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Coffee price dynamics: Volatility, Causality & Co-integration in spot and future markets

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ABSTRACT

Commodity market is a place which creates platform for market participants to trade in commodities to hedge their positions from contingencies. The financial experts & researchers had always been captivating on the association between spot price & future price across various investments, regions & countries over the past several decades. There is a necessity for a robust mechanism & framework in agricultural commodity derivatives due to its transition over the years. So, the author gathered secondary data (i.e. daily closings of spot & futures for 6 years) from well-known exchanges. In this paper the author evaluates the relationship between spot & future prices for coffee by considering the dataset of 6 years. The mission of this paper is to investigate the volatility, causation & co-integration between 2 variables (i.e. Spot & Future prices of Coffee). The study determines the volatility in the prices & also the long run relationship between spot & future prices. Based on these observations the farmers, traders & government can make suitable decisions in order to hold positions or to liquidate and also to make required changes in the policies respectively.

KEYWORDS: Spot Price, Future Price, Volatility, Causation, Co-Integration

INTRODUCTION

Commodity market has witnessed a drastic change in India over the previous two centuries. The very first futures trading in India was during the year 1857 and Cotton holds the first position in commodity trading. For several decades; that is, from 1952 to 2002 the markets could witness a ban on commodity derivatives trading & cash settlement, very few negligible activities carried on OTC basis. “Khusro committee (1980) and Kabra committee (1993)” suggested introduction of future trading in agricultural commodities as there was unusual speculation which might lead to rise in food prices in the country. The determination of prices & management of risk for agricultural commodity is possible in futures contract/trading, hence there is no need for the farmers to wait for longer duration in-order to get better prices, as futures market gives an opportunity for both the parties (i.e. farmer & buyer/dealer) to enter into a contract to fulfil their obligations at a pre-determined future price & date, on the other hand the parties can use spot market to close the trade on spot/immediately if the wish to liquidate their holdings/positions. Three national exchanges were given the permit to trade in the market, believing that the farmers & other stakeholders will be headed towards the right direction to make efficient decisions. The lead lag relationship between spot & futures markets is influenced by the dissemination of new information which helps in price discovery process. Futures market plays a vital role in discovery of prices for underlying spot market (Lien and Tse, 2000). In this paper the author examines the efficiency of selected commodity, by assessing the spot & futures prices.

REVIEW OF LITERATURE

Price Volatility;

Setiawati & Taufikurohman (2021), suggests the ARCH – GARCH model to be the best fit to estimate the price volatility for staple foods in Kebumen Regency. The market forces along with the policies results in volatility of staple foods in the market. The author concludes by saying that, the government need to implement MSP to protect the farmers & people so that the commodity market will witness a transition at global levels. Kaura & Rajput (2024); observes that the behaviour of non-agricultural commodity & agricultural commodity

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are totally indifferent. The futures market plays the dominant role in non-agricultural commodity market and spot market plays a crucial role in agricultural commodity market. The author also highlights that, the new information dissemination will influence the future market more evidently than spot market in non-agricultural commodity market which directly impacts the decision/positions of the traders. The author also concludes that the futures market is more efficient and mature in non-agricultural commodity markets. Similarly, the spot market will be highly beneficial in agricultural commodity markets as the farmers are unware about the futures market and they actively deal with the physical market. Sahadudheen & Kumar (2023) found that there exist a strong & consistent relationship between net oil & gold, where the relationship is positive. The author concludes that, the volatility spillover differs across various periods & the relationship have strengthened during the crisis period. Wu et al (2017), highlights the usage of forecasting models like ARIMA & GARCH, which can be used to predict the large number of data sets. The author concluded that, the results generated are accurate, helps in making policies & creating value to the consumers. RL & Mishra (2020), in their study considered 9 most liquid agricultural commodities traded in NCDEX. The author found that the variables were co-integrated in the long run and futures dominated the markets in price discovery. The author concluded that, there exist a lead-lag relationship between spot & future prices where futures drives the market and also helps in price formulation & market strategies for both producers as well as consumers by taking advantage of availability of information. Rout et al (2021), employed comparative analysis between 5 agricultural & 5 metal commodities by considering the data during 2010-15. In this study the author found that spot price leads the future price in agricultural commodities (Backwardation), on the contrary future price leads the spot price in metal commodities (Contango). The players in the commodity market will take the positions according to Contango & Backwardation effect.

