Is India's Coffee Futures Market Informationally Efficient? An Empirical Investigation

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Abstract

Coffee futures markets need to be efficient to benefit the various market participants. This paper explored whether India's coffee futures market was efficient. The study is significant as India has just over five years of experience with coffee futures market in a software-enabled trading environment. While earlier studies have used several econometric techniques for analyzing coffee markets, this paper contributes to two methodological improvements. The use of modified Pantula principle in testing co-integration and performance of weak exogeneity test enable better inferences on efficiency. The study concluded that India's coffee spot markets were efficient compared to the futures markets.

Key words: Modified Pantula principle, Weak Exogeneity Test, India, Coffee Futures

1. Introduction

Research on coffee markets has been extensive for the past more than three decades. A search on recent literature yielded more than twenty studies on coffee markets. More than half of these studies focused on econometric techniques to investigate the interdependence between coffee futures and spot markets. Futures and spot market interaction is important in examining the informational efficiency of these markets. Informational efficiency enables futures prices to be an unbiased predictor of spot prices. Informational efficiency thus is at the core of establishment of futures markets. It results in better price discovery and price risk management for all stakeholders in the coffee industry. India's coffee futures market, if informationally efficient, would justify its existence. This argument, therefore, requires an in-depth study.

There are several forms of efficiency observed in the market. Informational efficiency is one of them, has a great influence on liquidity and market transparency (O' Hara, 1997). Informational efficiency refers to the degree at which market aggregates and impounds all available information (including private) into the price of asset traded in the market and eventually, the asset reflects or reaches its fundamental or economic value. Market transparency expedites the price formation and transmission process through an informationally efficient market. O'Hara (1997) described market transparency as the ability of market participants to observe price information in the trading process.

In connection, futures market serves the purpose. Primary role of futures market is to provide real-time price information to a diverse group of participants including traders, market makers, and other agents. Prima facie, this enhances market viability, transparency, and stability. The simplest transparency issue to consider is how the degree to which the size and direction of order flow (observed in exchange-regulated commodity futures market) is visible to market participants affects the viability of the market. Madhavan (1992), Biais (1993), Pagano and Roell (1993), and Stoll (2003) analysed the effect of order/quote driven markets of several formats including financial futures/spot, currency/forex markets on agents' behaviour and market viability. However, similar kind of study in commodity futures market is quite sparse in Indian context.

Government encouraged coffee futures market in India in the late nineties. Coffee futures market operated through a regional exchange[*]and without enabling trading software. It had minimal participation. This resulted in the closure of the regional exchange. National Multi Commodity Exchange (NMCE) and later the National Commodity and Derivative Exchange (NCDEX) revived the coffee futures market in 2005. The new exchanges are IT enabled, follow trading using the gross/cross margining system on both buy and sell positions. They also possess a robust settlement system. These characteristics provide an efficient trading platform for coffee. With more than five years of existence, a key question that arises as to how have the India's newly revived coffee futures markets fared.

[*]Regional exchange, Coffee Futures Exchange India Ltd. (COFEI) at Bangalore came into existence in 1998. Due to insignificant trade volume and participation, trading members have not been greatly attracted to this exchange.

Investigation of interdependence between India's coffee spot and futures markets has been minimal. This paper seeks to address this gap. Methodologically, many researchers have not considered weak exogeneity test while studying the coffee futures markets. Several studies have used co-integration techniques to establish long-run equilibrium relationships between coffee futures and spot markets. However, modification in these techniques is required to identify the exact number of co-integrating vectors. We use the modified Pantula principle in this paper to achieve the same. A key contribution of this paper is in the use of two new approaches, namely co-integration using modified Pantula principle (Hjelm and Johansson, 2005) and weak exogeneity test (Enders, 1995). The broad research question that we address in this paper is whether India's coffee futures markets are efficient.

The paper outline is as follows. Section 2 briefly describes coffee futures and spot markets including India's coffee markets followed by literature review in section 3. Section 4 describes data, preliminary analysis. Section 5 discusses methodology. Section 6 analyses and interprets the results and the last section presents the conclusions.

2. Coffee Futures & Spot Markets

Globally, coffee is an important plantation crop grown in countries like Brazil, Columbia, Vietnam, and India. It is the second largest traded commodity in the world. The major varieties of coffee traded are Arabica including Columbian Milds (CM), Brazilian Milds (BM) & Other Milds) (OM), and Robusta. India holds the sixth position in coffee production following Brazil, Vietnam, Columbia, Indonesia, and Ethiopia. The main consumption centers are USA, EU, Japan, etc. India occupies about 2 percent of global coffee area and the country has a share of around 4 percent of world production and 4 percent of the exports from producing countries during 2009-10. India produces both Arabica and Robusta coffee. Sixty five percent of the India's coffee production is Robusta and thirty-five percent is Arabica. Arabica is widely traded on the New York Board of Trade (NYBOT) and Robusta on the London International Financial Futures Exchange (LIFFE).

In 2005, organized trading in coffee futures markets started in India. National Multi Commodity Exchange (NMCE) and National Commodity and Derivatives Exchange (NCDEX), the two national level exchanges have been facilitating coffee futures trading since then. Prior to 2005, Coffee Futures Exchange India (COFEI) existed until the early twenties. This regional exchange did not witness significant trade volume in coffee futures during its existence. Even after 2005, trade volume in coffee futures and participation has not been increasing significantly (for contract specifications of coffee futures, see, **Appendix-1**).

Rationale behind the selection of NMCE as a sampling frame for accessing coffee futures data is important for discussion. NMCE being the largest national level exchange to facilitate coffee futures trading has scored over COFEI on several counts. Parameters are professionalization of management through obtaining the status of demutualization, in-house clearing mechanism, computerization, and trade guarantee mechanism, timely reporting system to the Forward Markets Commission (FMC), daily mark-to-market margining system and novation, time stamping, customer protection, surveillance and risk management mechanism (for more details, refer to FMC, 2012). As mentioned above, Robusta Estate Plant (REP) bulk is the basis variety of coffee futures in India. NMCE launched Arabica and REP bulk -coffee futures in February 2005. However, trading activity with respect to Arabica variety came to a halt in September 2005 because of low participation, lesser trade volume (an average of 363 metric tons on daily basis) and value (an average of Rs. 46.27 lakhs) compared to REP bulk and finally suspended. Whereas REP bulk in NMCE futures platform witnessed higher volume and value to a tune of daily average of 19,212 metric tons and Rs. 15.17 crore, respectively from February 2005 to March 2011 (NMCE, 2011). In India, trade volume and value of coffee futures in NMCE reached its peak in 2011-12 as per the FMC statistics. However, participation in this trade has not been witnessed the similar trend since 2005.

