EFFICIENCY OF THE BRAZILIAN COFFEE FUTURES MARKET IN THE PERIOD 1992-1998+

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ABSTRACT - The basic function of futures markets is to give agents who negotiate a certain commodity a hedge or protection against future adverse price variations. Prices in the futures market are efficient when they reflect all the relevant information available up to the present date, which then enables the trader to estimate the best price attainable at the contract's deadline. This paper's objective is to test the efficiency hypothesis for the Brazilian coffee futures market from March 1992 to May 1998. Its final results suggest that cash and future prices are co-integrated and that futures prices are unbiased estimators of cash prices, given that the co-integration parameter is equal to the unit. The results also suggest that the coffee futures market properly carries out its open price function, and it can therefore facilitate and optimize the agents' decisions regarding production, commercialization, and storage costs. We concluded that that market is weakly efficient.

Key words: Future markets, efficiency, coffee, co-integration.

INTRODUCTION

In the last decades, the futures markets have been one of the most effective market instruments to eliminate the risk of price variation. In the world of finance and investment, the derivatives markets are important because they allow for effective risk administration through

+ The authors would like to thank for the suggestions and commentaries of the anonymous "ad-hoc's ", reminding that eventual mistakes and omissions are of our exclusive responsibility. The authors also thank the collaboration of the CNPq trainee, Roger Alan Marçal da Silva.
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hedging. The inherent risks of derivative operations are the same found in normal operations, especially systemic risk. According to Santos (1996), price risk will always exist; but with the use of derivatives that risk can be distributed to other agents, such as hedgers, speculators, and arbitrators.

The main function of futures markets is to offer the possibility of protection (a hedge) against future adverse prices variations to agents who negotiate certain commodity transactions. The unique economic objective of creating a hedge is to minimize price risks. There are two types of hedges: sale and purchase hedges. The sales hedge exists on the offer side, and is a strategy used by the owner or producer of a particular product. The merchandise vendor sells contracts for future delivery at specified prices to protect himself against a possible price fall in the commodity which he intends to sell. The purchase hedge is basically used by agents who demand certain merchandise from processors, makers, and exporters. These agents buy contracts for future delivery to protect against possible unfavorable oscillations in the price of the not yet acquired merchandise. Through the hedge, Clini (1995) points out that it is possible to transfer the risk of unexpected capital losses to another agent who is willing to carry this risk. This other agent may or may not be directly involved in the merchandise's production and commercialization processes.

The futures markets have another function besides the transfer of risk; they signal future prices. They indicate the price that will prevail in the cash market on the contract's due date. A futures market which exerts the price signal function in an adequate way is that market which instantly reflects all information received by the market's participants in the contracts' price-list.

If a specific futures market is efficient, the prices of its future contracts reflect the opinion of a great number of participants in this market about the conditions of offer and demand at issue. Therefore, the prices of future contracts would be a good signal of the prices which will prevail in the cash market on the contract's due date. According to Kastens and Schroeder (1995), viable futures markets must be efficient or at least unbiased over the long-term. Intuitively, efficient futures markets must be intimately related to the market's forecasting ability.

When an economic agent determines his future price expectation, he takes under consideration a series of variables which affect the cash price. Prices on the futures market, according to Morgan et al. (1994), are efficient when they reflect all the relevant information available up to the present date, and represent the best estimate of the cash price on the contract's due date.

During the last three years, the Brazilian agricultural futures market has gained wide acceptance. Today, Brazil has the most developed derivative stock market in Latin America and the world's sixth largest futures stock market in volume of contracts. On Brazil's Commodities & Futures Exchange (BM&F), agricultural (coffee, ox, sugar, soy, cotton and corn) and financial (coin, interests, gold and stocks indexes) future contracts are negotiated. Currently, currency and interest contracts represent 15% and 60% of the total volume respectively. The agricultural futures market is still a modest participant, representing less that 1% of all futures market activities in the first semester of 1998. The revenue brought into the futures market by Brazil's main agricultural commodities increased more than 50% in 1996. By August of 1998, the volume of agricultural transactions had reached 236,998 negotiated contracts, mainly dealing with coffee and ox future contracts, and involved a financial interest to the Exchange of R$ 2,879,439.

