7.6403	19.176	10.406	101.135	110.469	150.769	177.686	82.0900	130.165	132.599	146.283
	(0.0006)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**
Crude oil	30.024	13.938	7.2441	47.3662	67.4613	93.5737	113.854	71.1438	82.5977	90.7382	128.248
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000007)**	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000)**
Urea	40.195	19.54	10.113	57.4195	64.6547	97.9101	176.969	65.9271	79.8173	81.4722	102.594
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000171)**
Exchange Rate	68.977	27.388	13.417	12.4698	13.9419	23.2497	46.0303	116.84	119.64	129.042	161.249
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0288883)*	(0.1756581)	(0.2767007)	(0.6333764)	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**
Interest Rate	17.483	7.2811	8.3589	72.4735	97.214	115.195	173.278	52.4649	128.38	163.664	177.061
	(0.0000)**	(0.0000)**	(0.0000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**	(0.0000000)**

Note: p-values are shown in brackets, * shows the 5% level of significance and ** shows significance at 1%. Q-Statistics is the Ljung-Box statistics based on standardized residual and square of standardized residuals up to lag 50 with H_0: no serial correlation. LM-ARCH (n) Lagrange multiplier test for ARCH effect up to order n, its H0: series is not subject to ARCH effect.

5. Estimated GARCH Models

In order to find the best fitted model for each return series of food and agricultural commodity and other factors, initially we estimate the n-GARCH, t-GARCH, EGARCH and GJR-GARCH models. Results of GARCH (1, 1), EGARCH (1, 1) and GJR-GARCH (1,1) model with normal distribution for twelve foods and agricultural commodities and factors affecting their volatilities are reported in Table 5.1 (a & b) and Table 5.2 (a & b) in Appendix A.

To investigate the effect of the explanatory variables on the price returns, residuals of crude oil, urea, exchange rate and interest rate (R_{croil}, R_u, Rex, R_i ,respectively) are added in the mean equation and residual squares of crude oil, urea, exchange rate and interest rate (SqR_{croil}, SqR_u, SqRex, SqR_i ,respectively) are added in the variance equation. The effect of explanatory variables on food and agricultural commodities is estimated for GARCH (1, 1), EGARCH (1, 1) and GJR (1, 1), with normal and Student-t distribution (see Table 5.3 (a & b) and Table 5.4 (a & b) in Appendix A).

GARCH models with explanatory variables show the predicted significance of α_1 for all commodities except for tea, wheat, beef and rapeseed oil. Furthermore, the coefficient of β_1 is high (close to 1) and shows strong significance for all the commodities which implies that a shock to volatility is persisted for long duration. The estimated parameter γ_1 indicates that the asymmetric effects is insignificant and negative for sugar and cotton; implying that there is no leverage and asymmetric effects. Whereas, γ_1 is significant and negative for soybean oil and sunflower oil. This implies that there is leverage effect, but no asymmetry. Normally test applied concludes that the model is negatively skewed for tea, barley and beef series, whereas all the other commodities are positively skewed. The value of excess kurtosis is high for rapeseed oil and sunflower oil return series, which indicates the distribution is leptokurtic with higher probability of extreme value, whereas all the other commodities are platykurtically distributed. The JB test also indicates that the standardized residual shows non-normal distribution. Moreover, the LM-ARCH test demonstrates no model specification error. The Q-statistic for the standardized residuals and Q^2-statistic for squared standardized residuals shows no or little sign of serial autocorrelation and volatility clustering. Furthermore, the Residual Based Diagnostic Test of Tse (2002) indicates no heteroscedasticity.

For the sample period 1983:4 to 2012:4, EGARCH model is preferred to be the best fit for return price series of tea and beef. In case of barley, rice, wheat, poultry, lamb and rapeseed oil GARCH model is the best fit. For the remaining commodities (sugar, soybean oil, sunflower oil and cotton) GJR-GARCH model performed better than the other models. The coefficients in the mean equation show that the prices of barley, beef, lamb and rapeseed oil are positively and significantly affected by crude oil prices. Whereas, the volatility of crude oil prices has a significant positive effect on the volatility of cotton prices. A significant negative impact on the variations in sunflower oil and wheat market is observed as crude oil is an important input for their production. These results provide evidence that changes in international crude oil prices effect the domestic markets (Zhang *et al.,* 2010). Results are evident of volatility transmission from the crude oil market to food and agricultural market in Pakistan. In Pakistan economy the transmission from high crude price do not directly affect the production, rather indirectly through the high cost of food processing, transportation and distribution. Similarly, high input cost due to the use of tractors and tube well in harvesting leads to higher food and agricultural prices in Pakistan. These results are consistent with the finding of Ali, Ramzam, Razi and Bhatti (2012) for wheat, rice and chicken. Azeem, Munawwar and Mushtaq (2012) also found a negative relationship between Pakistan's wheat prices and international crude oil prices. This may be due to the government's unstable and inconsistent economic policies that lead to rise the general price level of the economy. Even if the price of crude oil is reduced internationally, but the sectors that use crude oil as an input, never reduce their output prices (Ali *et al.,* 2012; Azeem *et al.,* 2012).

The coefficients in the mean equation show that the prices of barley, wheat and soybean oil are positively and significantly affected by the exchange rates. The results show that the volatility of exchange rates do not affect the price volatilities of any commodity in Pakistan. An Increase in the price of inputs like fertilizer directly affect the output price, therefore urea is taken as a representative. Results show that in the mean equation of returns urea positively and significantly affects the coefficients of rice, sugar, rapeseed oil and sunflower oil. Furthermore, the volatility urea prices is transmitted to price volatility of sunflower oil. The interest rate has negative and significant effect on the mean price of beef and poultry. Further, positive and significant effect on the mean price of wheat is also observed. The volatility of interest rate affects negatively on the volatility of beef prices only.

