Empirical Study on Interdependence of Coffee Futures Prices and Farm Gate Prices in Major Coffee Producing Countries

ABSTRACT

Coffee is an export-oriented commodity for producing countries, and it is actively traded at international commodity exchange platforms *viz.*, Intercontinental Exchange (ICE), New York and ICEEurope. This study examined the interrelationshipbetween futures and farm gate coffee prices in major coffee producing countries. The study substantiates the presence of a stable long-run relationship between ICE coffee futures prices and farm gate prices (spot prices) in top coffee producing countries, inferring that both futures and spot prices react to the same set of market information. While, there is an indication of equilibrium between ICE Coffee futures (New York) and Arabica producer prices (at farm gate level) & ICE Coffee futures (Europe) and Robusta producer prices (at farm gate level). According to the study results, farm gate prices in Honduras, India and Uganda where dependent on ICE Futures prices,while Arabica farm gate prices in Brazil have substantial influence on the ICE New York futures price. The study results reveals that, Brazil with the lion share in global arabica coffee production, is the price maker in the international market. While, India and Uganda with the low share in global coffee production are basically ‘price takers’ rather than ‘price makers’ in the international market.

Keywords: Cointegration, Intercontinental Exchange, Coffee futures, Co-integration, Producers prices, Granger Causality, Coffee Prices

INTRODUCTION

“Coffee is most widely traded tropical agricultural commodities in the world since coffee is produced in developing countries in global south and more than 70 per cent is being exported to developed countries in the global north.Coffee is provided livelihood for about 25 million small coffee growers in the world. Coffee contributes substantially to the foreign exchange earnings for nearly 50 coffee producing countries. . Coffee is a main source of income generation for about 12 million farms in the world. About 25% of these 12 million farms are operated by women (ICO, 2019a and ICO, 2018b). Further, about 100 million familiesare directly or indirectly depending on the coffee sector for their livelihood” (ICO, 2019a).

Major Coffee producing countries in the world are grouped under four regions *viz.*, Caribbean, Central America & Mexico (11%), Africa (11%), South America (48%) and Asia and Oceana (30%) (ICO Monthly Report November 2023). Among these regions, Brazil (36.82%), Vietnam (18.50%), Colombia (6.65%), Indonesia (6.9%), Ethiopia (4.86%), Uganda (3.86%), India (3.68%), Honduras (3.18%), Mexico (2.41%) and Peru (2.13%) are the top 10 coffee producing countries in the world during 2022-23 (USDA, 2023). Brazil and Vietnam are the world's biggest coffee growers, accounting for about 54% of global coffee production. South America & Asia dominated coffee production globally, which accounts for about 78 per cent of total global coffee production.

India is the seventh largest coffee producing county with the share of about 3.68% in thethe global coffee production in 2022-23. India produces both Arabica and Robusta with the share of 28 per cent and 72 per cent in the total production, respectively. However, India is known for its fine Robustas as Indian Robusta fetches highest premium in the international market. India is the 5th largest producer of Robusta coffee in the world with the share of about 5.5 per cent in the global robusta coffee production, while India's share in the global arabica coffee production is just 1.5 percent. In India, coffee industry provides direct employment to more than two million people.

"Coffee is an export oriented commodity with about 70 per cent of the production is being exported to more than 120 countries across the world. The domestic purchase prices ofArabica coffee in the producing countries mainly depend on price movements in the Intercontinental Exchange (ICE), New York and domestic purchase of Robusta coffee in the producing countries depends on price movements in ICE, Europe" (ICO, 2019a).

ICE futuresprices playkey role in price transparency, price discovery, price dissemination and risk transfer (Hall et al., 2006). Coffee prices are more volatile compared to other tropical agricultural commodities like cocoa (Gilbert and Morgan, 2010). These volatile coffee prices have an adverse impact on the livelihood of 25 million small coffee growers across the globe and about 4.90 lakh smallholders in India. Against this backdrop, an attempt has been made to understand the relationship between the futures prices and farm gate prices of both Arabica and Robusta coffee in major coffee producing countries.