Spot markets of coffee in India came in existence much before the futures started. However, fragmented, disorganized spot markets have not contributed much to price discovery and its dissemination process until early 2000. The traditional coffee growing regions including Karnataka, Kerala, and Tamil Nadu produced over 98 percent of total production in the country while 70 percent contributed by Karnataka state alone. In recent years, tribal areas of the Eastern Ghats of Andhra Pradesh, Orissa, and North Eastern states witnessed coffee cultivation to some extent. About four lakh hectares occupied coffee cultivation in India comprising 1.84 lakh hectares of Arabica and 2.04 lakh hectares of Robusta in 2009-10. Total coffee holdings were about 2.2 lakh hectares of which small growers account for 2.18 lakh hectares in India. On the other hand, large growers held only 1 percent of total holdings and these holdings accounted for 30 percent of total production as reported by Rao (2009).

Spot markets are mostly concentrated in Southern region of the country including Kerala and Karnataka. This is why all delivery centers are in adjoining notified districts/areas of these states permitted by the FMC. This is an achievement on the part of national level commodity futures exchange for increasing the market transparency and stability through integration between spot and futures markets. To increase the degree of integration, Government of India in connection with some national level commodity exchanges, NCDEX and Multi Commodity Exchange (MCX) had promoted a few spot exchanges in 2006-07. However, these are yet to facilitate or offer coffee spot contracts across Southern parts of India.

3. Literature Review

Some studies have shown that coffee futures and spot markets are interdependent and predictive ability of futures appears to influence spot markets (Rajaraman, 1986; Kebede, 1993; Karbuz and Jumah, 1995; Fortenbery and Zapata, 2004). Milas and Otero (2002) explored the non-linear behaviour of four varieties of coffee prices in Brazil, Colombia, Latin American countries, Africa and Southeast Asia. They used co-integration and Vector Error Correction Model (VECM) as techniques for examining the interdependence between spot prices of four varieties of coffee. They obtained mixed findings since interdependence was not the same across varieties. Adrangi and Chatrath (2003) investigated the presence of non-linearity and dependence structures in global coffee futures prices. Their aim was to validate Samuelsson hypothesis of maturity-effects in futures price-changes. They used Chaos theory and maximum likelihood approach in their paper. They found that in most cases futures prices converged with the spot prices during the time of settlement.

Bryant and Haigh (2004) studied the bid-ask spread in global coffee futures markets. They proposed a new spread estimator in their paper analyzing the existing estimators. They suggested that optimal spread would result in maximizing the liquidity of coffee futures markets. Fortenbery and Zapata (2004) examined the relationship between New York coffee futures and cash export prices in Guatemala and Honduras. They studied the impact of speculative behaviour through futures on coffee export prices. In their paper they used techniques like co-integration test, Error Correction model (ECM) and Autoregressive Conditional Heteroskedasticity (ARCH) models. They found that developing country spot market price risk might increase with increased futures trading volume and open interest in developed markets.

Milas *et al*. (2004) attempted to forecast the spot prices of different coffee varieties in Brazil, Colombia, Africa and Southeast Asia. They used three different VECM models in their study namely Linear/Random, Asymmetric, and Polynomial Error Correction Model (VECM). The predictive ability of forecasting the spot prices increases with a low forecast error. With the use of the three different models, they concluded that Polynomial VECM was the best model for forecasting spot prices. Mohan and Love (2004) investigated whether coffee producers can benefit from coffee futures forecasts. They used Garbade–Silver test (1983) in their study. Researchers use this test to analyze intra-day futures spot behavior. They found that changes in lagged futures prices did not explain changes in spot prices. However, futures prices tend to adapt to prevailing spot prices.

Ghoshray (2009) studied the spot price relationships between four coffee varieties and explored how price adjustments happened over time. He also captured the asymmetric distribution of spot prices in major coffee export markets. He used Threshold Autoregression (TAR) and Markov-TAR (M-TAR) in his study. He found that while good news had a lower impact, bad news had a greater impact on spot prices. He thus established the asymmetricity in the coffee spot market. Ghoshray (2010) examined the co-integration among spot prices of four coffee varieties. He attempted to prove the operation of Stigler's Law of One Price postulate in the coffee spot market. He used linear and non-linear co-integration models and ESTAR (Exponential Smooth Transition Autoregressive) model in the paper. He found that LOP did not hold true in coffee spot prices as the market was imperfect. Fry *et al*. (2011) studied the interdependence of global coffee spot and futures markets and the impact of speculative behaviour on the price risk of spot markets of coffee in the world. They used Generalized Forecast Error Variance Decomposition test (GFEVD), Vector Autoregression (VAR), and Granger causality in their study. They found that spot and futures markets are interdependent. They also reported that spot market was more efficient than the futures market.

An analysis of the literature cited above shows that studies on India's coffee futures market have been minimal. A review of the techniques used show that weak exogenity tests have not been a key component of many studies. In order to identify co-integrating vectors, there is a need to incorporate modified Pantula principle. None of the studies reviewed above have explored modification during co-integration.