Causality - Spot & Futures;

Samal et al (2020) in his study says that, the theories will not be sufficient to determine the price movements. Author also found the Granger causality test to be more evident in order to speculate the causation effect between spot & future prices for the commodities. The study also emphasize on the short run dynamics of spot & future prices which improves the efficiency in price discovery process. Vijaykumar (2018) observes that the spot price of pepper is influenced by the futures price and also points out that there is no causal effect on future price by spot price. The study indicates the transparent mechanism for discovery of price at domestic derivatives exchange. Pradhan et al (2021) said that, the lead lag relationship between spot & future prices in commodity market includes various economic factors such as "interest rate, exchange rates, convenience yields, supply of money, uncertainty in monetary policy, stock prices, global & monetary liquidity conditions, spillovers in asset prices & capital flows." There is a need for alternative strategies to determine the directionality of spot & future prices in both short & long run. The spot market does not react quickly as futures because they are exposed to flexibility in short selling & low transaction cost. Raghavendra et al (2016) concluded that soybean & chana have unidirectional linkage from future to spot prices. However the other 3 agricultural commodities (i.e. Maize, Jeera & Turmeric) has bidirectional relationship between both future & spot prices. According to Raghavendra & Mani (2024) the outcomes of the Engle Granger Causality test reveals that there is a strong evidence to suggest the existence of long term relationship between spot and future price of Jeera, Barley and Castor-seed.

Co-Integration - Spot & Futures;

Singhal et al (2019) highlights the significant role of crude oil in shaping the changes in exchange rates & stock market index of Mexico. Minakshi (2018) concludes that the 2 variables move in different direction by considering spot & future prices of Chilly contract for the month of April 2009. To test the correlation the author employed co-integration test and founds out that there is no presence of long run relationship between spot & future prices of Chilly. Kailarasi et al (2023) by testing for correlation between spot & future prices he revealed both positive & negative relationship before and during covid-19 pandemic. The author concluded by saying that the relationship will not be constant over the year and the Indian commodity derivatives market can be used as a hedging tool to diversify the risk during crisis period. Nandini (2018) states that in India the futures market are not so developed because of "high volatility, low participation due to large lot size, high margin & membership fees etc.." and spot markets holds the dominant position in price discovery process.

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Henceforth there is a further scope for improvement in the developing economy like India for futures market. Kapor & Mittal (2022), focused on the dynamic relationship between variables. The author concluded that, there exist a long term association between variables but in short run there is no relationship between the variables. So the investor/trader need to consider all the factors which influences the price of commodities.

R Ranjith (2022) said that, the growers mainly dominate the production of goods. As the Indian population is mainly engaged in agriculture, it is advisable to provide attractive trading to the growers participating in futures trading, so development and reform towards 'growers-inclusive trade practices' is needed in the sector today. Aggarwal et al (2014), highlights the advantages of hedging effectiveness and also addressed the disputes that the participants faced in commodity trading. The issues such as "low credibility of warehouse receipts, lack of standardization of underlying commodities and mismatch between grades available & grades to be delivered". Also the state government holds significant control on the inventories held by traders, supply of commodities & suspension of trading in derivatives. Palaniappan & Armah (2017), considered 15 agricultural commodities for this study and carried co-integration, price causality & volatility. Out of which majority of the commodities had long term relationship, causation effect (both unidirectional & bidirectional) & price volatility between spot & future prices. The author concluded that, all these fluctuations were due to information dissemination/information flow from both the sides and both (spot & futures) are equally responsible for price discovery. By taking into consideration the above factors the decision making process & policy making will be more precise. Ahola (2023), speaks about the developments in logistics & information technology which creates opportunities. By stressing on supply chain management the commodity market can enter global markets. The author focuses on the challenges faced at the global market with regards to readiness & expertise to participate at global levels. The author concludes that, the actual challenge lies in geographical differences between the physical commodity market & futures market. Aragaw & Kebede (2019), found that storage, grading, market information provision & market development significantly influences the export performance. All the selected dimensions have a positive impact on dependent variable & export performance is correlated with independent variable. The author highlighted that the Ethiopian commodity exchange has a prominent role in enhancing the performance of its coffee exports with the help of "price discovery, facilitation of physical commodity trade, storage, grading, enabling competition, market development & market information provision. The author concluded that, few services of Ethiopian commodity exchange with regards to storage, grading & other facilities was below average which needs further improvement to stimulate the performance of exports.