MATERIAL AND METHODS

DATA

The study was carried out based on monthly Arabica farmgate prices in (from January 1965 to January 2022) Honduras(from January 1973 to July 2021) and Robusta farmgate prices in India (from October 1985 to February 2022), Uganda (from January1973to January 2022). Further, the study is also based on the ICE futures prices (average of 2nd and 3rd positions), New York - 'C' Contract for Arabica coffee and ICE futures prices (average of 2nd and 3rd positions), Europe for Robusta coffee.These two futures markets are the largest terminal markets for coffee (Scholer, 2004). The e secondary data for the study was sourced from the 'Database on Coffee' published by Coffee Board.

In the present study, prices paid to farmers in Braziland Hondurasfor Arabica coffee and prices paid to the farmers in India and Uganda for Robusta coffee are considered as spot prices.Coffee prices in ICE, New York and ICE Europe are considered as futures prices for Arabica and Robusta, respectively.

ANALYTICAL TOOLS

Augmented Dickey - Fuller Test (ADF)

Coffee futures prices (ICE New York and ICE Europe) and farm gate prices were subjected for stationary test using the Augmented Dickey-Fuller test (Dickey and Fuller, 1981), both with and without a trend. The ADF test was used to examine the null hypothesis of non- stationarity against an alternative hypothesis of stationarity of futures and farm gate pricesconsidered under the present study.The following ADF equation was estimated by using the ordinary least square method (Babuand Muniyappa, 2021).

$$\Delta y_t = \alpha_t + \beta_t y_{t-1} + \delta_t + \sum_{i=1}^{k} \gamma_i \Delta y_{t-i} + \varepsilon_t \text{ ……………………….. (Eq. 1)}$$

Where, t represents the time trend, k denotes the number of lags chosen in the model. The null hypothesis of the existence of unit root is H_0; β=0, includes both a constant and a linear time trend This methodology was employed in the earlier study by the International Coffee Organization (ICO, 2018a) and (Pradeepa and Arun, 2021). If coffee futures prices and farm gate prices are found to be integrated in the same orderI(1), then these prices can be subjected for the co-integration test.

Co – integration Test

"The ICE coffee futures prices and farm gate prices are tested for co-integration by using the Johansen Co-integration test. The procedure was introduced by Johansen during1991. As per the Johansen Co-integrationtestthe null hypothesis of no co- integration, will be tested against the alternative of at least one co-integrating equation" (Babu and Muniyappa, 2021). The Johansen Co-integration test is relies on maximum likelihood method and consist of two test statistics *viz.,* 1) Trace test and 2) Maximum Eigen value test. Under the Trace test, the null hypothesis is based on the assumption of nonexistence of co-integration equation between the coffee futures prices and farmgate prices, which needs to be rejected to establish the existence of co-integration equation between the two price series . The trace test statistic is given below:

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \text{ …………………………….. (Eq. 2)}$$

Here T is the sample size, and λi^ is the i^{th} largest canonical correlation. Trace test statistic is used in the present study to examine the existence of long run relationship between coffee futures prices and farm gate coffee prices.

Granger Causality Test

"After ensuring theexistence of a co-integration relationship between the coffee futures prices and farm gate prices, the influence/direction of causation (futures prices to farm gate prices or farm gate prices to futures prices) in coffee price discovery wasanalyzed using the Granger casualty test. In the case of two price-series, coffee futures prices are said to Granger-cause farm gate coffee prices if farm gate coffee prices can be better predicted using the histories of both coffee futures prices and farm gate coffee prices rather than using farm gate coffee prices alone" (Babu and Muniyappa, 2021). After identifying the requisite properties of the individual price series (lag length and unit root), the presence of Granger causality between ICE futures prices and farm gate prices is tested by estimating the following unrestricted model:

$$D.S_t^c = \alpha_0 + \sum_{i=1}^{m} \alpha_i D.S_{t-i}^c + \sum_{i=1}^{m} \beta_i F_{t-i}^c + \varepsilon_t \text{ ……… (Eq. 3)}$$