4. Data & Preliminary Analysis

The study used the daily closing coffee spot and futures prices from NMCE, India. The paper used near month futures prices for the study. The study avoided the potential problem of liquidity as per trading time hypothesis (Jegadeesh and Titman, 1993) using near month coffee futures contract. Mid-and far-month futures data were not considered for entire analysis. We considered spot and futures prices from February 22, 2005 to March 24, 2011 for the study. There were 1062 data points. In addition, 25 bi-monthly coffee futures series were available in NMCE for above-mentioned period. Delivery schedule decided coffee futures (CFR) name like CFR MAR 2011, CFR JAN 2011, and CFR NOV 2011 and so on up to CFR MAY 2005. However, NMCE did not report 12 bi-monthly coffee futures series from November 2006 to September 2008. This may be because of either excessive price hike in futures or illiquid coffee futures trade during that period. After September futures of 2006, March 2007 witnessed only one coffee futures delivery. Average close price in that period was Rs. 7,209.33 whereas September coffee futures in 2006 showed an average close price of Rs. 5,865.27. Despite very low trade volume and turnover recorded from November 2006 to September 2008, coffee futures trading, however, continued in NMCE platform without any intermittent ban/suspension. Except a lag of about a year, the exchange observed regularity in coffee futures trading and subsequently, reported its statistics. In addition, there was some increasing trend in participation observed. However, adequate data and analysis can support this. Intuitively, average trade volume and turnover may throw some light on participation. Nonetheless, this trend was temporary, observed only in six futures series of 2009 out of 25 futures (highlighted through broken lines in the table below). Table1A reports 25 coffee futures series statistics from May 2005 to March 2011. Table contains average close price of each future series, average turnover in Rs. lakhs, average trade volume in lots (one lot = 15 metric tons). In addition, logarithmic growth rate of evolution of open interest [OI] (number of coffee futures contracts outstanding on each trading date) and basis (the difference between spot and futures price at period, *t*) are mentioned from February 2005 to March 2011 in table 1B.

Table 1-A: Coffee futures series statistics from 2005 to 2011

Series No.	Futures Series	Avg. close price (in Rs.)	Avg. trade volume (in lots)	Avg. turnover (in Rs. lakhs)
1	CFR MAR2011	9,274.28	177.00	240.89
2	CFR JAN2011	8,654.11	260.00	342.81
3	CFR NOV2010	8,175.53	183.00	224.79
4	CFR SEP2010	7,612.61	383.00	427.59
5	CFR JUL2010	7,139.24	588.00	622.29
6	CFR MAY2010	6,902.24	509.00	529.97
7	CFR MAR2010	7,325.39	600.00	667.66
8	CFR JAN2010	7,872.39	899.00	1063.04
9	CFR NOV2009	7,818.93	1,074.00	1,262.54
10	CFR SEP2009	7,675.63	1,179.00	1,262.54
11	CFR JUL2009	7,736.31	1,052.00	1,199.18
12	CFR MAY2009	8,247.31	935.00	1,162.12

13	CFR MAR2009	8,619.51	1,400.00	1,803.26
14	CFR JAN2009	9,168.99	1,218.00	1,679.14
15	CFR NOV2008	9,415.12	1,069.00	1,537.95
16	CFR MAR2007	7,209.33	0.00	0.75
17	CFR SEP 2006	5,865.27	0.00	0.11
18	CFR JUL2006	5,710.64	0.00	0.32
19	CFR MAY2006	5,825.18	0.00	4.30
20	CFR MAR2006	5,656.10	13.00	11.48
21	CFR JAN2006	5,486.96	1.00	1.46
22	CFR NOV2005	5,700.56	5.00	4.57
23	CFR SEP2005	6,054.63	31.00	28.09
24	CFR JUL2005	5,978.80	149.00	138.50
25	CFR MAY2005	5,752.29	2,079.00	1,869.02

Note- coffee futures series data accessed from NMCE (2011) & compiled by authors.

Table 1-B: Logarithmic growth rate of OI & basis in coffee futures trade

OI growth rate (%) ($\ln [OI_t/OI_{t-1}]$)	Basis growth rate (%) ($\ln [S_t/F_t]$)	OI to basis (%)
-0.01271	-0.01353	-247.152

Source: authors' estimation

Growth rate of OI and basis were negative. It implies that even in near month futures, market depth often measured by OI (a crude estimate) was abnormally low. As a result, growth rate was negative. On the other side, growth rate of basis strongly supports the contango nature of the market where futures price is above the spot. In addition, OI to basis ratio was negative. We can draw some inference from the preliminary analysis that contango nature of coffee markets can potentially benefit the investors choosing a short (sell) position on futures and a long (buy) position on underlying spot. However, efficiency measure of coffee futures markets is important to verify the statement of prediction.

Spot and futures returns were calculated taking the first difference of logarithmic prices i.e., $r_t = \ln [P_t/P_{t-1}]$. There were no structural breaks in the India's coffee futures and spot markets during 2005-11 through either policy intervention or ban on futures. Therefore, the study did not employ either endogenous (Perron test) or exogenous (Chow breakpoint test) structural break tests for analysis. We used licensed version of E-Views 7.0 for the analysis reported in the paper. Both price and return series of coffee spot and futures are presented in figure-1, 2, 3, & 4 below.