OBJECTIVES

With reference to ICE data, the following have been formulated as the objectives for the study;

- To evaluate the volatility of spot & future prices of Coffee.
- To analyze the causality between spot & futures prices of Coffee.
- To estimate long run relationship between spot & future prices of Coffee.

DATA AND METHODOLOGY

In the current study the researchers has used daily closing prices of futures & spot for Coffee and the prices was collected from the leading commodity exchange (i.e. Inter-Continental Exchange) for the time period of 6 years (i.e. January 2018 to December 2024). Descriptive statistics are employed such as 'mean, standard deviation & co-efficient of variation'. In this study to verify the stationarity of spot & futures prices the authors used "Unit root tests based on Augmented Dickey Fuller test (ADF) & Phillips-Perron test (PP)" and to evaluate the volatility "ARCH - LM test" is employed. "Engle Granger Causality test" was employed to show the causation effect between spot & future prices. Johansen Co-Integration test was employed to estimate the long term relationship between spot & futures market.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1: Descriptive Statistics of the agricultural commodities

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		Mean	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
Coffee	SPOT	1.571798	0.568829	0.435946	2.906855	57.44112	0.0000
	FUTURE	1.596679	0.551280	0.616480	2.483217	133.5229	0.0000

The mean value of future price of Coffee is higher than the spot price. Standard deviation which measures the volatility shows that the spot price of Coffee is more volatile than future price of Coffee. Normality test using Jarque Bera shows that data attained that normality at 1%. It is found that, the skewness for Coffee to be positive and kurtosis is the measure of the peakedness of a dataset.

Unit Root Test

Unit root test is essential to determine the stationarity of variables at both levels & first difference. To prove the stationarity the author has used Augmented Dickey Fuller (ADF Test) & Philips-Perron (PP Test). Both ADF & PP test assumes non-stationarity for null hypothesis & stationarity for alternative hypothesis.

Table 2: Results of Augmented Dickey Fuller Test (ADF)

ADF Test		
Commodity	Level	1st Difference
Coffee	t-statistic	t-statistic
SPOT	-12.56682 (0.0000)***	-17.09823 (0.0000)***
FUTURE	-17.47169 (0.0000)***	-15.52982 (0.0000)***

*Note: *** denotes significance at 1%, 5% & 10% level, respectively.*

As seen from the above results, the ADF test revealed that both spot & future prices were stationary at level & also at 1st difference for Coffee, since p-value was significant the null hypothesis got rejected.
Results indicate that coffee prices were stationary at 1st differencing for both spot & futures. Hence, the ARCH test can be employed for further rigorous analysis.

ARCH Test

ARCH test emphasizes on volatility of prices over the period of time. The basic condition is to conduct unit root test to check for stationarity at 1st difference & later can proceed with ARCH model to evaluate the volatility.

Table 3: Results of ARCH Test

Commodity	Category	Estimate	Test Statistic	Distribution	Probability
Coffee	Spot Price	F-statistic	0.009265	Prob. F(1.1789)	0.9233
		Obs* R-squared	0.009275	Prob. Chi-Square (1)	0.9233
Coffee	Future Price	F-statistic	1.67	Prob. F(1.1789)	0.9990
		Obs* R-squared	1.67	Prob. Chi-Square (1)	0.9990

H_0: There is no heteroscedasticity in spot & future prices.
H_1: There is a heteroscedasticity in spot & future prices.
Table 3 the result of ARCH LM test shows that the P value is greater than 0.05. So there is a no heteroscedasticity in both spot & future prices of coffee, which means that the changes/error term is homoscedastic (changes are constant over time).
Equation: $\sigma^2_t = \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \varepsilon^2_{t-2} + \ldots\ldots\ldots\ldots + \alpha_p \varepsilon^2_{t-p}$
σ^2_t is the conditional variance at time t.

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α_0 is a constant representing the unconditional variance.
$\alpha_1, \alpha_2, ..., \alpha_p$ are coefficients for the lagged squared errors ($\varepsilon^2_{t-1}, \varepsilon^2_{t-2}, ..., \varepsilon^2_{t-p}$).
ε_t is the error term at time t.
p is the order of the ARCH model (number of lagged squared residuals).

