Volatility in Agricultural Commodity Futures Market: Empirical Evidence from MCX in India

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Abstract:

Price volatility in agricultural commodities has been a key area of interest both in the academia and policy circles. While there has been a consensus that spot prices of many agricultural commodities are influenced by futures prices and also there exist a long-run relationship between the two, the price volatility in these markets continues to be a controversial issue. The evidence is mixed as many studies have revealed that the futures prices are more volatile than the spot while others have argued the opposite. The analysis in most of the studies has been done on the basis of a few selected commodities. This paper expands the analysis by evaluating the movement of prices based on index of all commodities being traded in the futures. Data on daily spot and futures prices have been collected from the Multi Commodity Exchange, Mumbai. In all, trading takes place for 34 agricultural commodities under this exchange. The study begins with an analysis of cointegration and volatility between daily spot and futures agricultural price indices in India from June 2005 to December 2008. The cointegration test and GARCH model are used for the purpose. Finally, the implications obtained from the empirical analysis are drawn.

Key Words: commodity futures, volatility, ARCH and GARCH

1. Introduction

Now-a-days volatility has become a fashionable slogan in financial literature in general and futures trading in particular. Most of the studies have talked about volatility of futures prices as well as spot prices not only in India but also in abroad. Some of them revealed that the futures prices are more volatile then spot (Shively, 1996; Park, 1993) where as Jack (2005) and others have argued that spot prices are more volatile. At the same time Wahl (1996) and others have suggested that in some cases futures prices are more volatile then spot and in other cases it becomes reverse.

Under this backdrop the present study examines the relationship between futures and spot prices and estimates the volatility of both futures and spot prices particularly in

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Indian context. In order to explore this, present paper has been divided into four sections. Section one deals with the theoretical background along with the objective, hypothesis, methodology and data sources. Survey of related literature has been done to ascertain the research gap as well as to substantiate the research findings of the study in Section II. Section III deals with the empirical analysis and result interpretations coupled with concluding remark with the limitation of the study in Section IV.

2. Emergence of Indian Futures Market

Indian farmers' are risk averter than risk lover. Henceforth, in the late 1900s, India guesses futures trading in commodity markets. However, the commodity futures have been in the State of hibernation for the past few decades owing to a lot of government restrictions. Drastically changes in commodity futures took place in 2003-2004. The government issued a notification on 1st April 2003 withdrawing all previous notifications which prohibited futures trading in large number of commodities in the country. This was followed by a notification in May 2003 revoking prohibition on non-transferable specific delivery forward contacts. The futures market was open in anticipation of sound market institution and market design. In order to set up proper markets, the government of India (GoI) on recommendation of forward market commission (FMC) granted recognition to national multi-commodity exchange, Ahmadabad (NMCE); Multi-commodity Exchange, Mumbai (MCX); National commodity and derivative exchange, Mumbai (NCDEX) as nationwide multi-commodity exchanges. Trading commenced as MCX and NCDEX in November 2003 and December 2003 respectively. Every commodity had different set of Mandies to be pooled depending upon the proportion of spot market trade. The total volume of trade in the commodity futures market rises from Rs. 34.84 lakh crores in 2006 to Rs. 36.54 crores in 2007. The volume of growth of trade is primarily propelled by MCX and MCDEX. At present, we have three national level electronic exchange and 21 regional exchanges for commodity trading which allowed 80 commodities for delivery trading.

3. Literature Survey

Park (1993) estimated the price volatility of both spot and futures by using two estimators' i.e natural[2] as well as temporal estimators[3]. Besides this the author has also examined the intraday volatility that is open price and closing price volatility of both spot and futures which is a classic work of the author. The author has concluded from natural and

2. Natural estimator measures the volatility from closing to closing and from opening to opening for 30minutes contracts.
3. Temporal estimator measures volatility during given unit time interval. For more details see cho and frees (1988)

temporal estimator that volatility of opening prices are higher than the closing prices in both spot and futures market. But in order to give suitable reason to this difference the author has suggested it is not due to the trade mechanism rather auction market (futures market) and dealership market (spot market) are responsible for it.