The Brazilian coffee futures market, when compared to international patterns, is the most developed of Brazil's agricultural futures markets. With the largest volume of negotiated agricultural contracts in the BM&F, coffee is shown to be the country's most negotiated commodity. Coffee stands out for its historical and monetary importance in the national economy. Brazil is the world's largest coffee producer, responsible for 28% of total world production; and exported Brazilian coffee has a transactional volume superior to that purchased for domestic consumption (BM&F, 1997).

This study was developed to evaluate the Brazilian coffee futures market's efficiency due to its importance and its behavior between March 1992 and May 1998. This study is intended to provide market agents with more information when making decisions based on futures market pricing, as well as to assist in the formulation of risk reduction strategies.

METHODOLOGY

Theoretical Model

The ability of futures markets to act as prognosticators of future prices is a necessary condition for the effective reduction of risks through use of these markets. That risk reduction ability is formalized as the hypothesis of efficiency of futures markets, which is associated to the idea that future and cash prices converge over the long term. Information determines the bias of the interactive mechanisms between offer and demand; the efficiency of futures markets depends on the quality of that information flow. This property is known as the denominated price discovery function, and posits that the future price varies depending on each new bit of information. Flow of information will be influenced by the volume of business and by the nature of future prices relative to the asset's current cash price. Still, there must exist a close relationship among the negotiated asset's future and current cash value so that the market agents can consider future prices as representative of the current cash price.

The agents who act in futures markets - hedgers and speculators - are rational and look for protection against adverse variations in their product's price or profits facilitated by those same variations. All agents use the available information in order to evaluate their strategic plans, and then they work the derivative market. A specific forecast will be efficient if it has all the available relevant information for the current period. According to Fama (1970), mentioned by Kastens and Schroeder (1995), there are three efficiency forms in terms of the possible groups of information. A weakly efficient futures market bases its forecasts on information regarding the last future prices only. The semi-strong efficiency form makes use of all openly available, relevant information. And finally, the strong efficiency form combines private information with the information available to the two previous groups[1].

[1] In this work, only the concept of weak efficiency will be used, and is the basis for adopted model's formulation. The main restriction of this study comes from the difficulty of empirically testing the strong and semi-strong efficiency forms. The use of a larger set of information may, therefore, strengthen as well as weaken the results achieved in this work.

Generically, Fama (1970), mentioned by Crowder and Hamed (1993), describes an efficient future market as being one in which future prices are unbiased estimators of subsequent cash prices. According to Bigman et al. (1983), unexpected information can lead negotiators who act in an efficient future market to alter their plans. The concept of efficiency of future markets can be schematized as follows:

$$E(S_T) = F_{T-n} \qquad (1)$$

where $E(S_T)$ is the price expected at date T (contract's due date), F_{T-n} is the future price at the date T-n, and n is the number of periods (weeks, months) before the due date.

If only non-premature new information leads to a price variation, then the agents who base their assumptions on future price information acted efficiently. Decisions about production volume and the level of stocks warehoused are made based on the agents' expectation of future prices. The more information agents have on hand the more precise the expectation of the future behavior of the merchandise's price, and the more precise the process of timely resource allocation among the assets. Uncertainty in respect to future price behavior would lead agents make erroneous decisions and misallocate resources (Clini, 1995). Thus, the use of efficient future contracts by producers would have the same effect on the productive process as the absence of future price uncertainty. In this environment, agents could make allocational decisions in the most efficient way possible. The informational content built into a given future market's rates has an important impact on resource allocation for the entire economy.

Given an available group of information at a certain period of time, it is possible to define the efficiency of a futures market from the following relationship between some future price and expectation of that price being in effect on the contract's due date:

$$E_t(S_T - F_{t,T}/\phi_t) = 0 \qquad (2)$$

where $F_{t,T}$ is the future price at time t for expiration at time T, with $0 < t < T$; S_T is the cash price on the T due date; ϕ_t is the current available information at time t; E_t is the mathematical operator of expectation in the t period, conditional to the information evaluated in the period t (Bigman et al., 1983). Therefore, future price registered in time t for expiration in time T is an unbiased estimator of the S_T cash price on the due date, given the current available information evaluated at time t.