Figure 1: Coffee futures series

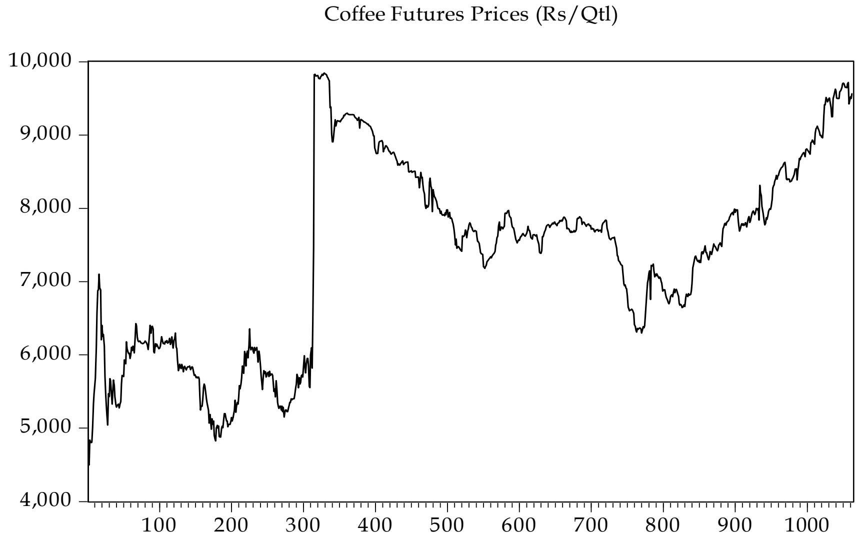


Figure 2: Coffee spot series

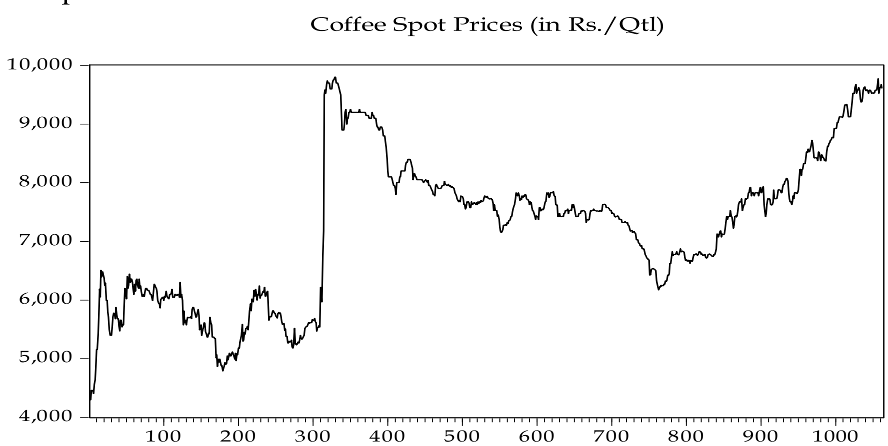


Figure 3: Coffee futures return series

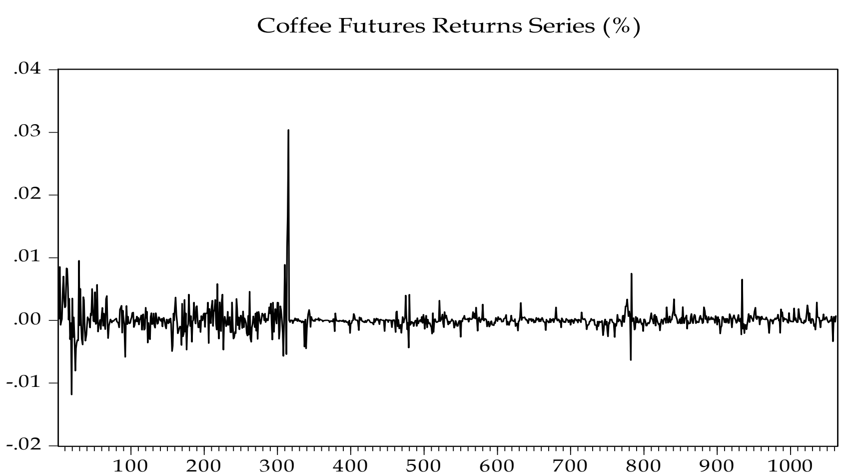
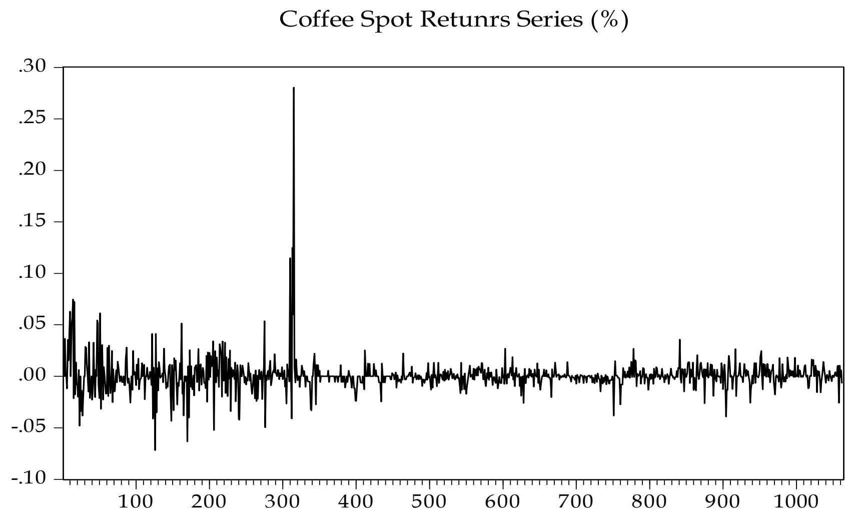


Figure 4: Coffee spot return series



5. Methodology

This study used co-integration tests (Johansen, 1988, 1991) on two non-stationary data series (namely daily closing futures and spot prices) to examine the number of co-integrating vectors binding them that make their relationship stationary. These tests are sensitive to assumptions about deterministic components (intercept and trend) of any times series data. Hansen and Juselius (1995) suggest a method referred to as "Pantula principle" for simultaneously determining matrix rank and deterministic (endogenous) components of the co-integration system. The five different cases based on the two deterministic components of the co-integration system are as follows:

i. no intercepts and no trends;
ii. restricted intercepts and no trends;
iii. unrestricted intercepts and no trends;
iv. unrestricted intercepts and restricted trends; and
v. unrestricted intercepts and unrestricted trends.

The five cases are nested so that case (i) is contained in case (ii) which is contained in case (iii) and so on. Hjelm and Johansson (2005) have however shown that the "Pantula principle" suffers from a major drawback. They proved that it was heavily biased towards choosing case (iii) when the correct data generating process is given by case (iv). They proposed a modification, called the 'modified Pantula principle', which improved the probability of choosing the correct model significantly. From five cases described above, we selected the case (through an iterative procedure) that resulted in identification of the exact number of co-integrating vectors where the test cannot reject the null hypothesis as the best co-integration model. This paper used the modified Pantula principle in identifying the co-integrating vectors.

Stationarity tests using ADF, PP, KPSS, and Ng Perron (Dickey and Fuller, 1981; Phillips-Perron, 1988; Phillips, 1991; Brooks, 2008) and normality test-using JB **(**Gujarati, 2006) preceded this test. Due to serial auto correlation, the distribution was non- independent identical (*niid*) except the residuals. Then we estimated the Vector Error Correction Model (VECM)

(Granger, 1981; Granger and Weiss, 1983; Engle and Granger, 1987). The VECM specification contains information on short and long run adjustment to changes in non-stationary time series. It determines whether and to what extent the system of equation is co-integrated. This represented the co-integrating constant in the VAR system. In Johansen and Juselius's (1990) VECM model, α measures adjustment speed of news/shock or convergence to the long-run steady state. β measures the number of co-integrating vectors. This model acts as test for weak exogeneity. We used this VECM model in the study.