Antoniou and Holmes (1995) have analyzed the impact of futures market on spot prices in commodity market particularly in Chicago by using FTSE index. They have tried to solve the earlier problem of studies like Simson and Ireland (1982) which suggested that futures market has no impact on spot prices. Volatility has used as a risk in authors point of view. Daily basis data for both pre and post-futures prices has been considered for study the impact by using GARCH analysis. The author has concluded that futures market brings more volatility in the spot prices, particularly in daily basis data where as in monthly and annually there is no impact.

Netz (1995) has examined the effect of futures market on spot price volatility particularly in commodity spot market. Besides this the author has suggested the impact of storage which increased at an alarming rate after the introduction of futures market on spot prices. Futures market reduces the risk of storage hence there is lesser volatility in the spot prices with reference to the agricultural commodity markets. In order to examine this author has taken weekly data of wheat spot price of Chicago board and concluded that it is less volatile after futures market. It is due to the increasing of storage facilities which came after the introduction of futures market. An econometric exercise has also been used in order to give support to his findings .At the same time author has also concluded that spot cash price is more volatile than commodity price. But the thing is that no suitable explanation has been given by the author, why and at what point it is more volatile, which requires a suitable and sophisticated methodology.

Hennessy and Wahl (1996) have examined the effect of decision making variables like demand (supply) analysis on futures price volatility. Except the decision making variables, the effect of time period on futures price volatility also appear in authors' analysis. On the basis of data availability, measure agricultural commodity such as wheat, Corn, Soyabean and rice in US have taken into consideration. The result shows that the decision made on the supply (demand) side makes futures supply (demand) response less elastic. Therefore a shock arising after a decision is made is more effect in changing the futures prices than a shock before the decision is made. Regarding the effect of time they have concluded that a contract with high maturity is less volatile than a less matured contract

Koekebakker and Liel (2004) have suggested how volatility in futures prices depends upon the calendar time (seasonality time) as well as maturity time. Authors analysis is nested with the previous literatures and their models. On the basis of this authors have pointed out that volatility in futures prices increases as the maturity time decreases particularly in wheat options. By using non-linear least square method authors have pointed out that wheat options also have jump effect which lead to serious problem in the mispricing of wheat options.

Jacks (2007) examine the effect of futures market on the fluctuations of commodity prices particularly in US commodity market. Author s paper has solved the argument between Populist Party (1890s) and the theorist .The former has argued futures market brings less fluctuation in the commodity prices whereas later argued it bring more. In order to have a solution author has taken an empirical analysis with the data of various commodity prices of before and after the introduction of futures market.

Dahl and Iglesias (2009) have drawn an attention towards the fluctuation in the spot prices with empirical result. Along with they have tried to prove the Muth (1961) theory[4] of rational expectation. For this, authors have used spot price data of various commodities to measure volatility and examine its impact over short run and long run. Result of their model estimation concluded Muth's 1961 don't hold well over long run and it is simply a short run phenomenon.

Author has estimated the coefficient of variation, average monthly change and likely hood ratio test which are unconditional term and concluded that commodity prices are less volatile after the intervention of futures market. The analysis could have better if the authors should have used the more sophisticated methodology for modelling volatility i.e. GARCH.

Most of the studies have analyzed and interpreted the volatility of prices in spot as well as futures market with reference to measure corps in agriculture .Some study also interpreted the effect of international volatility of prices on domestic market but a few of them have examined in Indian Context. The major gap of the study is, no study have included wholesale agricultural price index of both spot and futures and also have not made comparison between the volatility simultaneously. Whether spot prices are more volatile or the futures price. The present study wants to highlight this issue. The advantages of taking an index rather than taking the prices of few major crops is that the

4 Muth 1961 rational expectation theory tells that spot price risk associated with storable commodities has predictive content and should enter the conditional mean function as an explanatory variable in spot price. For further details interested researcher can see Muth.J,1961 Rational expectations and the theory of price movement,Econometerica 29,315-335

former can be used for comparison purposes for non-agricultural trading commodities like Metal index etc whereas the later cannot make such comparisons.

