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 in global south, and it is actively traded at international commodity exchange platforms *viz.*, Intercontinental Exchange (ICE), New York and ICE, London (in global north). This study examined the interrelationshipbetween futures and farm gate coffee prices in major coffee producing countries. The study confirms the existence of a stable long-run relationship between ICE coffee futures and farm gate prices in major coffee producing countries, implying that both prices react to the same set of market information. While, there is an indication of equilibrium or long-run relationship between ICE Coffee futures (New York) and Arabica producer prices (at farm gate level) & ICE Coffee futures (London) 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.

Keywords: Coffee futures prices, Co-integration, farm gate prices, Granger Causality, Coffee Prices

INTRODUCTION

Coffee is one of the most widely traded tropical agricultural commodities in the world. It is primarily an export-oriented commodity for many producing countries in global south. Coffee is providing a strong livelihood basis for about 25 million small coffee farmers in the world. Coffee is key contributor of foreign exchange earnings for nearly 50 producing countries, majority of them are developing economies. Coffee is a major source of income for more than 12 million farms globally, a quarter of which are operated by women (ICO, 2019a and ICO, 2018b). Further, an estimated 100 million families directly or indirectly depending on the coffee sector (ICO, 2019a).

Major Coffee growing countries have been distinguished under four regions *viz.*, Caribbean, Central America & Mexico (11%), Africa (11%), South America (48%) and Asia and Oceana (30%) (ICO Monthly Report November 2023). Across 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 growing countries 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 worldwide, which accounts for about 78 per cent of total world coffee production.

India is among the top 10 coffee-producing countries, with about 3.68% of the global output 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 in India.

Since coffee is an export-oriented commodity for producing countries like India, the domestic purchase prices of coffee in the producing countries mainly depend on international price movements. Coffee is actively traded at international commodity exchanges. There are two major international commodity exchanges for coffee, each of which effectively acts as a basis to compare coffees of different origins and quality. The coffee 'C' contract traded on the ICE in New York is the benchmark for Arabica coffee. The Robusta futures contract traded on ICE,London serves as the standard for Robusta coffee.

Futures markets play an important role in transparent price discovery, dissemination and risk transfer (Hall et al., 2006). Coffee is subject to significant price volatility compared to other tropical agricultural commodities like cocoa (Gilbert and Morgan, 2010). These volatile and low coffee prices have an adverse impact on the livelihood of 25 million small coffee growers across the world and about 4.80 lakh smallholders in India. Against this backdrop, an attempt has been made to understand the relationship between the futures prices (a contractual agreement to purchase the commodity at a future date) and farm gate prices (current coffee price for immediate delivery) of both Arabica and Robusta coffee in major Arabica and Robusta coffee producing countries.

MATERIAL AND METHODS

DATA

The analysis was carried out based on monthly observations of Arabica farmgate prices (Brazil from January 1965 to January 2022, Honduras- from January 1973 to July 2021) and Robusta farmgate prices (India- fromOctober 1985 to February 2022, Uganda- from January1973to January 2022). The futures prices comprise an average of 2nd and 3rd positions of ICE, New York - 'C' Contract for Arabica coffee and ICE, Europe for Robusta coffee traded in London. Here, we restrict to considering these two futures markets for coffee as these are, by far, the two largest (Scholer, 2004). The requisite data for the study sourced from various issues of 'Database on Coffee' published by Coffee Board.

In the present study, based on the availability of the consistent data for the entire study period, prices paid to farmers in producing countries *viz,* Brazil and Honduras for Arabica coffee; India and Uganda for Robusta coffee are considered as spot prices. Brazil is the largest producer of Arabica coffee and accounts for about 45 per cent of global arabica coffee production. While, Honduras is the fourth largest arabica coffee producer and accounts for about 6 per cent of global coffee production. Uganda is the 4th largest producer of Robusta coffee with the share of about 6.50 per cent in global robusta coffee production and India is the 5th largest producer of Robusta coffee with the share of about 5.50 per cent in global robusta coffee production.

ANALYTICAL TOOLS

Augmented Dickey - Fuller Test (ADF)

Both coffee futures prices and farm gate prices are tested for stationary using the Augmented Dickey-Fuller test (Dickey and Fuller, 1981), both with and without a trend. The ADF test is used to test the null hypothesis of non- stationarity against an alternative of stationarity of the price data under consideration. The following ADF equation isused for estimation by the ordinary least square method.

