Econometric analysis of cointegration and causality between agricultural spot and futures market in India: A case study of Raw Jute market in India.

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Abstract:

The aim of the study was to investigate the cointegration and causality between spot and futures market of raw jute market traded in NMCE during the period 01/01/2016 to 31/03/2018 using various econometric tools. The Johansen's cointegration test is used to analyse the cointegration relationship between the markets. The results reveal that both markets are co integrated in the long run. The causality between the markets was analysed using Granger causality test. The results reveal that there is a bi directional causality relationship between future and spot markets of raw jute. The study suggests that the farmers, traders, producers and policy makers should maximum prudence while investing in futures market and they should watch the spot prices vigilantly as the error correction model reveals that price changes are first reflected in spot market, which is then reflected in futures market.

Keywords: Econometric tools, Cointegration, Causality, Commodity Market

1. INTRODUCTION

Jute considered as golden fiber and is also called as fiber of the future. A Jute year commences on 1st July and ending with 30th June the following year. The largest producer of jute in the world is India accounting for about 60% of world's jute production. India has been exporting jute and fiber products for over a century, with Bihar and West Bengal which accounts for 50% of the total production in India. Jute is grown in around 1 million hectares of land in India and the worth of the produce is approximately equivalent to Rs.1500 crores. The approximate size of jute industry including the raw jute will amount to an incredible Rs.4500 crores. Over 4 million families are involved in cultivation of jute in India. There are over 76 jute mills in India. India produces its own jute seeds where state Seed Corporation of Andhra Pradesh and Maharashtra generates more than 90 percent of seeds. India imports jute to USA, UK, South Africa and Belgium which accounts for 25% of the total India's production of jute. Other countries like Bangladesh, China, and Myanmar are other significant exporters of jute. The world production of Jute is roughly around 3 million tonnes which amount to approximately 24-25K Rs. crores. The future contracts of jute are standardized products with specified specifications and quality, which is decided to be delivered at the desired location on the expiry of contracts. As these contracts are backed by commodity exchanges, there is an elimination of counter party risk.

2. REVIEW OF LITERATURE

(Swain & Samal, 2015) analysed the price discovery process of raw jute using daily spot and futures prices traded in NMCE for the period 2010 to 2014. The study revealed that the market is co integrated in the long run and the prices are first discovered in spot markets of raw jute.

(Vimal, 2015) analysed efficiency of agricultural commodities using cointegration and causality tests by using seven agricultural commodities(wheat, castor seed, jeera, chilly, pepper, mustard and soya bean) traded in NCDEX. The results confirm long relationship between futures and spot market for the selected commodities. Granger causality revealed a unidirectional causality, where futures market prices lead to spot prices for wheat, castor seed, and jeera as compared to chilly, pepper, mustard, and soybean, where bi-directional relationships existed in the short run.

(Amarante, et al., 2018) explored the existence of cointegration and causality between the market price of the live cattle in Brazil and the prices of the respective derivatives traded on BM&FBOVESPA – São Paulo, Brazil. The johansen cointegration test revealed and an existence of cointegration and the granger causality tests showed bidirectional causality indication to decision-makers in this agribusiness that the deviations in BM&FBOVESPA futures contracts cause changes in the prices of the spot prices, as well as the spot prices cause to the futures contracts of B&MFBOVESPA.

(Amin, Murshed, & Chowdhury, 2018) analysed the causal relationship between exchange rate of Bangladesh and its macro fundamentals such as money supply, Interest rate, GDP, Inflation etc. using annual time series data from 1980 to 2015. Johansen Cointegration test is used to analyse long run association between the variables. The study used Vector error correction model and granger causality to analyse the causality relationship between the variables. The study revealed that GDP and interest rate are influencing exchange rate in the long run while Money Supply and Inflation are found to be ineffective.