Impulse response analysis (Enders, 1995) proves inconsistent for measuring impulse responses for long horizons. Sims (1972, 1980), Abdullah, and Rangazas (1988) suggest that forecast error variance decomposition is advisable while analyzing dynamic relationship between variables. In its absence, inferences on statistical significance of interdependence between economic variables (like coffee futures and spot prices through various models) may be misleading. The VECM, Granger causality test and variance decomposition (Enders, 1995) examine information transmission between markets by investigating spillover effect using the first moment i.e. mean return. Forecast error variance decomposition provides the percentage of variation in returns of one variable as explained by the other variable of the underlying asset. In this paper, the two variables considered were returns in futures/spot ((for more details on models used in the study, refer to Appendix 2).

6. Results & Discussions

5.1. Descriptive statistics

Table-2 reports the descriptive statistics of both coffee spot and futures returns series. The kurtosis, a measure of peakedness, was high implying fat tailed distribution, not modestly sized deviations. High leptokurtic distribution indicated non-normality of both series. In addition, Jarque-Bera (J-B) test for normality rejected the null hypothesis of normality. The test found both the series positively skewed. This paper used the Augmented Dickey Fuller (ADF) test with both trend and intercept to detect unit root presence. The test reported Unit root at level-data series and not in return series of both spot and futures. This implied that both series had achieved the same order of integration i.e. one [I (1)].

Table 2: Summary statistics of daily return-series for coffee spot and futures

	Mean (%)	SD (%)	Skewness	Kurtosis	J-B	ADF
Spot	0.075	1.629	5.68	91.74	353902 (0.00)	-11.11 (0.00)
Futures	0.008	0.198	4.95	75.41	236187.7 (0.00)	-25.75 (0.00)

Note-figures in parentheses signify the *p*-values at 5% level of significance. The null hypothesis of ADF test was return on spot/futures has unit root. SD is standard deviation. Both mean and SD are expressed in terms of percentage. We conducted PP, KPSS, Ng Perron test too to detect unit root considering both trend and intercept of data series. Since these test results did not considerably differ from ADF test results, they are not reported.

Source: authors' estimation

5.2. Co-integration test

We employed Johansen's co-integration test using "modified Pantula principle" for this study. Results in table 3 shows that at least one (1) co-integrating vector ($\beta_j < N$) was found through the test, which satisfied the case (i) namely no intercept and no trend (under no deterministic assumption). The presence of at least one co-integrating vector implied that the number of co-integrating parameters (β_j) is less than the number of endogenous variables (N) considered in the model.

Table 3: Johansen's co-integration test statistics of coffee futures and spot prices

Coffee Spot & Futures Prices Series	Lag Length selected	Co-integration test using Trace				
	1-2 (in first difference of two series)	No of Co-integrating (CE) equations	Eigen value	Trace statistic	Critical vale at 5%	Prob**
		H$_0$: $r \leq 0$	0.029823	33.1207	12.32	0.00*
		H$_1$: $r \geq 0$	0.000998	1.0575	4.13	0.35

Coffee Spot & Futures Prices Series	Lag length	Co-integration test using maximum Eigen value				
	1-2 (in first difference of twos series)	No of Co-integrating (CE) equations	Eigen value	Max-Eigen statistic	Critical vale at 5%	Prob**
		H$_0$: $r \leq 1$	0.029823	32.06324	11.22	0.00*
		H$_1$: $r \geq 1$	0.000998	1.057510	4.13	0.35

Note-trace test indicates one co-integrating equation at 5% level of significance; *denotes rejection of the null hypothesis at 5% level of significance and **denotes Mackinnon-Haug-Michelis (1999) estimated *p*-values. Max-Eigen test indicates one co-integrating equation at 5% level of significance; *denotes rejection of the null hypothesis at 5% level of significance and **indicates Mackinnon-Haug-Michelis (1999) estimated *p*-values.

Source: authors' estimation

5.3. Weak exogeneity test

Result of weak exogeneity test indicated that spot prices did not respond to any shock from futures market in the long run. Thus, it was evident that coffee spot prices were weakly exogenous to coffee futures prices and not vice versa. Table-4 shows that Indian coffee spot market's response did not deviate too far from the long-run equilibrium relationship with futures. It seemed to indicate futures markets strongly supported the postulates of backwardation (Telser, 1958; Cootner, 1960; Dusak, 1973).

Table 4: Results of weak exogeneity test of coffee markets

Commodity	Spot & Futures Markets
Coffee	Chi-Square
	4.741066*

*Denotes rejection of alternate hypothesis at 5% level of significance,

Source: authors' estimation

5.4. VECM and Granger causality test

After examining long-run integration, we analyzed the short-run integration or return spillover between futures and spot markets. The study used the "Granger causality" or block exogeneity test to examine the lead-lag relationship between futures and spot markets. Table-5 reports the VECM results. We used SBC information criteria (Enders, 1995) to select the lags in the VECM. Results showed that error correction coefficient for futures returns (R_F) was positive whereas for spot returns (R_S), it was negative. This implied that VECM was out of equilibrium. Negative coefficient signified that spot prices moved downward to reach the equilibrium point. The short-run coefficients, γ_{fj}(i) measured the return spillover from futures to spot markets which was significant at its first lag. On the other hand, a short-run coefficient, γ_{si} (I), which measures the return spillover from spot to futures markets, was also significant.

Results of VECM indicated bidirectional causality between futures and spot markets. Estimation of Chi-Square statistics for Granger causality test (Table 6) indicated spot led futures markets and affected futures returns. The weak exogeneity test and results of error correction model also confirmed this phenomenon.

Table 5: Parameter estimates of VECM
Co-integrating equation, $S_t = -0.18 - 0.9773F_t + \varepsilon_t$

Estimates of VECM			
	R_{ft}		R_{st}
α_f (ect_{t-1})	0.041* (0.017)	α_s (ect_{t-1})	-0.039* (0.016)
β_{f1}	0.2005* (0.041)	β_{s1}	-0.24342* (0.04)
β_{f2}	-0.01974* (0.042)	β_{s2}	-0.0855* (0.3960)
γ_{s1}	0.382* (0.0435)	γ_{f1}	0.40048* (0.0389)
γ_{s2}	0.11714* (0.042)	γ_{f2}	0.066892* (0.0401)
c	0.00039 (0.00049)	c	0.000517 (0.00046)

*Denotes the level of significance at 5% and figures in parentheses are standard errors of parameters.