4. Objectives

- To examine the relationship between futures and spot commodity prices.
- To estimate the volatility in both futures and spot prices of the agricultural commodities.

Hypothesis

- Futures prices are more volatile than spot prices particularly in agricultural commodity prices.
- There exhibits a long run relationship between futures and spot prices.

5. Data Sources and Methodology

In order to achieve the above objectives, the study has used Unit root test, co-integration test and ARCH /GARCH model. Brief about methodology has been discussed in section three. Agricultural commodity index has collected from (MCX) which is daily basis covering from 6th June 2005 to 31st Dec 2008. The whole sale commodity index is based on real prices with major agricultural commodities.

In order to support and to fulfil our above objectives this section deals with the empirical analysis with appropriate data and methodology. Some sort of theoretical model for methodology is also explained in this section in order to make the analysis more flavour and vibrant. Interpretation of the result is made in this section also.

Though the study deals with time series analysis, few concepts relating to time series are analysed below, and are worth mentioning.

Unit Root Stochastic Process: it is the nonstationary[5] stochastic process and it is unit root because of $\rho = 1$.

$$Y_t = \rho Y_{t-1} + u_t \qquad -1 \le \rho \le 1 \qquad (1)$$

There are several tests available for testing the nonstationarity but the most celebrated and widely used test is unit root in time series. It includes Dickey-Fuller, Augmented

5 Stochastic process is said to be nonstionary when its mean and variance is time variant, means with the passage of time the value of mean and variance keep on changing. For more details see "applied time series econometrics" by Andres walter,wiley publication,2nd edition.

Dickey-fuller and Philips- perron test to check the presence of unit root in the data. These tests are necessary because the usual student-t test is inappropriate to the test the null hypothesis.

The basic Dickey-Fuller(DF) test examines whether the value of the parameter $\rho = 1$ in equation (3.1) , in other words, the underlying first order difference equation has a unit root by assuming the absence of trend term in equation (3.1)

And rewriting it in modified form we will get

$$\Delta Y^{t} = \mu c + \delta_0 Y_{t-1} + \varepsilon_t \qquad (2)$$

Where, ΔY_t = Y- Y. The null hypothesis is that the {Y} process has a unit root,i.e. H:$\delta=\rho-1=0$. Since $-1 \leq \rho \leq 1$, it follows that $-2 \leq \delta \leq 0$.

More generally, if the given time series follows a P th order autoregressive process[AR(p)] or even autoregressive moving average process [ARMA(p,q)], an extended Dickey-Fuller test called augmented Dickey-Fuller(ADF) test is suggested. Specifically, if the original time series follows AR(p), it can be represented as,

$$Y^{t} = \mu c + \sum \alpha_i \; Y_{t-1} + \varepsilon_t \qquad (3)$$

After some mathematical manipulation, equation (3) can be written as,

$$\Delta Y^{t} = \mu c + \delta \, Y_{t-1} + \sum_{i-2}^{p} \beta_i \, \Delta Y^{t-i+1} + \varepsilon_t \qquad (4)$$

Where, $\delta = -(1 - \sum_{i-2}^{p} \alpha_i)$, $\beta_i = p \sum_{j=1}^{p} \alpha_j$ and ε is white noise.

The ARCH and GARCH model has been used for measuring the volatility of the spot and futures prices of agricultural index in this study. So it is obligatory to discuss the model of ARCH and GARCH here.

Given the information set (Ω), a stochastic process, {Y}, is called autoregressive conditional heteroscedasticity process, if it's time-varying conditional variance, h, is heteroscedastic with autoregression as given below:

$$Y^{t} = \varepsilon_t$$

$$\varepsilon_t / \Omega_{t-1} \sim N(0, h_t) \qquad (5)$$

$$h_t = E(\varepsilon_t^{\,2}) = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \dots\dots\dots + \alpha_q \varepsilon^2_{t-q} \qquad (6)$$

Equation (5) is the conditional mean where regressors can generally be added to the right hand side along with the residuals (εò) and equation (5) is the conditional variance, assumed to be an AR (q) process. Equation (4) and (7) together are called an ARCH (q) model for {Y}.