Where, S_t^c is the log of each farm gate coffee price indicator (c) at year t, D is the first difference of variable, for example for coffee farm gate prices: D $S_t^c = S_t^c - S_{t-1}^c$ and D. $S_{t-1}^c = S_{t-1}^c - S_{t-2}^c$. F_{t-i}^c is the lagged ICE coffee futures prices (New York and Europe) at time t, in its stationary form, m is the optimal lag length. The residual sum of squares is recoded (ESSu) after estimating the model, then estimated with the following restricted model:

$$D.S_t^c = \alpha_0 + \sum_{i=1}^{m} \alpha_i D.S_{t-i}^c + \varepsilon_t$$ ……………………………….. (Eq.4)

The residual sum of squares (ESSr) is recorded after estimating the restricted model. Granger causality test is performed by calculating the F-statistic and comparing it to the F-critical value at a 5 per cent level of significance. The F statistic is computed as follows:

$$F = \frac{(ESS_r - ESS_u)/m}{\frac{ESS_u}{n-1-m}}$$ ………………… (Eq, 5)

where, m is the optimal lag length, n is the number of observations 'm' and (n-1-m) is the degrees of freedom. The Granger causality test compares the residual sum of squares of both unrestricted and restricted econometric model.

$$H_0 = \textit{ no causality between futures and spot prices}$$
$$H_1 = \textit{ causality between futures and spot prices}$$

The null hypothesis can be rejected when the estimated F statistic is greater than the F critical value and there is evidence of the existence of causality between two price series. (ICO, 2018C).

RESULTS AND DISCUSSION

Testing the Stationary of different price series using Augmented Dickey–Fuller (ADF) test

The results of the ADF test are presented in Table 1. It represents the ADF test of coffee price series with constant and time trend. ADF test results in the first column indicating price series considered under study in level. Arabica farm gate prices (Brazil&Honduras) and both coffee futures prices (ICE New York-Arabica, ICE Europe- Robusta) are stationary at the level ($p<0.05$). While, Robusta farm gate prices in Uganda and India are non- stationarity at level.

Table 1: ADF test results, including constant and trend

Futures/farm gate prices	Test Statistic		P Value	
	Level	First difference	Level	First difference*
Brazil Arabica farm gate prices	-4.11	-8.50	0.01	0.01
ICE New York Futures prices	-3.84	-7.69	0.02	0.01
Honduras Arabica farm gate prices	-3.72	-9.26	0.02	0.01
ICE New York futures prices	-4.18	-7.06	0.01	0.01
India Robusta farm gate prices	-2.76	-6.92	0.26	0.01
ICE Europe futures prices	-3.24	-6.22	0.03	0.01
Uganda Robusta farm gate prices	-3.21	-7.58	0.09	0.01
ICE Europe futures prices	-3.62	-6.36	0.03	0.01

*Statistical significance at 5%

"he first difference is considered to make the Robusta farm gate prices in Uganda and Indiastationary . Column 2 indicates coffee price series under study in first difference. Although farm gate prices of arabica coffeein Brazil& Honduras and coffee futures prices in ICE New York&ICE Europe were stationary at level itself, first difference is applied to all the price series considered under the study for making all the price series (both coffee futures prices and Arabica & Robusta farm gate prices) to have the same order of integration" (Babu and Muniyappa, 2021).

The estimated results of the ADF test reveals that, the ADF test cannot reject a null hypothesis that all the price series considered in the present study are non-stationary at the level of (5 per cent significance). However, in the first difference, both coffee futures prices and farm gate prices were found to be stationary and were integrated of order one, i.e. I (1).