(Sahu, Dey, Sinha, Singh, & Narsimaiaha, 2019) analysed the price discovery mechanism of four major spices (chilli, turmeric, cumin and coriander) traded in National Commodity and Derivative Exchange (NCDEX)by discovering the spread of price information between spot and futures markets during the period October 2015 to April 2017. Along with other statistical tools, econometric methods such as Cointegration test, Granger Causality test, Vector Error Correction Model (VECM) are used in evaluating the movement of price between spot and futures market. Cointegration analysis reveals long run associationship between spot and futures prices in chilli, turmeric, cumin. The study identifies both spot and futures market play leading role in the price discovery process and are informationally efficient in reacting to each other. On the other hand uni-directional causality is evident from futures to spot price in case of coriander.

From the above review of literature, it can be seen that even though there are lot of cointegration and causality studies on agricultural commodities, but studies on raw jute market is very few. As a major exporter and manufacturer of raw jute, and the development of commodity markets with technological advancements, studies on the raw jute futures and spot market is very relevant and needed, hence the study have been taken up.

3. DATA AND METHODOLOGY

3.1 DATA

The present study is based on daily spot and futures price data of raw jute collected from NMCE (www.nmce.com) from January 2016 to March 2018. The data have been converted into their log forms to reduce the heteroskedastic nature.

3.2 METHODOLOGY

The methodological process starts with a brief note on stationary and non-stationary time series data followed by testing of unit root i.e. stationarity test.

3.2.1 TEST OF STATIONARITY

Before testing for cointegration, the time series must be checked for stationarity. A time series is said to be stationary if its mean and variance are constant and independent of time and co variances depend only on the distance between time periods and not on time periods per se. These conditions imply that mean and variance of the stationary series remains constant over time. The stationarity properties and exhibition of unit roots in the time series are substantiated by performing Augmented Dickey Fuller tests. This test is conducted on the variables in original price series and first differences. The variables that are integrated in the same order may be co integrated, while the unit root tests find out which variables are integrated of same order, for example; if integrated by order one, which is denoted as 1(1).

For testing stationarity, Augmented Dickey-Fuller method is applied where study variable , Yt can be expressed in following manner:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \epsilon_t, \quad \text{……(1)}$$

where, Yt is a vector to be tested for cointegration, t is time or trend variable, $\Delta Y_t = Y_t - Y_{t-1}$ and ∈t is white noise error term, α0 is constant and α1 is the coefficient of trend. The null hypothesis that δ = 0 signifying presence of unit root, i.e., the time series is non-stationary and the alternative hypothesis is δ = 0 signifying the time series is stationary, therefore, rejecting the null hypothesis. The required test statistics

$$DF_{\tau} = \frac{\delta - 1}{SE(\delta)} \quad .....(2)$$

The value of the test statistic computed and compared with relevant critical values for Dickey-Fuller test.

3.2.2 JOHANSENS COINTEGRATION TEST:

To analyse the nature of long-run relationship between spot and the futures market for precious metals market, Johansen's cointegration test is performed. One of the preconditions for using the cointegration test is that the data must be stationary at first difference and not at levels. Johansen Cointegration test can be conducted through the *k*th order vector error correction model (VECM) represented as

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-1} + \nu + \varepsilon_t \quad ....(3)$$

Where, Yt is $(n \times 1)$ vector to be examined for cointegration, $\Delta Yt = Yt - Yt\text{-}1$, ν is the vector of deterministic term or trend (intercept, seasonal dummies or trend), Π and Γ́ are coefficient matrix. The lag length k is selected on minimum value of an information criterion1. The existence of cointegration between endogenous variable is tested by examining the rank of coefficient matrix Π. If the rank of the matrix Π is zero, no cointegration exists between the variables. If Π is the full rank (*n* variables) matrix, then variables in vector *Yt* are stationary. If the rank lies between zero and *p*, cointegration exists between the variables under investigation. Two likelihood ratio tests are used to test the long run relationship

- The null hypothesis of at most r cointegrating vectors against a general alternative hypothesis of more than r cointegrating vectors is tested by trace Statistics. Trace statistics is given by

$$(\lambda - \text{trace}) = -T \sum_{i=r+1}^{n} \ln\left(1 - \tilde{\lambda}\right)_i \quad ......(4)$$

where T is the number of observations and λ is the eigenvalues.