Bollerslev (1986) has generalized the ARCH (q) process where the time- varying conditional variance is heteroscedastic with both autoregressive and moving average structure. The general GARCH model can be written as:

$$Y^{t} = \varepsilon_t$$

$$\varepsilon_t / \Omega_{t-1} \sim N(0, h_t) \qquad (7)$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \dots\dots\dots + \alpha_q \varepsilon^2_{t-q} + \beta_1 h_{t-1} + \dots. + \beta_p h_{t-p}$$

$$= \alpha_0 + \sum \alpha_i \varepsilon^2_{t-1} + \beta_j h^{t-j} \qquad (8)$$

With α_0>0, 0d" α_i d"1 for I=1, 2......q and 0d" β_j d"1 for j=1, 2.... ...p.

The equation (7) and (8) represent a GARCH (p, q) process where the conditional variance of $εò_t$ has an autoregressive and moving averages component of order q and p respectively. In higher order processes, GARCH model may claim priority over an ARCH model because the former will be more parsimonious than latter in view of the positive (and <1) sign restriction on all the parameters. Bollerslev (1986) has shown that the GARCH process will be stationary, i.e. all characteristics roots of equation (3.9) will lay within the unit circle, provided the process satisfies the finite variance condition,

$$\phi = \sum_{j=1}^{p} \beta_j < 1 \qquad (9)$$

In empirical applications, if the above condition is not satisfied, in GARCH (or in ARCH) model, restriction need to be imposed on the parameters to keep the conditional variance positive and finite. This may not be an easy task. If ϕ>1, it implies that any shock will continue to increase the conditional volatility forever. On the other hand, if =1, then the process is not covariance stationary (Engel and Bollerslev, 1986) and it is known as integrated GARCH (I GARCH) model. In this case, the conditional variance behaves like a random walk and may persist over infinite time horizon. However, the standard asymptotically based inference has been shown to be valid for I GARCH process, even though its covariance is non stationary (Bougerol and Picard, 1992).

In addition to the above commonly used models, there is a few other variance of GARCH process that is used in special cases. These include models, which incorporates asymmetry in volatility in mean equation (ARCH-M or GARCH-M), power ARCH (PARCH) and EGARCH some of these are specially proposed for modelling volatility of financial market variables.

In GARCH model we are ensuring that all of the estimated co-efficient are positive, but it is not necessary to have all positive co-efficient, so if we will allow this condition, we will deal with a new GARCH model, which is popularly known as asymmetric GARCH model or exponential GARCH, i.e. EGARCH.

If we will consider the following equation

$$\operatorname{Ln}(h_t) = \alpha_0 + \alpha_1(\varepsilon_{t-1}/h^{0.5}_{t-1}) + \lambda_1|\varepsilon_{t-1}|h^{0.5}_{t-1}/ + \beta_1 \ln(h_{t-1}) \quad (10)$$

There are three interesting features to notice about the EGARCH model.

1. The equation for the conditional variance is in log-linear form. Regardless of the magnitude of ln (h_t), the implied value of h can never be negative. Hence it is permissible for the co-efficient to be negative.

2. Instead of using the value of εò, the EGARCH model uses the level, of standardized value of εò [i.e. εò dividing by (h)]. Nelson argues that this standardization allows for a more natural interpretation of the size and persistence of shocks. After all, the standardized value of εò is a unit-free measure.

3. The EGARCH model allows for leverage effects. If ε/ (h) are positive, the effect of shock on the log of the conditional variance is $\alpha + \lambda$. If ε/ (h) is negative, the effect of the shock on the log of the conditional variance is $-\alpha + \lambda$.

Although EGARCH model has some advantages over general GARCH and TGARCH model, but it is difficult to forecast the conditional variance of an EGARCH model.

In regressing a time series variable or another time series variable, we may obtain a very high R-square but there is no meaning full relation between two variables. So it is the problem of spurious regression. That is they are not co-integrated but over long run their linear combination may be linear i.e. they are co-integrated.