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

Where, t is the time trend, k represents the number of lags chosen in the model. The null hypothesis of the existence of unit root is H_0; $\beta=0$, includes both a constant and a linear time trend, δ_t. This methodology was employed in the study by the International Coffee Organization (ICO, 2018a) and (Pradeepa and Arun, 2021). In summary, if futures and farm gate prices are found to be I(1), they can be tested for co-integration.

Co – integration Test

The conformation that all prices used in the study are stationary at I (1) allows proceeding for the co- integration test. The ICE futures prices and farm gate prices are tested for co-integration by employing the Johansen test. The procedure introduced by Johansen (1991), the null hypothesis of no co- integration, will be tested against the alternative of one co-integrating equation. The Johansen tests are likelihood ratio tests as it relies on maximum likelihood method there are 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 no co-integration equation, which needs to be rejected to establish co-integration between the time series variables. 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 futures and farm gate prices.

Granger Causality Test

Having ensured the presence of a co-integration relationship between the futures and farm gate prices, the influence/direction of causation (farm gate prices to futures or otherwise) in coffee price discovery is examined using the Granger casualty test. In the case of two time-series price variables, futures prices are said to Granger-cause farm gate prices if farm gate prices can be better predicted using the histories of both futures prices and farm gate prices rather than using farm gate prices alone. 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 London) 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 estimated results of the ADF test are presented in Table 1. It represents the ADF test of 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 London- 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 London futures prices	-3.24	-6.22	0.03	0.01
Uganda Robusta farm gate prices	-3.21	-7.58	0.09	0.01
ICE London futures prices	-3.62	-6.36	0.03	0.01

*Statistical significance at 5%

To make data stationary the first difference is considered for robusta farm gate prices both in India and Uganda. Column 2 indicates price series under study in first difference. Although farm gate prices of arabica (Brazil, Honduras) and futures prices (ICE New York-Arabica, ICE London- Robusta) which were stationary at level itself, first difference is applied to make two series (both coffee futures prices and both Arabica & Robusta farm gate prices) have the same order of integration.

The estimated results reveal 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 employed to test the existence of the long-run relationship between the coffee futures and farm gate prices. Given that all the price series *viz.*, ICE New York futures prices and prices paid to Arabica coffee growers in Brazil & Honduras and also ICE London futures prices and prices paid to Robusta coffee growers in India & Uganda are integrated into the same order I (1), Table 2 represents the co-integration test results between coffee futures prices (ICE New York and ICE London markets) and farm gate prices in major coffee producing countries. The number of equations in the analysis depends on the number of price series used. The maximum number of equations could be the number of price series minus one. Since we have only two price series, the maximum number of equations we can have is only one.

The study tested the presence of co-integration between coffee futures market prices and farm gate prices. The authors found the existence 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 New York coffee futures prices and farm gate prices of Arabica coffee in Brazil and Honduras can be rejected at a 5 per cent level of significance as per Trace statistic. This indicates that, any deviations from this long-run relationship will be corrected. Thus, New Yorkcoffee futures market is efficient in price discovery process in Arabica coffee. Co-integration between ICE New York coffee futures prices and Arabica farm gate prices is not just an indication of the presence of a long-run or equilibrium relationship between the two-price series caused by market forces. Still, there may exist acausal relationship among them, which is further examinedusing the Granger causality test.

Similarly, the null hypothesis of the existence of no co-integration relationship between ICE London 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 London 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 ICE London coffee futures prices and Robusta farm gate prices in India. The absence of co-integration between ICE London coffee futures prices and Robusta farm gate prices in India suggests that there might be only a short-run relationship between two-time series variables. 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

Price series	**No. of Co-integration equations**	**Trace test**	
		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 London futures prices and Robusta farm gate prices in India	1	9.24	0.06
	0	19.96*	0.05
ICE London 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 ascertaining the long-term relationship between ICE Coffee futures prices and farm gate prices, Granger Causality test is employed to study the causal interaction between ICE coffee futures prices and farm gate prices in major Arabica and Robusta coffee producing countries.