Considering the effect of past price on current price, strong positive evidences are found for all the commodities except for soybean oil, sunflower oil and cotton. Volatility analysis shows a significant and positive effect of lagged volatility on the volatility of poultry prices. Whereas the negative and significant effect on the price volatility of barley, lamb, sunflower oil and cotton is observed due to past price volatility. It is clear from the high GARCH value and volatility analysis that the current prices are more dependent on the past (old) event and their effect is of long duration.

6. Conclusion

In this study, sources of food and agriculture commodity price volatility in Pakistan is investigated through GARCH models. For this purpose, monthly data from April 1983 till April 2013 of selected food and agricultural commodities for Pakistan is used for analysis. Results show crude oil prices are positively and significantly affecting the mean prices of barley, beef, lamb and rapeseed oil. Whereas, volatility of crude oil prices is positively affecting the price volatility of cotton and negatively effects the volatility of sunflower oil and wheat prices. These results indicate that changes in international crude oil prices affect the Pakistani goods market. The exchange rate has a positive and significant effect on mean prices of barley, wheat and soybean oil. The exchange rate volatility does not affect the price volatilities of any commodities selected in this study. The prices of urea positively and significantly affect the mean prices of rice, sugar, rapeseed oil and sunflower oil. Volatility of urea prices is only transmitted on the price volatility of sunflower oil. The interest rate has negative impact on the beef and poultry prices, whereas, it has a positive and significant effect on mean prices of wheat. The volatility of interest rate impacts negatively on the volatility of beef prices. Subsequently, analysis shows that price volatility has significant impact on current prices for all the commodities except for soybean oil, sunflower oil and cotton in Pakistan.

The farmers should be encouraged to use the hedging instruments to reduce the price volatility. Uncertainty in weather conditions, heavy/low rains and floods effect the crop production, low stocks of grains and delayed shipments of the imported edible oil is the source of high prices. Policies need to be developed to control the volatile nature of food/agricultural prices, which is directly effecting the low income group. Whereas, prices of grains can be stabilized by stabilizing the value of Pakistani rupee. So the government should give attention to sustain agricultural sector and agricultural volatility by involving individual institution that will ultimately help to increase GDP. Subsidy on agricultural and food sector inputs will reduce impact of the high cost on small producers and it may also help to attain a general equilibrium level that ultimately reduces the price of food. Developing countries, including Pakistan needed to develop flexible policies and increase investment in the agricultural sector that would boost growth to meet the increasing need of food for the growing population.

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Appendix A

Table 5.1: (a) GARCH (1, 1) Model for Individual Series

	Tea	Barley	Rice	Wheat	Beef	Poultry	Lamb	Sugar
Model	ARMA (2, 3)	ARMA (2, 3)	ARMA (2, 1)	ARMA (1, 0)	ARMA (2, 1)	ARMA (1, 2)	ARMA (2, 0)	ARMA (1, 0)
Specifications	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	n-GARCH (1, 1)
Mean Equation								
C	0.000275	0.005876	0.001023	-0.000615	0.000872	0.004228	0.000170	-0.000218
t-prob	0.872300	0.028400	0.652400	0.852800	0.646600	0.004300	0.942200	0.967500
AR(1)	-0.207830	0.874844	0.703357	0.245373	0.210163	0.397071	0.302338	0.243416
t-prob	0.001800	0.000000	0.000700	0.000000	0.000300	0.009100	0.000000	0.000000
AR(2)	0.713983	-0.785430	-0.280306		-0.072156		-0.045344	
t-prob	0.000000	0.000000	0.000000		0.198800		0.388200	
MA(1)	0.412858	-0.643273	-0.393246			0.236158		
t-prob	0.000000	0.000000	0.068300			0.116900		
MA(2)	-0.869539	0.515341				0.123561		
t-prob	0.000000	0.000000				0.204500		
MA(3)	-0.309733	0.111723						
t-prob	0.000000	0.111400						
Variance Equation								
C	0.001176	2.419234	3.080723	2.048525	1.849499	0.000000	5.781901	0.000179
t-prob	0.094500	0.123900	0.045400	0.191200	0.117600	1.000000	0.130400	0.224400
α(1)	0.221185	0.182563	0.261568	0.114276	0.141340	0.069682	0.204533	0.087828
t-prob	0.020300	0.027800	0.006000	0.038000	0.049200	0.006400	0.083300	0.005900
β(1)	0.595857	0.798348	0.685648	0.838163	0.725777	0.927044	0.388469	0.887660
t-prob	0.000500	0.000000	0.000000	0.000000	0.000000	0.000000	0.223700	0.000000
Student (DF)	6.533039	3.519292	4.016960	4.546079	5.559765	9.686879	6.176436	
t-prob	0.015500	0.000000	0.000100	0.001100	0.000500	0.063700	0.012800	
α(1)+β(1)| α(1)+β(1)+γ(1)[10]	0.817040	0.980910	0.947220	0.952440	0.867120	0.996730	0.593000	0.975490
Log Likelihood	438.550000	515.604000	581.441000	551.882000	710.793000	969.144000	694.645000	395.708000
Akaike Criteria	-2.380835	-2.808912	-3.185784	-3.032670	-3.909960	-5.339688	-3.820252	-2.170600
Schwarz Criteria	-2.272887	-2.700965	-3.099426	-2.967907	-3.834397	-5.253330	-3.744689	-2.116627
Shibata Criteria	-2.382323	-2.810401	-3.186743	-3.033219	-3.910697	-5.340647	-3.820989	-2.170979
Hannan-Quinn	-2.337913	-2.765991	-3.151446	-3.006922	-3.879915	-5.305350	-3.790206	-2.149139