There are several methods to test conintegration but here the study has used simple ADF test which is meant for a two variable analysis.

The present study has been tested with daily data series covering 6th June 2005 to 31st December 2008. Data has been collected from the sources of the MCX. Selected variables like wholesale agricultural index of both spot and futures prices has been taken as variable for the study.

6. Econometric Results and Interpretation

At first stationarity test (unit root test) has been employed in order to make the variable stationary. Before that the variable has transfer into logarithm to avoid heterosecdasticity problem.

The table given below shows that at level both LSAGRIDEX and FAGRIDEX are nonstationary which is evident from the p-value.6 But at 1st difference both are stationary i.e. they are integrated of order one. The whole study has used p-value as tool to justify the result. P-value less than 10 percent is significant.

Table 3.1 Unit Root Test- Augmented Dickey-Fuller Tests

Variables	Level	1st order difference	Inferences
LSAGRIDEX	-0.004253 (0.140)	-0.92(0.00)	I(1)
LFAGRIDEX	-2.78(0.144)	-7.35(0.00)	I(1)

Note: the parenthesis shows the p- value against the t-statistics.

LSAGRIDEX=log of spot prices of agricultural commodity index

LSAGRIDEX = log of futures prices of agricultural commodity inde

Result of the Co-integration test (ADF test)

By regressing two nonstationary data we will get the following result

Variables	value of R^2	D-W-statistics	inferences
LSAGRIDEX (Dep. Variable)	0.89(0.00)	0.13	R^2>d
LFAGRIDEX(Ind. Variable)			

Note: the parenthesis shows the p- value against the t-statistics. d=value of D-W-statistics

The above result show that the regression is spurious(R^2>d) however their linear combination over long run is tested below.

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6. P-value is nothing but the exact probability of commiting the type-I error. Lower the p-value , higher the significance but in some cases it may not hold good, it depends upon the hypothesis which you have considered as null hypothesis. For details see Gujurati,D,N. "basic econometrics", 4th edition, Tata McGra-Hill .

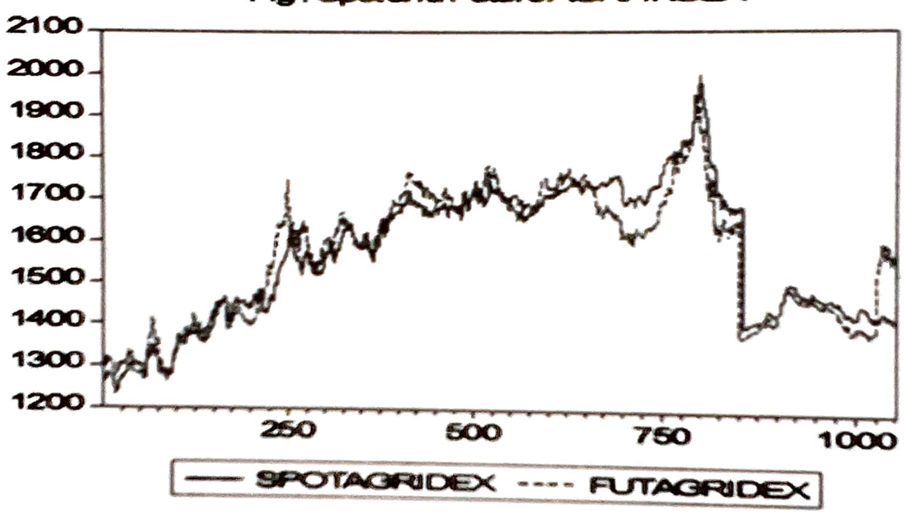
ADF test result for cointegration

Variables	value of co-efficient	R^2	D-W-statistics	inferences
Est. residual (Dep.Var.) Lag(1) of residual(Ind.Var)	0.93(0.00)	0.87	1.91	cointegrated I(0)

Note: the parenthesis shows the p- value against the t-statistics.