Successively, new information is accumulated and used by rational negotiators. The individual's set of information becomes gradually larger as the contract's due date approaches. Therefore, the available current information at time t is contained in the available information of all subsequent periods, being:

$$\phi_{t+r} \supseteq \phi_t \;\; ; \; r \geq 0, \; \forall t. \qquad (3)$$

Consider two prices as $F_{t,T}$ and $F_{t+1,T}$ where T is the due date. Since $\phi_{t+1} \supseteq \phi_t$ and the market is efficient, these prices should supply unbiased estimates cash price of the same product on the future date. Also, price $F_{t+1,T}$ should supply a better cash future price estimate than $F_{t,T}$, given that it was registered when more information was available.

Empiric Model

The hypothesis of efficiency of the Brazilian coffee future market will be tested using the model presented by Morgan et al. (1994) and then applying a regression test by the method of Ordinary Square Minimum. Admit a sequence of future prices $F_{t,T}$, F_{t+1},T,..., F_{t-1},T registered in serial trade dates for the same due date. If the market is efficient, then there exists an equation of regression as follows:

$$S_T = \alpha_i + \beta_i F_{T-i,T} + \varepsilon_T \qquad i=1, ..., T-1 \qquad (4)$$

where S_T is the logarithm of the cash price on date T and $F_{T-i,T}$ is logarithm of the future price on T-i, with due date on T.

The efficiency hypothesis in that model will be formalized by the acceptance of the null hypothesis H_0: α_i=0 and β_i=1 for every i, representing the number of weeks before the due date at which the future price is registered. By presupposition, it is expected that ε_T, disturbance or random mistake be independent and identically distributed with expected value equal to zero, $E(\varepsilon_T)=0$. The hypothesis of efficiency of the future market presupposes that the future price registered on the due date (F_T) must be necessarily equal to the cash price on this date (S_T). Moreover, the accumulation of information over time also suggests that the value of R^2 may increase monotonically with T-i. Thus, the prices of the closer futures contracts should estimate the physical price at expiration better than the prices of the further-out contracts.

In the analysis of a temporal series, the series' stochastic process generator's behavior must be documented and studied over time. If the characteristics of the stochastic process change with time, the process is denominated as non-stationary and difficult to model. Random walks are examples of a non-stationary temporal series. On the other hand, a stationary series is a stochastic process, constant in time, modeled by an equation of fixed coefficients, which are estimated from given data (Pindyck and Rubinfeld,1991).

Although, in practice most temporal series are not stationary, many of them can be differentiated one or more times, so the resulting series becomes stationary. That is, some non-stationary series in any level can be stationary, such as on first differences. The co-integration concept means that non-stationary variables can move in unison and over the long term appear to be a balanced relationship. In general terms, two variables are co-integrated when a lineal combination of these is integrated to a smaller degree (Bacchi, 1995). If S_T and F_t are co-integrated, they cannot distance themselves because their difference is stationary. For verification of the futures markets efficiency hypothesis, cash and future price synchronization is a needed but not sufficient condition. Efficiency also requires that the β parameter be equal to the unit, that is $\beta = 1$.To test the stationarity of the series, the test of the unitary root introduced by Dickey and Fuller is suggested. The following model is considered initially:

$$F_t = \rho F_{t-1} + \varepsilon_t \tag{5}$$

where ε_t is the term of stochastic mistake, independent and identically distributed with an expected value equal to zero. This mistake term is known in the literature as the term of mistake "white noise".