[10] α(1)+β(1)+γ(1) is for GJR-GARCH model

Table 5.1: (b) GARCH (1, 1) Model for Individual Series

	Rapeseed Oil	Soybean Oil	Sunflower Oil	Cotton	Crude oil	Urea	Exchange Rate	Interest Rate
Model	ARMA (1, 0)	ARMA (1, 0)	ARMA (2, 0)	ARMA (1, 1)	ARMA (0, 1)	ARMA (3, 3)	ARMA (3, 0)	ARMA (0, 3)
Specifications	n-GJR (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	t-GARCH (1, 1)	n-EGARCH (1, 1)	t-GARCH (1, 1)	t-EGARCH (1, 1)	t-GARCH (1, 1)
Mean Equation								
C	0.001605	0.002139	-0.000971	-0.002574	-0.005328	0.004711	0.001930	-0.000099
t-prob	0.680400	0.585600	0.734400	0.498900	0.054200	0.338100	0.000200	0.892300
AR(1)	0.081151	0.299812	0.225698	0.299243		0.619897	0.401188	
t-prob	0.093200	0.000000	0.000000	0.004300		0.053600	0.000000	
AR(2)						-0.738434	0.041373	
t-prob						0.000900	0.531900	
AR(3)						0.099793	0.050708	
t-prob						0.572500	0.371700	
MA(1)				0.270674	0.310213	-0.276385		-0.333847
t-prob				0.011400	0.000000	0.395600		0.000000
MA(2)						0.642519		-0.049006
t-prob						0.000600		0.405900
MA(3)						0.050403		-0.029838
t-prob						0.778700		0.524200
Variance Equation								
C	4.206131	2.605837	17.117957	2.792065	0.000000	0.001851	0.000000	0.000001
t-prob	0.000200	0.239900	0.051400	0.046300	1.000000	0.053400	1.000000	1.000000
α(1)	0.078256	0.072645	1.000000	0.231741	0.181332	0.262104	-0.289169	1.000000
t-prob	0.007300	0.078900	0.071000	0.013300	0.421000	0.053100	0.000400	0.003100
β(1)	0.765239	0.844251	0.356086	0.683727	0.990026	0.485583	0.893397	0.538828
t-prob	0.000000	0.000000	0.001400	0.000000	0.000000	0.009100	0.000000	0.000000
γ(1)	0.232487							
t-prob	0.001700							
θ(1)					-0.069009		0.102831	
t-prob					0.294800		0.427400	
θ(2)					0.764323		0.888949	
t-prob					0.000000		0.000000	
Student (DF)		8.335187	2.538609	5.702489		4.886020	3.274801	3.005050
t-prob		0.009600	0.000000	0.023500		0.000700	0.000000	0.000000
α(1)+β(1)| α(1)+β(1)+γ(1)[11]	0.959739	0.916900	1.356090	0.915470	1.171358	0.747690	0.996100	1.538830
Log Likelihood	436.216000	531.010000	526.653000	599.012000	406.648000	427.878000	1220.381000	166.509000
Akaike Criteria	-2.390089	-2.916721	-2.892517	-3.288958	-2.220266	-2.315989	-6.724341	-0.880606
Schwarz Criteria	-2.325321	-2.851952	-2.827748	-3.213395	-2.144703	-2.197247	-6.616394	-0.794248
Shibata Criteria	-2.390633	-2.917264	-2.893060	-3.289695	-2.221003	-2.317784	-6.725830	-0.881565
Hannan-Quinn	-2.364336	-2.890967	-2.866764	-3.258913	-2.190221	-2.268775	-6.681419	-0.846268