- The null hypothesis of *r* cointegrating vector against the alternative of *r* + 1 is tested by Maximum Eigen value statistic Maximum Eigen Value is given by

$$(\lambda - \max) = -T \ln\left(1 - \lambda_{r+1}\right) \quad ......(5)$$

3.2.3 VECTOR ERROR CORRECTION MODEL

The existence of an cointegrating equation implies that price relationship between futures and prices can be represented by Error Correction Model. A form of restricted VAR is the vector error correction (VEC) model. It can be used on non-stationary series which are known to be co integrated. It allows short run adjustment dynamics while restricting the endogenous variables long-run behavior of converging to their cointegrating relationships. Since it includes the correction of the deviation from long-run equilibrium gradually by making partial adjustments in the short run it is called error correction. (Yadav et.al 2014). After identifying single cointegrating vector, between spot and futures prices of copper, the Vector Error Correction Model was applied the long run and short run causality between spot and futures prices. It can be represented as below:

$$\triangle Spot = c1 + \sum_{k=1}^{n} \alpha_{li} \triangle Spot_{t-k} + \sum_{k=1}^{n} \beta_{2i} \triangle Fut_{t-k} + \rho_1 ECT_{t-1} + u_{1t} \quad ...(6)$$

$$\triangle Fut = c2 + \sum_{k=1}^{n} \beta_{li} \triangle Fut_{t-k} + \sum_{k=1}^{n} \alpha_{2i} \triangle Spot_{t-k} + \rho_2 ECT_{t-1} + u_{2t} \quad ....(7)$$

Where $Spot_t$ and Fut_t are spot and future prices of the commodity at time t. u_{1t} and u_{2t} are the white noise disturbance terms and ECT_{t-1} is the lagged error correction term. (Sharma 2015).

3.2.4 GRANGER CAUSALITY TEST:

The Granger causality test is a statistical hypothesis test for determining whether one time series is useful in forecasting another. This study examines the lead-lag relationship between futures trading activity and cash price volatility using Granger Causality (1969) test. The dynamic linkage between the futures prices series and the spot prices series is given by the Pair-wise Granger Causality tests (Granger, 1986). With the prerequisite of testing stationary done, the widely-accepted Granger causality test is deployed to detect the direction of relationship between two variables (Granger, 1969) Estimation of two basic VAR tests the causal relationship.

$$y_t = \beta_0 + \sum_{k=1}^{M} \beta_k y_{t-k} + \sum_{l=1}^{N} \alpha_l x_{t-l} + u_t \quad ....(8)$$

where *xt* and *yt* are two variables at time '*t*'; *k* and *l* are the number of lags; β0 is deterministic; *ut* is an error term; α and β are coefficients on the lagged *x* and *y* values, respectively.

$$x_t = \gamma_0 + \sum_{k=1}^{M} \delta_k y_{t-k} + \sum_{l=1}^{N} \gamma_l x_{t-l} + v_t \quad ......(9)$$

xt and *yt* are two variables at time '*t*' and *t* denotes the time period and *k* and *l* are the number of lags; γ0 deterministic; *vt* is an error term; δk and γ*l* are coefficients on lagged *y* and *x* values, respectively. The null hypothesis is α= 0 for all *l*'s and □δ*k* = 0 for all *k*'s versus the alternative hypothesis that α*l* ≠0 and δk ≠ 0 for at least some *l*'s and *k*'s. If the coefficient α*l*'s are statistically significant but δ*k*'s are not, then *x* causes *y;* in the reverse case, *y* causes *x*. But if both α*l* and δ*k* are significant, then causality is bidirectional.