If two time series variables are found to be co-integrated, the possibility of Granger causality between them arisesas highlighted by Miller (1991) and Miller and Russek (1990). While co-integration analysis is essential for examining the long-term relationship between price series, it does not provide insight into the direction of causation. The question of whether farm gate prices in coffee producing countries drive ICEcoffee futures prices or vice versa remains unanswered. Thus,Granger causality test between ICE coffee futures prices and farm gate price in producing countries would reveal that the price in one market often Granger causes the price in the other market, and vice versa, as observed by Fackler and Goodwin (2001).

Thus, the Granger causality test provides additional evidence of whether and in which direction price transmission occurs between two markets (Paul and Sinha, 2015). Sometimes the causality may be bidirectional. The present study examines whether a similar relationship exists between ICE coffee futures prices and farm gate prices in major coffee producing countries. The results of Granger causality tests are extremely sensitive to the lag condition (Paul and Sinha, 2015). Too few lags indicate a biased test due to residual auto-correlation, and too many lags allow for potentially spurious rejections of the null hypothesis (Lütkepohl, 2005). The optimum lag for the Granger causality test is selected based on the lowest information criteria. In the present study, it is found that the Akaike Information Criterion (AIC) values are minimum at lag two to four (for different farm gate prices). Accordingly, a specific lag length of two to four is used for testing the Granger causality

Unidirectional causality, with significant P-values indicating one direction of causation, is observed in the relationship between ICE New York coffee futures prices 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 local arabica coffee prices in Brazil seem to incorporate new market information faster than the New York coffee futures market. However, Brazil farm gate prices Granger cause ICE New York futures prices, with a P-value below the 5% level of significance, which is mainly due to Brazil is the largest coffee producer globally with the share of about 45% in the global Arabica coffee production; the influence of Brazilian Arabica coffee price on coffee futures price is evident. It was reported that, the existence of adequate liquid exchange and strong domestic consumption in Brazil add to such prominent causation (ICO, 2018a; Pradeepa and Arun 2021).

ICE New York 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 6.5 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 to a greater extent.

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 London futures prices & Prices paid to (Robusta) coffee growers in India	ICE London 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 London futures prices	0.0214	0.98
ICE London futures prices & Prices paid to (Robusta) coffee growers in Uganda	ICE London 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 London futures prices	0.7387	0.53

*****Statistical significance at 5%

Similarly, ICE London futures prices Granger cause Robusta farm gate prices in India and Uganda, with a P-value below the 5% significance level. However, Robusta farm gate prices in India and Uganda do not Granger cause ICE coffee futures prices, London, as the P-value is above the 5% significance level. Thus, Robusta farm gate prices in Indian and Uganda remains influenced by ICE London coffee futures prices to a greater extent. The study results are in line with the study conducted by Fry et al. (2011). Thus, India and Uganda with their respective share of 5.5 per cent and 6.5 per cent in global Robusta coffee production, does not significantly influence ICE London 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 London coffee futures prices and Robusta coffee farm gate prices in India, there is a unidirectional relationship between the ICE London coffee futures prices Ganger cause Robusta farm gate prices in India. Therefore, there is feedback from ICE 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 London play a prominent role in discovering farm gate coffee prices for Robusta coffee in India.

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 New York coffee future prices and Arabica farm gate prices in Brazil and Honduras signifying both the New York futures prices and prices paid to Arabica farmers in Brazil and Hondurasshare a common stochastic factor and react to the same set of market information.Similarly, the study results divulge the existence of long-term relationship between ICE London futures prices and Robusta farm gate prices in Uganda. However, no long-term relationship has been found between ICE coffee futures prices and Robusta farm gate prices in India.

The results of the study reveal the dominance of the Brazilian Arabica farm gate coffee prices on ICE New York futures prices. Further, the Granger causality test providedthe additional evidence that, there exists a unidirectional relationship of the Brazilian Arabica coffee farm gate prices ganger causing ICE New York coffee futures prices, indicating local producer prices in Brazil seem to incorporate new market information faster than the New York coffee futures. Thus, the influence ofArabica farm gate prices on New York coffee futures price is evident. The existence of sufficiently liquid exchange and strong domestic coffee consumption in Brazil add to such prominent causation. Brazil 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 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 London 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 London futures prices. Thus, India and Uganda with a mere share of about 5.5 per cent and 6.5 per cent in global Robusta coffee production, does not significantly influence 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 objective of the coffee futures market is to develop an efficient pricing mechanism, in case of small high quality 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 depending on ICE, London Robusta coffee futures prices.

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