Co-integration test

“Johansen co-integration test is used to test the presence of the long-run equilibrium relationship between the ICEcoffee futures prices and farm gate coffee prices in the major coffee producing countries. Given that all the price series *viz.*, ICE New York Arabica coffee futures prices and prices paid to Arabica coffee growers at farm gate in Brazil & Honduras and also ICE Europe futures prices and prices paid to Robusta coffee growers at farm gate in India & Uganda are integrated into the same order I (1), Table 2 represents the co-integration test results between ICE coffee futures prices (New York and Europe markets) and farm gate coffee prices in major coffee producing countries. The number of equations considered for the co-integration analysis depends on the number of coffee price series were used. The maximum number of equations could be the number of coffee price series minus one. Since we have only two price series (coffee futures prices and Farm gate coffee prices), the maximum number of equations we can have is only one” (Babu and Muniyappa, 2021).

The study examined the presence of co-integration betweenICE coffee futures prices and farm gate coffee prices in major coffee producing countries . “The authors found the presence of co-integration between ICE New York coffee futures prices and Arabica farm gate prices in Brazil and Honduras. Thus, the null hypothesis of the existence of no co-integration relationship between ICE coffee futures prices in New York and Arabicacoffee farm gate prices in Brazil and Honduras can be rejected at a 5 per cent level of significance according to the Trace statistic. This denotes that, any deviations from this long-run relationship will be corrected. Thus, coffee futures pricesin ICE New York market is more efficient in discovering the farm gate pricesof Arabica coffee in Brazil and Honduras. The existence of Co-integration between ICE New York coffee futures prices and Arabica farm gate prices in Brazil & Honduras is an indication of the presence of a long-run equilibrium relationship between the two-price series caused by market forces. However, there may exist acausal relationship among them, which is further examinedusing the Granger causality test” (Babu and Muniyappa, 2021).

Similarly, the null hypothesis of the existence of no co-integration relationship between ICE Europe coffee futures prices and farm gate prices of Robusta coffee in Uganda cannot be rejected based on the estimated Trace Statistic values at 5 per cent level of significance. However, the null hypothesis of the existence of no co-integration relationship between ICE Europe coffee futures prices and Robusta farm gate prices in India can be rejected based on the estimated Trace statistic. Thus, no long-term or equilibrium relationship has been found between ICEEurope coffee futures prices and Robusta farm gate prices in India. The absence of co-integration between ICE Europecoffee futures prices and Robusta farm gate prices in India suggests that there might be only a short-run relationship between two price series. The study results are in consonance with the earlier studies conducted by Rajaraman (1986) and Pradeepa and Arun (2021).

Table 2: Co-integration test results of ICE coffee futures prices and farm gate coffee prices in major coffee producing countries

	No. of Co-	**Trace test**

Price series	integration equations	Test Statistic	P-value
ICE New York futures prices and Arabica farm gate prices in Brazil	1	9.24*	0.01
	0	19.96	0.05
ICE New York futures prices and Arabica farm gate prices in Honduras	1	9.24*	0.00
	0	19.96*	0.00
ICE Europe futures prices and Robusta farm gate prices in India	1	9.24	0.06
	0	19.96*	0.05
ICE Europe futures prices and Robusta farm gate prices in Uganda	1	9.24*	0.02
	0	19.96*	0.04

***Statistical significance at 5%**

Granger causality test

In the present study after finding the existence of long-termequilibrium relationship between ICE Coffee futures prices and farm gate coffee prices, Granger Causality test is employed to study the causal relationship between ICE coffee futures prices and farm gate coffee prices in major Arabica and Robusta coffee producing countries.

If two price series are found to be co-integrated, the possibility of Granger causality between them arisesas highlighted by Miller (1991) and Miller and Russek (1990). "co-integration analysisindicates the existence or non-existence of long-term equilibrium relationship between price series. However, Co-integration analysis does not provide insight into the direction of causation*viz.*,whether farm gate coffee prices in coffee producing countries influence ICEcoffee futures prices or vice versa.Thus,Granger causality test" (Fackler and Goodwin,2001)was used to test the Granger causebetween thecoffee futures prices and farm gate coffee prices .