Source: authors' estimation

Table 6: Results of Granger causality test

Coffee Returns Series	Futures → Spot	Spot → Futures
	105.889*	7.77275*

*Denotes rejection of null hypothesis at 5% level of significance, Chi-Square test considered two degrees of freedom.

Source: authors' estimation

5.5. Forecast error variance decomposition test

We estimated the orthogonal variance decomposition of forecast error up to 10 lags from the VECM. Panel-A of table-7 presents variation in futures returns as explained by its own lagged returns and spot returns. Panel-B reports variation in spot prices as explained by its own lagged returns and futures returns. Variations in futures returns explained by its lagged value are much lower than that of spot returns. Similarly, variations in spot returns explained by its lagged value are higher than futures returns. Variation in futures return explained by its own lagged value ranged from 58.32% to 56.53%. Similarly, variation in futures return explained by spot returns varied from 41.67% to 43.47%. On the other hand, explanation of variation in spot returns by its own lagged value was much higher (100% to 89.7%) than futures returns (0% to 10.39%). This strongly indicated the informational efficiency of spot markets in decomposing the forecast errors variance.

Table 7: Forecast error variance decomposition of coffee markets

Coffee futures return explained by			**Panel-A**				
Futures returns				*Spot returns*			
1	4	7	10	1	4	7	10
58.32%	56.57%	56.54%	56.53%	41.67%	43.43%	43.46%	43.47%

Coffee spot return explained by			**Panel-B**				
Spot returns				*Futures returns*			
1	4	7	10	1	4	7	10
100%	89.63%	89.62%	89.7%	0.00%	10.37%	10.38%	10.39%

Note-periods are mentioned in numbers, 1, 4, 7 and 10.

Source: authors' estimation

5.6. Discussions

Skewness and kurtosis coefficients for spot were greater than futures implying a greater probability of higher returns on investing in spot market. This supports the lower risk expected in investing in futures. JB test revealed the non-normality of the futures and spot distribution**.** Intuitively it suggests asymmetricity of the distribution. Thus, JB acted as a diagnostic test to ensure empirical distribution of futures and spot return series so that we could conduct further tests. ADF confirmed the non-stationarity of the futures and spot price series. This is a necessary condition for co-integration and VECM. The residuals in the spot/futures price series were white noise or random disturbance. Therefore, residuals would not provide any information about futures/spot.

We can infer from co-integration analysis that coffee futures responded to spot markets. This is evident from the positive error correction coefficient. The spillover effect seemed to generate from spot to futures and was positive. On the contrary, spot responded to futures in a negative manner as evident from the negative coefficient of error correction. However, the test found both coefficients to be significant at 5% level, indicating bidirectional causality with a long-run equilibrium relationship. From weak exogeneity test, it is clear that spot was weakly exogenous relative to futures. This also presupposes the presence of thickly traded spot markets. In the short run change in spot prices, “Granger” causes change in futures prices and vice versa. This established bidirectional causality in the short run too. The study found that variance decomposition of forecast error was more pronounced in spot than in futures.

7. Conclusions

Informational efficiency enables greater participation and liquidity in any commodity futures market. Better participation and liquidity enhances the value of the commodity futures market. In effect, it helps in better price discovery and price risk management for the participants in the commodity system (producers, buyers, suppliers, processors, etc). Thus, a key condition for an effective commodity futures market in operation is informational efficiency. In a globally produced and traded commodity like coffee, it becomes all the more important. In the absence of informational efficiency, real time price dissemination and aggregation/incorporation of private level information in commodity prices becomes difficult. This in turn affects all the participants in the system.

Several studies have explored international coffee futures markets extensively for the past several decades. However, new coffee futures exchanges in India operating since 5 years provide an opportunity to explore this market. Studying informational efficiency of India’s coffee futures market helps to understand whether the market has been performing its function effectively.

Several econometric methods are available to test informational efficiency in commodity futures markets. Most methods employ tests to examine the direction of causality between futures and spot. In this paper, we contributed to literature on coffee futures market with the adoption of weak exogeneity test and a modified co-integration technique. These represent better tools and are parsimonious.

We found that India’s coffee futures market is not efficient compared to spot market. Spot market was weakly exogenous to futures. This indicates that spot market does not respond to shocks in the long -run. In the short run, the shocks in the spot market do not affect the fair value and therefore are not persistent. Thus, it is informationally efficient. It also implies that the spot market is resilient. In the short run, futures had a higher impact on spot prices in direction of causality. However, this did not translate into impact on the spot market.

Co-integration is a necessary condition for market efficiency. We can conclude on market inefficiency if the futures and spot prices are not co-integrated. However, standard co-integration techniques suffer from drawbacks. The linearity assumption is one of them. In this study, we assumed linear distribution of data series. As the market is asymmetric, the distribution of prices as a data series must be asymmetric. Further research can therefore explore the use of Markov's Threshold Autoregression/ other smoothing transformation regression models (Ghoshray, 2009, 2010) that incorporate use of non-linear data series. Data on participation in futures market was not available. Participation too can have an impact on informational efficiency. This study could not capture this aspect. Future studies could incorporate data on participation using times series models for better inferences.

Appendix-1

The Contract specification for NMCE coffee futures is as follows: minimum lot/contract size of trading and delivery unit is 1.5 metric tonnes (mt) which is equivalent to 25 bags of 60 kg each. Trading is from Monday to Friday of each month (except holidays) from 10 A.M. to 5 P.M. On Saturday, the timing is 10 AM to 2 P.M. Tick size (minimum price difference between different buy (bid) and sell (offer) prices of the same contract) is kept 0.05 INR (Indian Rupee). Quotation or base value of coffee futures is standardized at INR per 100 kg. Other specifications are presented in the table below.