[11] α(1)+β(1)+γ(1) is for GJR-GARCH model

Table 5.2: (a) Diagnostic Test for GARCH (1, 1) Model for Individual Series

	Tea	Barley	Rice	Wheat	Beef	Poultry	Lamb	Sugar
Normality Test								
Skewness	0.079790	-0.222370	0.672770	0.545280	-0.382670	-0.241180	0.170500	-0.048153
p-value	0.534850	0.083697	0.000000	0.000022	0.002916	0.060663	0.184790	0.708000
Excess Kurtosis	1.136600	2.686900	2.668500	1.667000	3.480300	0.841290	1.163500	0.354710
p-value	0.000009	0.000000	0.000000	0.000000	0.000000	0.001035	0.000006	0.166600
Jarque-Bera	19.760000	111.260000	133.970000	59.522000	190.470000	14.107000	22.050000	2.026400
p-value	0.000051	0.000000	0.000000	0.000000	0.000000	0.000864	0.000016	0.363060
Q-Statistics on Standardized Residuals								
Q(5)			4.475810	0.837732	4.862490	6.278900	5.827930	1.372700
p-value			[0.1066819]	[0.9333192]	[0.1821478]	[0.0433065]*	[0.1202885]	[0.8489265]
Q(10)	7.448330	7.128290	7.989080	8.039960	12.337000	23.386800	16.482600	2.921740
p-value	[0.1893750]	[0.2112724]	[0.3335578]	[0.5301241]	[0.1367899]	[0.0014593]**	[0.0359704]*	[0.9673169]
Q(20)	23.235900	13.630100	26.928700	18.165500	27.465000	62.666300	27.898000	10.978700
p-value	[0.0792582]	[0.5537500]	[0.0591223]	[0.5114100]	[0.0706767]	[0.0000004]**	[0.0636249]	[0.9245522]
Q(50)	92.879200	67.445700	69.534600	40.449400	64.691800	173.274000	56.487500	30.797900
p-value	[0.0000354]**	[0.0167535]*	[0.0179689]*	[0.8027183]	[0.0542658]	[0.0000000]**	[0.1875255]	[0.9804828]
Q-Statistics on Squared Standardized Residuals								
Q(5)	6.785330	1.722860	2.913910	6.378660	2.093800	7.992200	3.709460	5.210500
p-value	[0.0790641]	[0.6318639]	[0.4050900]	[0.0945728]	[0.5531672]	[0.0461732]*	[0.2945948]	[0.1570166]
Q(10)	8.221050	6.708720	6.402940	9.222920	3.611080	9.896220	5.491970	11.180000
p-value	[0.4121810]	[0.5683605]	[0.6021926]	[0.3238409]	[0.8903997]	[0.2723853]	[0.7039291]	[0.1917070]
Q(20)	20.023100	26.719300	17.071700	20.404100	6.883720	13.900000	36.347100	18.079500
p-value	[0.3315223]	[0.0844134]	[0.5181838]	[0.3105336]	[0.9910708]	[0.7355853]	[0.0063675]**	[0.4504279]
Q(50)	63.418500	96.261600	41.500500	59.961000	26.457100	48.797200	54.275200	58.884600
p-value	[0.0671323]	[0.0000445]**	[0.7346716]	[0.1153120]	[0.9951172]	[0.4408046]	[0.2476522]	[0.1349151]
ARCH TEST								
ARCH(1-2)	1.826200	0.025858	0.683540	0.619640	0.462660	2.123800	0.448720	0.313720
p-value	[0.1625]	[0.9745]	[0.5055]	[0.5387]	[0.6300]	[0.1211]	[0.6388]	[0.7309]
ARCH(1-5)	1.428100	0.356000	0.594700	1.230200	0.413770	1.382700	0.666330	1.006900
p-value	[0.2134]	[0.8783]	[0.7041]	[0.2944]	[0.8391]	[0.2301]	[0.6492]	[0.4135]
ARCH(1-10)	0.901650	0.673070	0.643860	0.818620	0.338210	0.505710	0.543290	1.078300
p-value	[0.5318]	[0.7495]	[0.7759]	[0.6109]	[0.9702]	[0.8858]	[0.8589]	[0.3781]
Residual based diagnostic								
RBD(2)	1.237590	-0.313595	-0.060119	-0.341200	2.409050	50.093400	-8.838740	0.513363
p-value	[0.5385935]	[1.0000000]	[1.0000000]	[1.0000000]	[0.2998341]	[0.0000000]	[1.0000000]	[0.7736146]
RBD(5)	6.612950	1.045610	1.659690	6.890390	4.123650	-22.801600	4.905260	5.522160
p-value	[0.2510534]	[0.9588035]	[0.8939390]	[0.2289206]	[0.5317542]	[1.0000000]	[0.4275514]	[0.3555225]
RBD(10)	8.578350	6.118970	8.764570	9.030900	5.937550	4.025180	6.433910	16.452900
p-value	[0.5725316]	[0.8051709]	[0.5545830]	[0.5291740]	[0.8204820]	[0.9462039]	[0.7775863]	[0.0873812]

Note: * shows the 5% level of significance and ** shows significance at 1%. Q-Statistics is the Ljung-Box statistics based on standardized residual and square of standardized residual up to lag 50 with H_0: no serial correlation. LM-ARCH (n) Lagrange multiplier test for ARCH effect up to order n, its H_0: series is not subject to ARCH effect. JB (Jarque Bera) test H_0: series is normal