The Granger causality test provides additional evidence for price transmission between two markets along with the direction (Paul and Sinha, 2015)*viz.*, "unidirectional or bidirectional. The present study examines whether price transmission between ICE coffee futures prices and farm gate coffee prices in major coffee producing countries are unidirectional or bidirectional. TheGranger causality testresults s are sensitive to the lag condition" (Paul and Sinha, 2015), "Few lags results ina biased test due to residual auto-correlation, and too many lags leads to spurious rejections of the null hypothesis" (Lütkepohl, 2005). Hence, based on the Akaike Information Criteria (AIC), the optimum lag for the Granger causality test was selected. In the present study, the AIC values were minimum at lag two to four (for different farm gate coffee prices). Therefore, a specific lag length of two to four was used for testing the Granger causality between two price series considered under the study.

"Unidirectional causalitywith significant P-values was observed in the relationship between ICE Coffee futures prices, New York and the prices paid to Arabica coffee growers in Brazil and Honduras, as detailed in Table 3. The results reveal that, ICE New York coffee futures prices do not Granger cause Brazil farm gate prices, given the P-value surpasses the 5% level of significance, indicating arabica coffee prices at farmgate in Brazil seem to incorporate new market information faster than the ICE New York coffee futures market. However, Brazil farm gate coffee prices Granger cause ICE New York coffee futures prices, with a P-value below the 5% level of significance. o Brazil is the largest coffee producer in the world with the share of about 46% in the global Arabica coffee production, hence the influence of Brazilian Arabica coffee farm gate price onthe ICE, New Yorkcoffee futures price is evident on account of the existence of adequate liquid exchange and strong domestic coffee consumption in Brazil" (ICO, 2018a; Pradeepa and Arun 2021).

ICE New York Coffee futures prices Granger cause Honduras farm gate prices, as the P-value is below the 5% significance level, but Honduras farm gate prices do not Granger cause ICE New York futures prices, as the P-value exceeds the 5 per cent significance level.Unlike Brazil, Honduras share in global arabica coffee production is just about 6% per cent, hence it does not have much influence on ICE New York coffee futures prices. However, ICE New York coffee futures prices granger cause the Arabica coffee prices in Honduras indicating that, Arabica farm gate prices in Honduras remains influenced by ICE New York coffee futures prices..

Table 3: Granger causality between coffee futures prices and farm gate prices

Price series	Null hypothesis	F-Statistic	P-value
ICE New York futures prices & Prices paid to (Arabica) coffee growers in Brazil	ICE New York futures price does not granger cause farm gate prices of Arabica coffee in Brazil	0.7267	0.55
	Farm gate prices of Arabica coffee in Brazil does not granger cause ICE New York futures prices	4.7922	0.02
ICE New York futures prices & Prices paid to (Arabica) coffee growers in Honduras	ICE New York futures prices does not granger cause farm gate prices of Arabica coffee in Honduras	8.2510	0.00
	Farm gate prices of Arabica coffee in Honduras does not granger cause ICE New York futures prices	2.7519	0.06
ICE Europe futures prices & Prices paid to (Robusta) coffee growers in India	ICEEurope futures prices does not granger cause farm gate prices of Robusta coffee in India	9.9608	0.00
	Farm gate prices of Robusta coffee in India does not granger ICE Europe futures prices	0.0214	0.98
ICE Europe futures prices & Prices paid to (Robusta) coffee growers in Uganda	ICE Europe futures prices does not granger cause farm gate prices of Robusta coffee in Uganda	6.7338	0.00
	Farm gate prices of Robusta coffee in Uganda does not granger cause ICE Europe futures prices	0.7387	0.53