Table 8: Contract specification of coffee futures in NMCE futures exchange, India

Futures contract parameters of coffee futures	
Price Band	Daily Price Limit: Initial- (+)/(-) 2%, Final price limit:(+)/(-)4% (2+2)
Delivery logic **Limit on Position**	• Compulsory delivery Member-6,000 mt or 15% of total Open Interest (OI) Client-2,000 mt • Near-month Limit Member-1,200 mt or 15% of OI Client-400 mt
No. of delivery contracts in a year	Maximum 6, bi-monthly contracts in a year (12 months)
Delivery centers	Kushalalnagar or Coorg, Hassan, Chikmagalur in Karnataka & Kalpetta in Kerala, India

Basis variety and Quality Specifications	Coffee REP bulk ▪ min of 60% by weight (flat beans) stand on a sieve with round holes of 6.00 mm (screen no 15), 20% flat beans on a sieve of 6.65 mm (Screen no 17); ▪ BBB (Black, brown and bits): max 8%, >8% -15% (price reduction in a ratio of 1:0.25); ▪ Husk and foreign matter-max 0.5%, >0.5 – 2%, (price deduction in a ratio of 1:1); ▪ Moisture-max 13%, >13-14% (price deduction in a ratio of 1:1.25); ▪ 60 kg net wt in hydrocarbon free (HCF) jute bags

Source: Accessed from NMCE web site *(www.nmce.com)* on November 6, 2011

Appendix-2

Diagnostic tests of stationarity in time series data

Regressing non-stationary variables on each other leads to potentially misleading inferences about the estimated parameters and the degree of association. Therefore, before testing for co-integration, the order of integration of any futures and spot price series must be determined. To identify whether two series are *I* (1), we employ both the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and the Phillips-Perron† (1988) [P-P] test.

(a) Augmented Dickey-Fuller regression with respect to single or time trend, or/and seasonality

$$\Delta X_t = \rho_0 + a_0 t + \rho X_{t-i} + \sum \delta_i \Delta X_{t-1} + \varepsilon_{it}, \quad i = 1, 2, 3, \ldots, n \tag{1}$$

Where X_t = the log price series, ρ_0 = a constant or drift, ρ = (α-1), Δ = the first difference operator, ε_t = a pure white noise error term and $\Delta X_{t-1} = (X_{t-1} - X_{t-2})$, $\Delta X_{t-2} = (X_{t-2} - X_{t-3})$ etc., i = 1 to n, the number of lagged difference terms which is determined empirically to remove any autocorrelation in error term ε_t. The null hypothesis is to test that $\rho = 0$. If $\rho = 0$, then $\alpha = 1$, that is, equation contains a unit root, meaning the time series under consideration is non-stationary. However, for stationarity, α must be less than one and hence, ρ must be negative.

(b) Phillips-Perron (PP) regression

Consider the following regression model for a time series (X_t):

$$-X_t = \alpha_0 + \sum \alpha_i X_{t-1} + \mu_t \tag{2}$$

†P-P test is conducted to overcome the problem or erroneous findings associated with size of sample and power test (type II error), which is not detected by ADF test.

Where, μ_t is the error term. To test for a unit root, the regression t-statistic for the null hypothesis (H_0: $\alpha = 1$), denoted by t_α is adjusted non-parametrically to account for possible serial correlation in μ_t. If each price series is I (1) process, the series can be modelled by co-integration analysis.

Co-integration & Error Correction Model (VECM)

The concept of co-integration (Granger, 1981; Granger and Weiss, 1983; and Engle and Granger, 1987) usually applies to model multivariate or bivariate non-stationary time series. The literature on this is extensive. The most frequently used representations for a co-integrated system are the error correction models (ECM) of Engle and Granger (1987), the common trends form of Stock and Watson (1988) and the triangular model of Phillips (1991). The ECM has its own significance to address various practical problems, such as determining exchange rates, capturing the relationship between consumption, expenditure and income, modeling and forecasting inflation, etc. From the equilibrium point of view, the term "error correction" reflects the correction on the long-run relationship by the short-run dynamics (Li and Pan, 2009; pp. 45-61). Engle and Granger (1987) proposed a procedure for testing the co-integration hypothesis. A level regression is performed to generate residuals that may be thought of as equilibrium (static) pricing errors. Residuals are then subjected to tests for. With two time series-say spot prices (S_t) and futures prices (F_t) each of which is I(1), the co-integration regression equation is:

$$S_t = \eta_0 + \eta_1 F_t + \varepsilon_t \tag{3}$$

Where, S_t is regressed on a constant η_0 and F_t, η_1 is the regression coefficient and ε_t is the residuals or error terms. Now, the spot prices and futures prices will be co-integrated if and only, ε_t, is stationary or devoid of heteroscedasticity problem (Brooks, 2008).

Tests for co-integration proposed by Engle and Granger (1987) rely upon a super convergence result and apply an Ordinary Least Squares (OLS) estimation to obtain parameter estimates of the co-integrating vector. Johansen (1988, 1991), Johansen, and Juselius (1990) derive maximum likelihood estimators of the co-integrating vectors for an autoregressive process with independent Gaussian errors and a likelihood ratio test for the number of co-integrating vectors. Their procedure has the advantage of taking into account the error structure of the underlying process. It can incorporate different short- and long-run dynamics of a system of economic variables. In addition, it takes into account of Vector Autoregression (VAR) model, sometime referred to as a nested model of the Vector Error Correction Model (VECM). It enables us to estimate and test the equilibrium relationship of containing deterministic trend or stochastic trend among non-stationary series while abstracting from short-term deviations from equilibrium. Thus, it provides relatively powerful tests when the model is correctly specified. Co-integration model using modified Pantula principle already described in methodology section.

Given a set of two I(1) series, Johansen's (1988, 1991) tests are used to determine whether the series stand in a long-run relationship between them. It means that they are co-integrated. The following VECM (Johansen, 1988) is estimated:

$$\Delta X_t = \sum \Gamma_i \Delta X_{t-i} + \pi X_{t-i} + \varepsilon_i, \quad i = 1, \ldots, \rho \tag{4}$$
$$\varepsilon_t \Omega_{t-i} \in (0, \Xi_t)$$

Where X_t is a *2 X 1* vector $(S_t, F_t)'$ of the spot and futures prices respectively, Δ denotes the first difference operator, ε_t is *2 X 1* vector of residuals $(\varepsilon_{St}, \varepsilon_{Ft})'$ that follow an as-yet-unspecified conditionally distributed with a mean zero and time-varying covariance matrix, H_t. The VECM specification contains information on the short-and the long-run adjustment to changes in X_t, via the estimated parameters Γ_i and Π, defined as – [I- $\Pi_1 - \Pi_2 \ldots, \Pi_p$] and – [I – $\Pi_1 - \Pi_2 \ldots, \Pi_{p+1}$], respectively, Π_1 through Π_{p+1} *2 X 2* matrices of coefficients. The term determines whether and to what extent the system of equation is co-integrated. VAR system specifies it as co-integrating constant.