Table 5.2: (b) Diagnostic Test for GARCH (1, 1) Model for Individual Series

	Rapeseed Oil	Soybean Oil	Sunflower Oil	Cotton	Crude oil	Urea	Exchange Rate	Interest Rate
Normality Test								
Skewness	0.338080	0.316550	5.339300	-0.033660	-0.217370	-0.756070	4.529800	3.533100
p-value	0.008548	0.013810	0.000000	0.793460	0.090883	0.000000	0.000000	0.000000
Excess Kurtosis	3.882700	1.698200	70.478000	0.869130	0.689350	2.805700	34.276000	39.858000
p-value	0.000000	0.000000	0.000000	0.000701	0.007183	0.000000	0.000000	0.000000
Jarque-Bera	232.990000	49.268000	76217.000000	11.399000	9.963200	152.380000	18854.000000	24579.000000
p-value	0.000000	0.000000	0.000000	0.003348	0.006863	0.000000	0.000000	0.000000
Q-Statistics on Standardized Residuals								
Q(5)	0.449135	7.370060	3.689700	6.647270	3.927090		0.668564	3.100910
p-value	[0.9782601]	[0.1175774]	[0.4496252]	[0.0840320]	[0.4159629]		[0.7158517]	[0.2121509]
Q(10)	3.305100	9.243770	6.931410	14.560800	7.412210	8.515190	2.324930	6.846070
p-value	[0.9509616]	[0.4150831]	[0.6442603]	[0.0682696]	[0.5942848]	[0.0744282]	[0.9396934]	[0.4450812]
Q(20)	16.752300	13.708300	11.421200	31.250800	25.372200	29.068900	21.883300	29.478400
p-value	[0.6066439]	[0.8004211]	[0.9088550]	[0.0269220]*	[0.1486509]	[0.0102282]*	[0.1892493]	[0.0303613]*
Q(50)	45.453600	53.795800	52.265000	57.648000	57.121800	78.288700	51.694800	61.679300
p-value	[0.6177004]	[0.2958518]	[0.3483413]	[0.1604622]	[0.1988991]	[0.0011194]**	[0.2955434]	[0.0739068]
Q-Statistics on Squared Standardized Residuals								
Q(5)	3.634840	4.205550	0.168354	6.576790	4.435180	1.376070	0.528775	0.605223
p-value	[0.3036904]	[0.2401067]	[0.9825287]	[0.0866827]	[0.2181454]	[0.7111528]	[0.9125257]	[0.8952358]
Q(10)	6.151480	6.114020	0.289105	9.546600	14.189100	3.868430	0.958538	0.763137
p-value	[0.6302686]	[0.6344614]	[0.9999838]	[0.2983003]	[0.0769683]	[0.8687946]	[0.9984970]	[0.9993478]
Q(20)	12.981900	10.057200	0.456381	17.605200	23.627200	12.175400	73.220200	25.497500
p-value	[0.7926481]	[0.9300241]	[1.0000000]	[0.4819313]	[0.1676262]	[0.8380499]	[0.0000000]**	[0.1118154]
Q(50)	53.431600	27.016900	11.916200	47.519400	46.964900	38.913700	77.271800	27.583700
p-value	[0.2735119]	[0.9937711]	[1.0000000]	[0.4924399]	[0.5152274]	[0.8222822]	[0.0046817]**	[0.9921098]
ARCH TEST								
ARCH(1-2)	0.708680	1.237800	0.029811	1.001100	0.171810	0.365260	0.093733	0.166720
p-value	[0.4930]	[0.2913]	[0.9706]	[0.3685]	[0.8422]	[0.6943]	[0.9105]	[0.8465]
ARCH(1-5)	0.788470	1.966300	0.031634	1.296200	0.926680	0.270460	0.108150	0.113150
p-value	[0.5585]	[0.0831]	[0.9995]	[0.2650]	[0.4637]	[0.9291]	[0.9905]	[0.9894]
ARCH(1-10)	0.667390	1.157600	0.026473	0.918730	1.446800	0.356970	0.102220	0.071498
p-value	[0.7546]	[0.3188]	[1.0000]	[0.5159]	[0.1583]	[0.9638]	[0.9998]	[1.0000]
Residual based diagnostic								
RBD(2)	1.667440	7.238770	0.052895	1.300760	5.115080	1.817610	0.021133	0.432463
p-value	[0.4344312]	[0.0267992]	[0.9738992]	[0.5218469]	[0.0774952]	[0.4030059]	[0.9894894]	[0.8055489]
RBD(5)	3.795140	7.024360	0.150346	6.832980	10.092200	2.076030	0.083496	0.518440
p-value	[0.5792719]	[0.2188353]	[0.9995581]	[0.2333612]	[0.0726638]	[0.8385279]	[0.9998960]	[0.9914325]
RBD(10)	6.330680	11.048500	0.250990	9.972830	16.954000	3.705040	0.345620	0.721150
p-value	[0.7867579]	[0.3537558]	[0.9999998]	[0.4428804]	[0.0753891]	[0.9596736]	[0.9999989]	[0.9999623]

Note: * shows the 5% level of significance and ** shows significance at 1%. Q-Statistics is the Ljung-Box statistics based on standardized residual and square of standardized residual up to lag 50 with H_0: no serial correlation. LM-ARCH (n) Lagrange multiplier test for ARCH effect up to order n, its H_0: series is not subject to ARCH effect. JB (Jarque Bera) test H_0: series is normal