*****Statistical significance at 5%

Similarly, ICE Europecoffee futures prices Granger cause Robusta farm gate prices in India and Uganda, with a P-value below the 5 per cent significance level. However, Robusta farm gate coffee prices in India and Uganda do not Granger cause ICEEurope coffee futures prices, as the P-value is above the 5% significance level. Thus, Robusta farm gate prices in Indiaand Uganda remains influenced by ICE Europe coffee futures prices. The study results are in line with the study conducted by Fry et al. (2011). Thus, "India and Uganda with their respective share of 6 per cent and 7 per cent in global Robusta coffee production, does not significantly influence ICE Europe coffee futures prices. Hence, both Indian and Uganda coffee farmers are basically 'price takers' rather than price makers in the international market. It is pertinent note that, although the Johansen test results rule out co-integration between ICE Europe coffee futures prices and Robusta coffee farm gate prices in India, there exist a unidirectional relationship between the ICE Europe coffee futures prices and Robusta farm gate prices in India. Therefore, there is feedback from ICE Europe coffee futures prices to Robusta farm gate prices in India, leading to an efficient price discovery mechanism, providing a basis for making coffee production and marketing decisions by the Robusta coffee farmers in India. Hence, the ICE coffee futures Europe play a dominant role in discovering farm gate coffee prices for Robusta coffee in India" (Fry et al., 2011).

CONCLUSION

The present study results reveal that,all coffee futures and farm gate prices are stationary at first difference. The findings of the study also prove the existenceof long term or equilibrium relationship between ICE New York coffee future prices and Arabica farm gate prices in Brazil and Honduras signifying both the ICE New York coffee futures prices and prices paid to Arabica farmers in Brazil and Hondurasreact to the same set of market information and sahre common stochastic factor.Similarly, the study results divulge the existence of long-term relationship between ICE Europecoffee futures prices and Robusta farm gate prices in Uganda. However, no long-term relationship has been found between ICE Europecoffee futures prices and Robusta farm gate prices in India.

The results of the study revealthe presence of a unidirectional relationship between Brazilian Arabica coffee farm gate prices and ICE New York coffee futures prices, indicating local farm gate prices in Brazil seem to incorporate new market information faster than the ICE New York coffee futures. Thus, the influence ofArabica coffee farm gate prices onICE New York coffee futures price is evident, which may be due to the existence of sufficiently liquid exchange and strong domestic coffee consumption in Brazil. Brazil with the largest producer of Arabica coffee with the lion share in global arabica coffee production, is the price maker in the international market. In an economic context, despite market demand and supply considerations, the dominance of efficient producers like Brazil, which grows coffee in open conditions by adopting intensive cultivation practices poses challenges for the high-quality Arabica coffee producing origins like Honduras. Honduras is just the price taker in the international market as ICE New York coffee futures prices Granger cause Honduras farm gate prices, but Honduras Arabica farm gate prices do not Granger cause ICE New York coffee futures prices. Thus, domestic Arabica coffee prices in Honduras are mainly depend on the ICE New York coffee futures prices.

ICE Europe futures prices Granger cause Robusta farm gate prices in both India and Uganda, but Robusta farm gate prices in India and Uganda do not Granger cause ICE Europe futures prices. Thus, India and Uganda with a mere share of about 6 per cent and 7 per cent in global Robusta coffee production, does not significantly influence the international coffee prices. Hence, Robusta coffee farmers in India and Uganda are basically 'price takers' rather than 'price makers' in the international market. Thus, the study shows that, though the main objective of the coffee futures market is to develop an efficient and transparent pricing mechanism, in case ofhigh quality (sustainably grown) coffee producers like India, the cost of production incurred by the farmers does not have consideration while setting the price for coffee in the international market.

HIGHLIGHTS

- ICE New York coffee futures prices and arabica farm gate prices in Brazil and Honduras react to the same set of market information, which indicates the existence of long run stable relationship between these two price series.
- Local Arabica farm gate prices in Brazil incorporates the new market information faster than ICE New York coffee futures prices.

- Robusta coffee farm gate prices in India is dependent on ICEEurope Robusta coffee futures prices.

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