Engle Granger Causality Test using VAR

Granger Causality test is helpful to verify the usage of one variable in forecasting the another variable. Henceforth, Granger causality test was employed to check whether there are any speculative causality between the 2 variables (i.e. Spot & Future prices of Coffee).

Table 4: Results of the Engle Granger Causality Test using VAR

Commodity	Direction of causality	Chi-sq	P-value	H_0
Coffee	FUTURE (DV)	0.011711	0.9138	Accepted
	SPOT (DV)	67.11939	0.0000	Rejected

Note: DV = Dependent Variable

H_{01}: Spot does not Granger Cause Future
H_{11}: Spot does Granger Cause Future
H_{02}: Future does not Granger Cause Spot
H_{12}: Future does Granger Cause Spot
Table 4 shows the causality between spot & future for coffee. Since the p-value is greater than 0.05 for futures, the null hypothesis is accepted (i.e. there is no causation between spot & futures) and p-value is lesser than 0.05 for spot, so the author rejects null hypothesis (i.e. future prices granger causes spot prices). There is unidirectional relationship between FUTURE & SPOT prices for Coffee.

Johansen Co-Integration test using VAR

Co-integration test helps to determine the long-run relationship between spot price & future price of Coffee. The pre-requisite is that all the variables must be non-stationary at levels and attain stationarity at first difference. Once the variables attain stationarity, co-integration test can be employed to evaluate the long term relationship.

The co-integrating regression is as follows:
$Y_t = \beta_0 + \beta_1 Z_t + u_t$
Spot = $\beta_0 + \beta_1$ Future + u_t

Table 5: Results of Johansen Granger Co-Integration test using VAR

Table 5.1: At Level

ADF Test		PP Test	
Prob.	0.9731	Prob.	0.1054

Table 5.2: At 1st Difference

ADF Test		PP Test	
Prob.	0.0000***	Prob.	0.0000***

*Note: *** denotes significance at 1%, 5% & 10% level, respectively.*

Table 5.3: Co-Integration using VAR

Trace Value			Maximum Eigenvalue		
Trace Statistic	Critical Value (0.05)	Prob.	Max-Eigen Statistic	Critical Value (0.05)	Prob.
94.27456	15.49471	0.0000***	94.23989	14.26460	0.0000***

*Note: *** denotes significance at 1%, 5% & 10% level, respectively.*

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Table 5.4: Normalized co-integrating coefficients

Normalized co-integrating coefficients	
Future	Spot
1.0000	-1.0275

H_0: There is no long term relationship between spot & future prices of Coffee.
H_1: There is a long term relationship between spot & future prices of Coffee.

Johansen Granger Co-Integration test is used to study the long term relationship between spot & future prices of Coffee. To proceed with co-integration test, it is mandatory that the variables must be non-stationary at level and stationary at 1st difference which can be observed in the above mentioned table 5.1 & 5.2.

There are two ways to identify whether there is a long term relationship between spot & future prices of coffee.

1. The trace statistic value must be greater than critical value in order to prove whether there is a long term relationship between spot & future prices of coffee or p-value should be less than 0.05 to reject the null hypothesis.
2. The maximum eigenvalue must be greater than critical value in order to prove the long term relationship between spot & future prices of coffee or p-value must be lesser than 0.05 to reject the null hypothesis.

Hence the co-integration using VAR model indicates that there exist a long-term relationship between spot & future prices of coffee which can be seen in table 5.3.

Also the normalized co-integrating coefficients in table 5.4, indicates that for every one rupee rise in future price, the spot price will be increased by 1.0275 rupee.

CONCLUSION & IMPLICATIONS

The study is carried on by considering the various critical parameters of descriptive statistics like standard deviation, skewness & kurtosis (table 1), which are deployed to assess the normality of the data. After conducting the unit root test with the help of ADF & PP test the variables are proved to be stationary (table 2), hence the variables are qualified for further rigorous data analysis. As evidenced by ARCH LM test (table 3), the changes are homoscedastic between spot & future prices of coffee. There is a unidirectional relationship between spot & future prices of coffee as per Engle Granger Causality test as witnessed in table 4. The outcome of Johansen Co-Integration test shows the strong evidence of long term relationship between spot & future prices of coffee as mentioned in table 5.3, also when future price increases spot price will increase significantly, as evidence in table 5.4. Henceforth, spot prices can be used as a good indicator to speculate the movement and strength of future price fluctuations.