Table 5.3: (a) GARCH (1, 1) Modelling and Factors Effecting Volatility

	Tea	**Barley**	**Rice**	**Wheat**	**Beef**	**Poultry**
Model	ARMA (2, 3)	ARMA (3, 3)	ARMA (2, 3)	ARMA (1, 3)	ARMA (2, 1)	ARMA (1, 1)
Specifications	n-EGARCH (1, 1)	n-GARCH (1, 1)	n-GARCH (1, 1)	n-GARCH (1, 1)	t-EGARCH (1, 1)	t-GARCH (1, 1)
Mean Equation						
C	0.002268	-0.001643	-0.000300	0.001049	-0.001450	-0.000955
t-prob	0.350100	0.510300	0.910200	0.549400	0.365900	0.048800
Rcroil	-0.003926	**0.079640**	-0.042237	-0.008316	**0.061500**	-0.003961
t-prob	0.895700	**0.007200**	0.168800	0.747400	**0.000000**	0.522700
Rex	-0.280251	**0.262956**	-0.455654	**0.463099**	0.144770	0.028193
t-prob	0.074400	**0.003800**	0.091900	**0.002900**	0.258800	0.620300
Ru	0.012458	0.037407	**0.126906**	0.027490	0.001241	0.003971
t-prob	0.658500	0.204500	**0.000000**	0.441600	0.955100	0.520800
Ri	**-0.019864**	0.001417	-0.001402	**0.020394**	**-0.008621**	**-0.007592**
t-prob	**0.000500**	0.823800	0.857300	**0.003500**	**0.024100**	**0.006000**
Lagged CondM	**0.630128**	**0.869554**	**1.770410**	**0.647853**	**1.187496**	**1.121253**
t-prob	**0.015600**	**0.000000**	**0.000100**	**0.000600**	**0.000000**	**0.000000**
AR(1)	**0.552140**	**-0.580784**	**0.769914**	**0.946654**	**-1.000000**	**0.811548**
t-prob	**0.005800**	**0.004200**	**0.001900**	**0.000000**	**0.000000**	**0.000000**
AR(2)	-0.489195	-0.899320	-0.416297		-0.013006	
t-prob	0.018600	0.000000	0.040800		0.835500	
AR(3)		-0.401970				
t-prob		0.042900				
MA(1)	**-0.479026**	**0.628401**	**-1.000000**	**-0.866977**	**0.979315**	**-0.961775**
t-prob	**0.005500**	**0.001600**	**0.000000**	**0.000000**	**0.000000**	**0.000000**
MA(2)	0.473527	0.988513	0.678205	-0.126682		
t-prob	0.027700	0.000000	0.003700	0.129800		
MA(3)	-0.124294	0.432963	0.031026	-0.035315		
t-prob	0.097900	0.032500	0.791400	0.605900		
Variance Equation						
C	0.000000	1.835683	3.809330	2.112167	0.000000	0.136676
t-prob	1.000000	0.003600	0.001100	0.005600	1.000000	0.290900
SqRcroil	0.880751	-0.005982	0.002196	**-0.016221**	-17.430403	-0.000516
t-prob	0.916300	0.230200	0.799800	**0.000000**	0.082200	0.624000
SqRex	-100.000000	-0.003067	0.144914	-0.008169	82.390333	0.055075
t-prob	0.547600	0.865800	0.667300	0.780100	0.772500	0.207000
SqRu	3.000308	0.005416	-0.008784	0.007163	9.193257	-0.001218
t-prob	0.661600	0.145700	0.314900	0.283000	0.226100	0.213400
SqRi	-0.410239	-0.000259	0.000038	-0.000267	**-0.831344**	0.000038
t-prob	0.239200	0.057300	0.906400	0.069200	**0.023300**	0.622200
Lagged CondV	-52.096306	**-0.103255**	-0.039208	-0.004733	-100.000000	**0.327140**
t-prob	0.275800	**0.000000**	0.682600	0.911100	0.665200	**0.047200**
α(1)	1.176278	**0.097406**	**0.323885**	0.036421	0.802665	**0.235363**
t-prob	0.127700	**0.000100**	**0.000000**	0.158500	0.129600	**0.020100**
β(1)	**0.990800**	**0.991151**	**0.624360**	**0.932157**	**0.469657**	**0.396124**
t-prob	**0.000000**	**0.000000**	**0.000000**	**0.000000**	**0.001100**	**0.024000**
θ(1)	-0.023473				0.041552	
t-prob	0.531200				0.544200	
θ(2)	0.428289				0.423854	
t-prob	0.016600				0.002400	
Student (DF)					8.433904	11.242758
t-prob					0.010300	0.154500
α(1)+β(1)/ α(1)+β(1)+γ(1)[12]	2.167078	1.088560	0.948240	0.968580	1.272322	0.631490
Log Likelihood	431.908000	512.749000	578.706000	560.274000	714.332000	986.696000
Akaike Criteria	-2.282824	-2.737497	-3.109476	-3.012633	-3.857398	-5.387200
Schwarz Criteria	-2.056135	-2.521602	-2.904376	-2.818328	-3.641504	-5.203690
Shibata Criteria	-2.289143	-2.743247	-3.114683	-3.017323	-3.863149	-5.391398
Hannan-Quinn	-2.192688	-2.651653	-3.027924	-2.935374	-3.771554	-5.314233