Johansen and Juselius (1990) showed that the coefficient matrix Π contains the essential information about the relationship between S_t and F_t specifically, if rank (Π) = 0, then Π is *2 x 2* zero matrix establishing that there is no relationship between S_t and F_t. In this case, the VECM reduces to a Vector Autoregressive (VAR) model in first differences. If Π has a full rank, that is rank (Π) = *2*, then all variables in X_t are I(0) and the appropriate modeling strategy is to estimate a VAR model in levels. If Π has a reduced rank, that is rank (Π) = 1, then there is a single co-integrating relationship between S_t and F_t, which is given by any row of matrix Π and the expression ΠX_{t-1} is the error correction term. Π can be factored into two separate matrices α and β. Assume that both have dimensions *2 x 1* where *1* represents the rank of Π, such as $\Pi = \alpha\beta'$. β' represents the vector of co-integrating parameters and α is the vector of error correction coefficients measuring the speed of adjustment of news of shocks or the convergence to the long-run steady state (referred to as weak exogeneity test).

Since rank (Π) equals the number of characteristic roots (or Eigenvalues) which are different from zero, Estimation of these Eigen values can help to obtain the number of distinct co-integrating vectors, which are significantly different from zero. The characteristic roots of the *n x n* matrix Π, are the values of λ which satisfy the following equation [$\Pi - \lambda I_n$] = 0 where I_n is an *n x n* identity matrix. Johansen (1988) proposed the following two statistics to test for the rank of Π:

$$\lambda \text{ trace } (r) = -T \sum \ln(1 - \lambda_i), \quad i = 1, 2, 3, \ldots, n \tag{5}$$

$$\lambda \max(r, r+1) = -T \sum \ln(1 - \lambda_i + 1)$$

Where, λ' are the Eigenvalues obtained from the estimate of the Π matrix and T is the number of usable observations. The λ_{trace} tests the null hypothesis that there are at most r co-integrating vectors, against the alternative that the number of co-integrating vectors is greater than r $[Ho: r \leq 0; H1: r \geq 0]$ and the λ_{max} tests the null that the number of co-integrating vectors is r, against the alternative of $r + 1$ $[Ho: r \leq 1; H1: r \geq 1]$.

VECM & Granger Causality

If spot and future prices are co-integrated, then causality must exist in at least one direction (Granger, 1981). Granger causality can identify whether two variables precede one after other or contemporaneously follow each other. When they move contemporaneously, one provides no information for characterising the other. If "S_t causes F_t", then changes in S_t should precede changes in F_t. Consider the VAR and VECM specification of equations (6) & (7) below.

$$R_s, t = \alpha_s + \sum \beta_{si} R_{st} - i + \sum \gamma f_j R_{ft} - j + \varepsilon_{st}$$
$$R_f, t = \alpha_f + \sum \beta_{fi} R_{ft} - i + \sum \gamma_{sj} R_{st} - j + \varepsilon_{ft}. \tag{6}$$

The VAR model does not consider the possibility that the endogenous variables could be co-integrated in the long term. If two prices are co-integrated in the long-run, then VECM is more appropriate, which accounts for long-run co-integration between spot and futures prices (Lien, 1996). If the futures and spot series are co-integrated of the order one [*I (1)*], then ECM of the series can be presented as below.

$$R_{st} = \alpha_1 + \alpha_s ect_{t-1} + \sum \beta_{si} R_{s,t-i} + \sum \gamma_{fj} R_{ft-j} + \varepsilon_{st}$$
$$R_{ft} = \alpha_2 + \alpha_f ect_{t-1} + \sum \beta_{fi} R_{ft-i} + \sum \gamma_{sj} R_{st-j} + \varepsilon_{ft} \tag{7}$$

Where R_{st} or ΔS_t is the return series from spot market and R_{Ft} is the return series of futures market, β_{si}, γ_{si}, β_{Fi}, γ_{Fi} are the short-run coefficients, Ω (S_{t-1}-F_{t-1}) is the ECT, and $\varepsilon_{s,t}$ and $\varepsilon_{F,t}$ are residuals (as explained earlier). The magnitude of the coefficients α_S and α_F determines the speed of adjustment back to log-run equilibrium following a market shock or unit shock that is from spot to futures, within spot, within futures, and from futures to spot and vice versa (captured through impulse response analysis or forecast error variance decomposition). When these coefficients are large, adjustment is quick, and so Ω will be stationary and reversion to the long-run equilibrium will be rapid: [$E(\Omega) = E(S) - \zeta E(F)$], where ζ is error coefficient, is adjusted through error correction term (ECT).

When S_t and F_t are co-integrated asset prices, the ECM will capture dynamic correlations and causalities between their returns. If the coefficients on the lagged F_t returns in the S_t equation are found to be significant, then turning points in *Ft* will lead turning points in S_t, that is, F_t 'Granger' causes S_t. this is called 'statistical causality'. There must be causalities when a spread (error coefficient of ECT) is mean reverting and two asset prices are moving in line or in tandem, but the direction of causality may change over time.

Weak exogeneity test

The weak exogeneity test measures the speed of adjustment of prices towards the long-run equilibrium relationship. If two price series are co-integrated in long-run, then the coefficient matrix $\prod$ (explained in equation 4) can be decomposed as $\prod = \alpha\beta'$, where β contains co-integrating vectors and α measures the average speed of adjustment towards the long-run equilibrium. The larger the value of α, the faster is the response of prices towards the long-run equilibrium. If prices do not react or respond to a shock or value of α is zero for that series, then the variable (price/market) refers to be weakly exogenous. We tested the weak exogeneity of India's coffee futures and spot markets employing log likelihood-ratio test with null hypothesis denoted as, $\alpha_i = 0$ and the test specification used in the study for weak exogeneity was $\{\beta_j[1,1]=1, \alpha_i[2,1]=0\}$.

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