REFERENCES:

1. Aggarwal, N., Jain, S., & Thomas, S. (2014). Do futures markets help in price discovery and risk management for commodities in India?.
2. Ahola, A. (2023). Commodity price risk hedging practices in Finnish manufacturing industries: examining the role of commodity derivatives.
3. ARAGAW, F., & KEBEDE, H. (2019). THE ROLE OF ETHIOPIA COMMODITY EXCHANGE (ECX) IN STIMULATING AGRICULTURAL COMMODITIES EXPORT (THE CASE OF EXPORT COFFEE).
4. Kalaiarasi, D., Rohini, A., Palanichamy, N. V., Shivakumar, K. M., Selvi, R. P., & Sekhar, K. C. (2023). Time Series Analysis of Spot and Future Commodity Market in India During Covid–19. *Asian Journal of Agricultural Extension, Economics & Sociology*, *41*(9), 989-995.

ISSN: 2178-7727

5. Kapoor, S., & Mithal, A. K. (2022). Dynamic relationship between commodities and Indian Stock Market. *South India Journal of Social Sciences*, *20*(1), 2-12.
6. Kar, M. (2018). Price discovery mechanism in spot and futures market of agricultural commodities: The case of India. *FOCUS: Journal of International Business*, *5*(2), 44-67.
7. Kaura, R., & Rajput, N. (2024). Future–spot relationship in commodity market: A comparison across commodity segments in India. *Global Business Review*, *25*(5), 1314-1335.
8. Nandini, H. D. Price discovery dynamics of agri commodity markets in India.
9. Palaniappan Shanmugam, V., & Armah, P. (2017). The Relative Efficiency and Volatility of Indian Agricultural Commodity Futures Markets. *Velmurugan and Armah, Paul, The Relative Efficiency and Volatility of Indian Agricultural Commodity Futures Markets (May 26, 2017)*.
10. Palaniappan Shanmugam, V., & Raghu, R. R. (2016). Relationship between Spot and Futures Markets of Selected Agricultural Commodities: An Efficiency and Causation Analysis. *Journal of Business & Financial Affairs*, *5*(1).
11. Pradhan, R. P., Hall, J. H., & Du Toit, E. (2021). The lead–lag relationship between spot and futures prices: Empirical evidence from the Indian commodity market. *Resources Policy*, *70*, 101934.
12. Raghavendra.R, & Mani, D. S. (2024). Relationship between Spot and Futures Markets of Selected Agricultural Commodities in India using co-integration and causality tests. *South Eastern European Journal of Public Health*, 460–468.
13. RL, M., & Mishra, A. K. (2020). Price discovery and volatility spillover: an empirical evidence from spot and futures agricultural commodity markets in India. *Journal of Agribusiness in Developing and Emerging Economies*, *10*(4), 447-473.
14. Rout, B. S., Das, N. M., & Rao, K. C. (2021). Functional effectiveness of commodity futures market: A comparative assessment of agricultural and metal commodities. *Paradigm*, *25*(1), 42-60.
15. Sahadudheen, I., & Kumar, P. S. (2023). Time-varying relationship and volatility spillovers among oil, gold, forex and stock markets in Indian context: The juxtaposition of global economic crisis and COVID-19 pandemic. *The Indian Economic Journal*, *71*(4), 748-767.
16. Samak, N., Hosni, R., & Kamal, M. (2020). Relationship between spot and futures prices: The case of global food commodities. African Journal of Food, Agriculture, Nutrition and Development, 20(3), 15800-15820.
17. Setiawati, I., & Taufikurohman, R. (2021, February). Price volatility of staple food using ARCH-GARCH model. In IOP Conference Series: Earth and Environmental Science (Vol. 653, No. 1, p. 012146). IOP Publishing.
18. Singhal, S., Choudhary, S., & Biswal, P. C. (2019). Return and volatility linkages among International crude oil price, gold price, exchange rate and stock markets: Evidence from Mexico. Resources policy, 60, 255-261.
19. Vijayakumar, A. N. (2018). Causality of Pepper Spot and Futures Prices at Indian Commodity Market. IUP Journal of Financial Risk Management, 15(4), 49-59.
20. Wu, H., Wu, H., Zhu, M., Chen, W., & Chen, W. (2017). A new method of large-scale short-term forecasting of agricultural commodity prices: illustrated by the case of agricultural markets in Beijing. Journal of Big Data, 4, 1-22.