[12] α(1)+β(1)+γ(1) is for GJR-GARCH

Table 5.3: (b) GARCH (1, 1) Modelling and Factors Effecting Volatility

	Lamb	**Sugar**	**Rapeseed Oil**	**Soybean Oil**	**Sunflower Oil**	**Cotton**
Model	ARMA (2, 0)	ARMA (3, 3)	ARMA (3, 3)	ARMA (2, 0)	ARMA (2, 0)	ARMA (2, 3)
Specifications	t-GARCH (1, 1)	n-GJR (1, 1)	t-GARCH (1, 1)	n-GJR (1, 1)	n-GJR (1, 1)	n-GJR (1, 1)
Mean Equation						
C	0.000473	0.003025	0.001256	0.006189	-0.000430	0.000669
t-prob	0.474200	0.219600	0.633800	0.166700	0.891100	0.830700
Rcroil	**0.042803**	0.008337	**0.098328**	0.055792	-0.019087	0.023462
t-prob	**0.001400**	0.877100	**0.003300**	0.074000	0.396100	0.451700
Rex	-0.098262	-0.118415	0.011179	**0.259919**	0.108979	-0.015001
t-prob	0.156100	0.698300	0.963000	**0.037900**	0.468800	0.916500
Ru	0.003765	**0.163614**	**0.093928**	0.041963	**0.093408**	0.045460
t-prob	0.787400	**0.001200**	**0.004100**	0.250800	**0.021300**	0.127500
Ri	-0.001806	0.010830	-0.000635	0.001772	0.002981	0.001016
t-prob	0.498700	0.336200	0.949800	0.834500	0.683000	0.864500
Lagged CondM	**1.958054**	**1.022506**	**1.012391**	-0.538844	0.035333	0.401070
t-prob	**0.000000**	**0.000000**	**0.000400**	0.401600	0.932500	0.398800
AR(1)	**-0.311667**	**0.856912**	**0.284580**	**0.531171**	**0.411213**	**0.658905**
t-prob	**0.000000**	**0.000000**	**0.000000**	**0.008100**	**0.000700**	**0.000000**
AR(2)	-0.168914	0.875720	0.009504	-0.193408	-0.161641	-0.815656
t-prob	0.000300	0.000000	0.889900	0.105900	0.109600	0.000000
AR(3)		-0.777928	-0.870649			
t-prob		0.000000	0.000000			
MA(1)		**-0.871416**	**-0.284528**			-0.370292
t-prob		**0.000000**	**0.000000**			0.112200
MA(2)		-0.901384	-0.047717			0.738040
t-prob		0.000000	0.386500			0.000000
MA(3)		0.797508	0.947201			0.211964
t-prob		0.000000	0.000000			0.317600
Variance Equation						
C	12.171101	0.000382	7.164106	0.000000	3.649995	1.992625
t-prob	0.002800	0.357100	0.437700	1.000000	0.000000	0.000900
SqRcroil	0.004528	0.035075	0.010703	0.006016	**-0.013469**	**0.014149**
t-prob	0.106600	0.376100	0.780700	0.124500	**0.000500**	**0.021400**
SqRex	0.029081	0.138436	2.157008	-0.034697	-0.028969	-0.021796
t-prob	0.200200	0.696300	0.418200	0.548900	0.382600	0.666200
SqRu	0.001741	-0.010836	0.030420	0.016170	**0.022848**	0.003990
t-prob	0.324100	0.697700	0.644100	0.067700	**0.000000**	0.535200
SqRi	0.000071	-0.000494	0.007657	0.000420	-0.000103	0.000053
t-prob	0.285500	0.563000	0.348900	0.168300	0.358300	0.726900
Lagged CondV	**-1.259163**	0.076215	0.125905	0.051155	**-0.078040**	**-0.140668**
t-prob	**0.003100**	0.562700	0.568000	0.603100	**0.001000**	**0.022600**
α(1)	**0.372048**	**0.177569**	0.171705	**0.093717**	**0.140113**	**0.249840**
t-prob	**0.008100**	**0.032700**	0.310300	**0.026500**	**0.001200**	**0.000000**
β(1)	**0.994868**	**0.726425**	**0.629037**	**0.872651**	**0.960321**	**0.825897**
t-prob	**0.000000**	**0.000000**	**0.001400**	**0.000000**	**0.000000**	**0.000000**
γ(1)		-0.121846		-0.162047	-0.067735	-0.095297
t-prob		0.263300		0.000100	0.000000	0.168500
Student (DF)	7.388074		2.401002			
t-prob	0.085300		0.000000			
α(1)+β(1)/ α(1)+β(1)+γ(1)[13]	1.366920	0.782148	0.800740	0.804321	1.032699	0.980440
Log Likelihood	712.826000	412.084000	501.462000	542.438000	459.622000	606.569000
Akaike Criteria	-3.865701	-2.172689	-2.669235	-2.919102	-2.459011	-3.258715
Schwarz Criteria	-3.682190	-1.945999	-2.442545	-2.735591	-2.275500	-3.042820
Shibata Criteria	-3.869898	-2.179007	-2.675553	-2.923299	-2.463208	-3.264466
Hannan-Quinn	-3.792734	-2.082553	-2.579099	-2.846135	-2.386044	-3.172871

[13] α(1)+β(1)+γ(1) is for GJR-GARCH

Table 5.4: (a) Diagnostic Test for GARCH (1, 1) Modelling and Factors Effecting Volatility

	Tea	Barley	Rice	Wheat	Beef	Poultry
Normality Test						
Skewness	-0.020163	-0.23559	0.45617	0.31592	-0.11505	0.01517
p-value	0.875380	0.066881	3.88E-04	1.40E-02	0.37087	0.90605
Excess Kurtosis	0.414060	1.1403	1.6711	0.92837	1.7972	0.59063
p-value	0.106380	8.72E-06	7.19E-11	2.94E-04	2.41E-12	0.02127
Jarque-Bera	2.596100	22.835	54.372	18.916	49.244	5.24640
p-value	0.273070	1.10E-05	1.56E-12	7.80E-05	2.03E-11	0.07257
Q-Statistics on Standardized Residuals						
Q(5)				1.613150	1.50318	2.56614
p-value				[0.2040499]	[0.4716153]	[0.4634567]
Q(10)	9.198560	6.60951	4.67836	8.11273	9.7788	10.99380
p-value	[0.1014014]	[0.1580198]	[0.4563796]	[0.2299603]	[0.2014583]	[0.2020530]
Q(20)	20.904900	9.74274	23.3874	17.8307	23.3032	40.09200
p-value	[0.1398938]	[0.7807397]	[0.0762545]	[0.3339016]	[0.1396374]	[0.0020279]**
Q(50)	90.317600	64.3758	77.7006	38.7101	61.6395	122.81800
p-value	[0.0000715]**	[0.0241661]*	[0.0017689]**	[0.7684698]	[0.0743887]	[0.0000000]**
Q-Statistics on Squared Standardized Residuals						
Q(5)	10.060300	4.51525	1.98484	5.05315	2.86271	2.88152
p-value	[0.0180602]*	[0.2109344]	[0.5755586]	[0.1679463]	[0.4132807]	[0.4102552]
Q(10)	14.616300	9.82186	4.96053	6.72725	5.63167	7.09625
p-value	[0.0670492]	[0.2777526]	[0.7617866]	[0.5663255]	[0.6884124]	[0.5262848]
Q(20)	26.516000	36.9939	13.0021	20.7451	14.8833	10.80480
p-value	[0.0885319]	[0.0052502]**	[0.7914456]	[0.2924684]	[0.6699607]	[0.9024543]
Q(50)	73.753600	100.71	37.0058	43.9046	43.2787	41.58410
p-value	[0.0098553]**	[0.0000131]**	[0.8753232]	[0.6412859]	[0.6663876]	[0.7315850]
ARCH TEST						
ARCH(1-2)	1.723300	0.96715	0.34748	1.7123	0.25611	0.12414
p-value	[0.1800]	[0.3812]	[0.7067]	[0.1820]	[0.7742]	[0.8833]
ARCH(1-5)	1.923900	0.85472	0.39545	1.0425	0.58965	0.53023
p-value	[0.0897]	[0.5118]	[0.8519]	[0.3924]	[0.7079]	[0.7534]
ARCH(1-10)	1.534600	0.95682	0.49186	0.67385	0.5358	0.78450
p-value	[0.1255]	[0.4812]	[0.8951]	[0.7487]	[0.8645]	[0.6438]
Residual based diagnostic						
RBD(2)	5.895610	3.20717	0.862393	3.61906	16.1609	0.11139
p-value	[0.0524546]	[0.2011744]	[0.6497312]	[0.1637311]	[0.0003095]	[0.9458254]
RBD(5)	14.910300	4.16143	2.15905	6.10789	1.10841	2.62676
p-value	[0.0107527]	[0.5264160]	[0.8267283]	[0.2958622]	[0.9533565]	[0.7572959]
RBD(10)	35.565500	7.76805	6.51142	8.37384	25.8656	11.20300
p-value	[0.0000999]	[0.6514813]	[0.7706238]	[0.5923712]	[0.0039252]	[0.3419260]