4. RESULTS AND DISCUSSION

4.1 AUGMENTED DICKEY FULLER TEST

Table 1: Results of ADF tests

	Spot at level	Spot at 1st differencing	Futures at level	Futures at 1st differencing
ADF test statistic	-1.723	-9.044	-1.758	-7.613
P Value	0.418	0.000	0.401	0.000
Conclusion	Non Stationary	Stationary	Non Stationary	Stationary

The results reveal that all the variables are non-stationary at level. But they are found to be stationary at their first difference. Therefore, necessary condition for cointegration is satisfied. So Cointegration test is performed to examine the long run relationship between spot and futures prices of raw jute and the results are presented in table:2

4.2 JOHANSEN'S COINTEGRATION TEST

To analyze the nature of long-run cointegrating relationship between spot and the futures market for raw jute futures market, Johansen's cointegration test is performed. One of the preconditions for using the cointegration test is that the data must be stationary at first difference and not at levels. The results of cointegration tests are presented in the table 2.

Table 2: Johansen's cointegration test results

Vector(r)	Trace Statistics (λ_{trace})	Maximum Eigen Value(λ_{max})	5% Critical Value for Trace Statistics	5%Critical Value for Max.Eigen Statistics	Remarks
H_0 r=0	25.976	22.470	15.494	14.264	Cointegrated
H_1 r≥1	3.505	3.505	3.841	3.841	

The results reveal that there is at most 1 cointegrating equation between the variables. Both trace statistics and maximum Eigen values support the presence of cointegration. So, it has been concluded that there is long run cointegration relationship between spot and future of raw jute.

Table: 3 Results of long run causality analysis

Long run Causality Analysis						
		Coefficient	Std.Error	t-Statistic	Probability	Inference
Raw Jute (Dependent variable: Spot price)	C (1)	-0.0367	0.025	-1.494	0.135	S→F
Raw Jute (Dependent variable: Future price)	C (1)	-0.077	0.021	-3.638	0.000	

Table 4: Short run causality results

Wald test results					
	Test Statistic	Value	df	Probability	Inference
Raw jute (Dependent Variable: Spot price)	F-statistic Chi-square	2.011 4.022	(2, 543) 2	0.135 0.134	S→F
Raw jute (Dependent Variable: Future Price)	F-statistic Chi-square	17.655 35.310	(2, 543) 2	0.000 0.000	

From the above table 3 and 4, it can be seen that the error correction term C (1) is having a negative sign for both future to spot and from spot to future. But it is significant only for spot to future, this means that there is a long run causality running from spot price to future price, and the long run causality is not present from future to spot prices as the p value is greater than 0.05. This reveals that for raw jute, future price plays a lead role in price discovery process and the prices are discovered first in futures market. Short run Causality is checked using Wald test and the results confirm the presence of short run causality running from spot to future but not from future to spot. The causality is further examined using Granger causality test

4.3 GRANGER CAUSALITY TEST

Null Hypothesis:	F-Statistic	Prob.
Spot does not Granger Cause Future price	30.0930	0.0000
Future price does not Granger Cause Spot Price	2.46058	0.0863

Granger causality test reveals that there is a unidirectional relationship between future price and spot price. The test reveals that Spot price influence future price but future price does not influence spot price. This shows that spot prices of raw jute can be useful to predict the future prices of raw jute. The results confirm that price discovery function of raw jute market is done by spot market.

5. CONCLUSION

The cointegration and causality analysis of raw jute have been done using Johansen's Cointegration technique along with VECM and wald test. The empirical analysis was done on the daily time series during the period 01/01/2016 to 31/03/2018. Using ADF test, it was found that all the variables are stationary at their first difference. Johansen's Cointegration test revealed there is a long run equilibrium relationship between the futures and spot prices. Further, VECM and Wald test are used to find out the long run and short run causality between the variables. The analysis revealed that there is a presence of long run and short run causality running from spot to future prices and there is an absence of long run and short run causality from future to spot. The causality is further confirmed by granger causality test, where the null hypothesis spot prices does not granger cause future price is rejected. So, study confirms that spot prices can be useful to predict future prices and price discovery function is done in the spot market of raw jute. These findings have important implications for farmers, traders and investors as they have to consider the movement of spot prices of raw jute closely as any changes in spot prices is transferred to the future prices and they should use spot prices to find the future prices of raw jute.

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