From the above result it is clear evident that over long their linear combinations is integrated. i.e. both futures and spot prices exist a relationship over long run.

Fig : Spot and Future AGRI-INDEX



This figure shows that there exhibits a relationship between spot and futures prices of agricultural index i.e.-they are cointegrated which has also shown on the above table.

Test of volatility in spot and futures prices

Volatility of both commodity prices has been tested by employing GARCH model and the results are as follows.

Volatility in spot prices (LSAGRIDEX)

The volatility of LSAGRIDEX has test with asymmetric GARCH analysis which is popularly known as EGARCH model and it has already explained in the theoretical model set ups. It follows EGARCH (1, 1) for LSAGRIDEX which is as follows

$X_t = \beta_1 X + \beta X + \beta_3 \varepsilon + \varepsilon$, where X_t = 1st first difference of LSAGRIDEX (3.12)

σ= μ+ ρ ε+ε+ δ σ (12)

ε /&! ~N (0, h) t=1, 2, 3..........

Table given below, β, β and β are the slope coefficient of the AR (1) ,AR (2),and MA (1), respectively. μ is the intercept term of the GARCH model and it is statistically significant. The ρ is the slope coefficient of ARCH which shows that, it is highly statistically significant and δ is the slope coefficient of which shows that, it is statistically significant also. The Q refers to the Ljung-Box statistics. The above table shows that, there is complete absence of serial correlation in the mean equation at lag order Q (7), Q (10) and Q (12). There is also absence of serial correlation in the variance equation in the same lag order. The conditional variance of LSAGRIDEX which is capture from the estimated EGARCH (1, 1) model is given in the following figure.

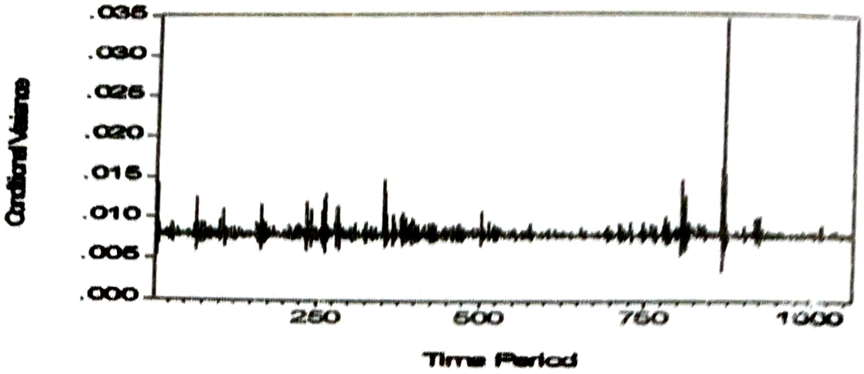
Table 3.4 EGARCH (1, 1) Estimates of LSAGRIDEX

Coefficient	Values
β_1	-0.71(0.04)
β_2	0.05(0.01)
β_3	0.75(0.03)
μ	-9.94(0.00)
ρ	-0.34(0.00)
$\lambda_{1\ 3}$	0.39(0.00)
δ_4	0.38(0.00)
Q(7)	3.59(0.16)
Q(10)	3.68(0.59)
Q(12)	9.99(0.18)
Residual square	
Q(7)	3.73(0.15)
Q(10)	5.05(0.41)
Q(12)	5.05(0.65)

Note: the parenthesis shows the p- value

The following conditional variance graph of LSAGRIDEX shows that in the month of March 2008 it is more volatile. The cause for volatility is not mentioned in the study. It is simply an empirical analysis.

Fig-1 Conditional Variance of Spot AGRI-INDEX



Volatility i

The LFAGRIDEX also follows an asymmetric GARCH model (EGARCH) i.e. EGARCH (1, 1) which is as follows

$Y_t = \beta_1 Y_{t-1} + \beta_2 \varepsilon_{t-1} + \varepsilon$, where Y_t = 1st first difference of LFAGRIDEX (13)

$\sigma = \mu + \rho\ \varepsilon + \varepsilon + \delta\ \sigma$ (14)

εò /&! ~N (0, h) t=1, 2, 3..........