Table 5.4: (b) Diagnostic Test for GARCH (1, 1) Modelling and Factors Effecting Volatility

	Lamb	Sugar	Rapeseed Oil	Soybean Oil	Sunflower Oil	Cotton
Normality Test						
Skewness	0.301770	0.043420	0.666850	0.253770	2.259000	0.028219
p-value	0.018916	0.735570	0.000000	0.048394	0.000000	0.826270
Excess Kurtosis	0.785280	0.319410	8.921900	1.130800	22.252000	0.536620
p-value	0.002197	0.212920	0.000000	0.000010	0.000000	0.036383
Jarque-Bera	14.714000	1.643400	1220.700000	23.044000	7733.400000	4.367200
p-value	0.000638	0.439680	0.000000	0.000010	0.000000	0.112640
Q-Statistics on Standardized Residuals						
Q(5)	2.706250			1.792070	2.366920	
p-value	[0.4391670]			[0.6166615]	[0.4998229]	
Q(10)	8.558860	2.430830	3.884410	2.839640	7.091640	12.140100
p-value	[0.3808640]	[0.6570624]	[0.4218754]	[0.9440140]	[0.5267780]	[0.0329172]*
Q(20)	16.765900	8.663470	14.809600	8.725470	15.683900	31.880600
p-value	[0.5392506]	[0.8519860]	[0.3912935]	[0.9657669]	[0.6146006]	[0.0066834]**
Q(50)	43.189500	31.328700	53.418600	50.430500	51.856900	52.453600
p-value	[0.6699260]	[0.9243294]	[0.1562126]	[0.3775867]	[0.3259107]	[0.2073950]
Q-Statistics on Squared Standardized Residuals						
Q(5)	3.369510	5.377780	5.417790	4.039500	0.207096	8.031770
p-value	[0.3380847]	[0.1461341]	[0.1436394]	[0.2572306]	[0.9764357]	[0.0453597]*
Q(10)	5.945800	6.498050	7.146470	5.805940	0.539511	14.650200
p-value	[0.6533031]	[0.5916236]	[0.5209157]	[0.6689586]	[0.9998220]	[0.0663155]
Q(20)	26.891200	13.622400	20.873900	10.621000	1.457000	20.587900
p-value	[0.0810585]	[0.7533528]	[0.2858246]	[0.9097438]	[0.9999999]	[0.3007092]
Q(50)	50.103000	48.177400	97.854200	50.304800	24.106900	45.984700
p-value	[0.3899539]	[0.4656655]	[0.0000289]**	[0.3823150]	[0.9984408]	[0.5557833]
ARCH TEST						
ARCH(1-2)	1.041100	0.615950	2.320200	0.726450	0.018897	0.521550
p-value	[0.3541]	[0.5407]	[0.0997]	[0.4843]	[0.9813]	[0.5941]
ARCH(1-5)	0.633230	1.157700	1.676000	2.107300	0.040554	1.628900
p-value	[0.6745]	[0.3297]	[0.1397]	[0.0641]	[0.9991]	[0.1516]
ARCH(1-10)	0.599060	0.667450	1.003200	1.482300	0.050769	1.176300
p-value	[0.8146]	[0.7546]	[0.4403]	[0.1443]	[1.0000]	[0.3057]
Residual based diagnostic						
RBD(2)	2.373560	1.487060	2.150860	3.458030	0.162740	1.241160
p-value	[0.3052023]	[0.4754317]	[0.3411506]	[0.1774587]	[0.9218525]	[0.5376332]
RBD(5)	3.267680	4.037120	12.073300	6.407440	0.213144	10.141800
p-value	[0.6587931]	[0.5440848]	[0.0337964]	[0.2685665]	[0.9989658]	[0.0713154]
RBD(10)	7.532770	4.981760	30.581600	11.643700	0.459238	19.154500
p-value	[0.6743709]	[0.8923929]	[0.0006877]	[0.3096077]	[0.9999956]	[0.0383436]

Note: * shows the 5% level of significance and ** shows significance at 1%. Q-Statistics is the Ljung-Box statistics based on standardized residual and square of standardized residual upto lag 50 with H_0: no serial correlation. LM-ARCH (n) Lagrange multiplier test for ARCH effect up to order n, its H_0: series is not subject to ARCH effect. JB (Jarque Bera) test H_0: series is normal