Table given below, β, β and are the slope coefficient of the AR (1), and MA (1), respectively. μ is the intercept term of the GARCH model and it is statistically significant. The ρ is the slope coefficient of ARCH which shows that, it is highly statistically significant and δ is the slope coefficient of which shows that, it is statistically significant also. The Q refers to the Ljung-Box statistics. The above table shows that, there is complete absence of serial correlation in the mean equation at lag order Q (9), Q (14) and Q (16). There is also absence of serial correlation in the variance equation in the same lag order. The conditional variance of LFAGRIDEX which is capture from the estimated EGARCH (1, 1) model is given in the following figure.

Table 3.4 EGARCH (1, 1) Estimates of LFAGRIDEX

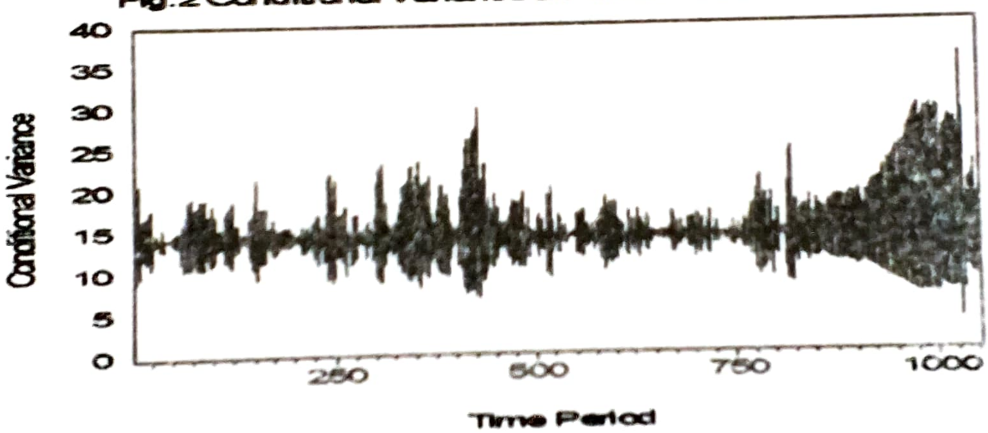
Coefficient	Values
β_1	-0.71(0.04)
β_2	0.05(0.01)
β_3	0.75(0.03)
μ	-9.94(0.00)
ρ	-0.34(0.00)
$\lambda_{1\ 3}$	0.39(0.00)

δ_4	0.38(0.00)
Q(7)	3.59(0.16)
Q(10)	3.68(0.39)
Q(12)	9.99(0.18)
Residual square	
Q(7)	3.73(0.15)
Q(10)	5.05(0.41)
Q(12)	5.05(0.65)

Note: the parenthesis shows the p- value

The following conditional variance graph of LFAGRIDEX shows that in the month of March 2008 it is also more volatile. But the volatility is more evident in futures prices than spot prices it is because, spot prices are regulated prices. Government takes necessary steps like MSP to control the fluctuation of spot prices. on the other hand futures prices are greatly affected by external shocks like exchange rate volatility etc.

Fig.2 Conditional Variance of Future Price of AGRIINDEX



7. Conclusion

From the above econometric analysis it is concluded that volatility is present both in spot and futures prices but it is more in futures prices than in spot prices. So any shock that arises outside or inside the system is affecting the futures prices more than the spot prices. Along with this the result of the unit root test and cointegration test tells that both variables are integrated of order one and have long run relationship between the two respectively. On the basis of the previous studies and the gap of the studies, the present study has explored the thing in a slight different way which is new one. The study has taken agricultural commodity index rather than by taking prices of the major crops. Suitable and sophisticated econometric tools are also used to make the analysis more interesting and vibrant. Except the numerical results the study has also presented a graphical interpretation in order to bring attention to the analysis. The major findings of the study are futures commodity prices are more volatile than spot commodity prices and they exhibit a long run linear relationship between the two. The limitation of the study could be only agricultural commodity index has been taken into consideration and very limited time period.

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