The model considered above implies in a regression of F in time t in relation to its value over the period (t-1). The easiest method of verifying the existence of *unitary root* in a temporal series is to test (5) the hypothesis H_0: $\rho=1$ (series has unitary root) against H_1: $\rho<0$. If the coefficient of F_{t-1} equals 1 ($\rho= 1$), it has a *unitary root* problem and characterizes a non-stationarity situation[2]. To test the null hypothesis that $\rho= 1$, statistically calculated t is known as statistically τ (tau), the critical values of which were tabulated by Dickey and Fuller based on simulations taken from Monte Carlo. The test τ (tau) is known literature as the Dickey-Fuller test and was later refined by MacKinnon, through use of new simulations tested in Monte Carlo (Mackinnon, 1991).

The non co-integration hypothesis among two variables is tested through use of the Engle-Granger test (EG) or the Increased Engle-Granger (EGA), which estimates regression with obtained residues from the Dickey-Fuller test (DF) or the Increased Dickey-Fuller (DFA). Using the Dickey-Fuller test, it is acceptable that F_t and S_t are random walks, but that ΔS_t and ΔF_t are stationary. The F_t and S_t co-integration test initially leads to rotating one regression per Ordinary Square Minimum (named co-integration regression), with specification given by equation (4). Parameter β is denominated as the co-integration parameter. Specifically, the hypothesis is tested that ε_t is non-stationary, that is, the non co-integration hypothesis among the series (Pindyck and Rubinfeld, 1991).

This study's efficiency hypothesis test of the coffee futures market used 32 observations taken between March 1992 and May 1998. The variable S_0 is defined as the logarithm of the medium cash price on the first week of every expiration month. The series of future prices were gapped by ten weeks, totaling eleven variables of the study (F_0 to F_{10}), with F_0 as the logarithm of the medium future price on the first week of every expiration month and successively up to F_{10}, the logarithm of the medium future price ten weeks before the first week of the

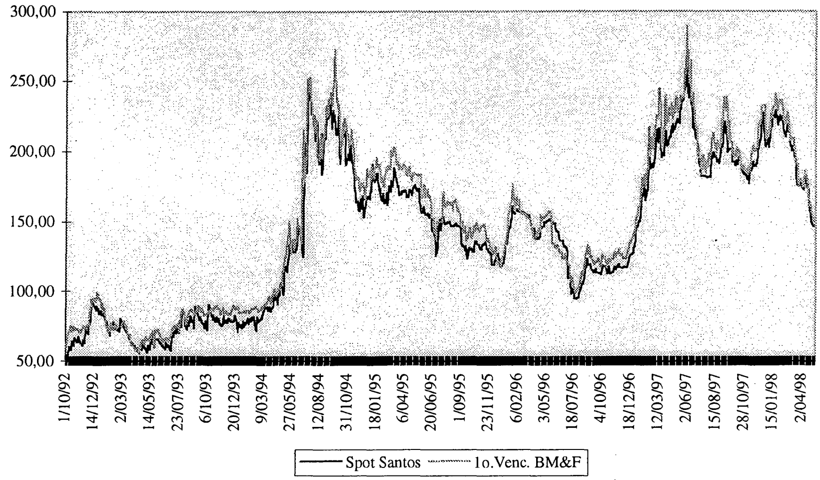
[2] Non Stationary series denominated random walks are specific cases of series with unitary root. A series may have unitary root and not be a random walk. However, every random walk has unitary root.

expiration month. In a previous study to test the efficiency hypothesis of the soy and coffee futures markets, the same methodology was used but a series of future prices gapped by only four weeks was substituted (Arbex and Silva, 1998). The results of that study are similar to the ones presented in the present work.

RESULTS AND DISCUSSION

During the analysis period (1992-1998), the cash and future international prices of coffee oscillated substantially, generally following the high and low tendencies of internationally registered prices, especially in New York Coffee, Sugar, and Cocoa Exchange. In April 1994, internally negotiated coffee prices reached highs of US$ 200 to US$ 250 dollars per 60 kilo bag (Figure 1). This period was followed by a soft fall in prices. The fall was reversed in December 1996, as the risk of frost in the main coffee producing countries generated uncertainties in product supply; and the market price of coffee elevated worldwide.

Figure 1 - Cash coffee price Port of Santos, and future coffee contract price negotiated in The Commodities & Futures Exchange (BM&F)



Source: BM&F

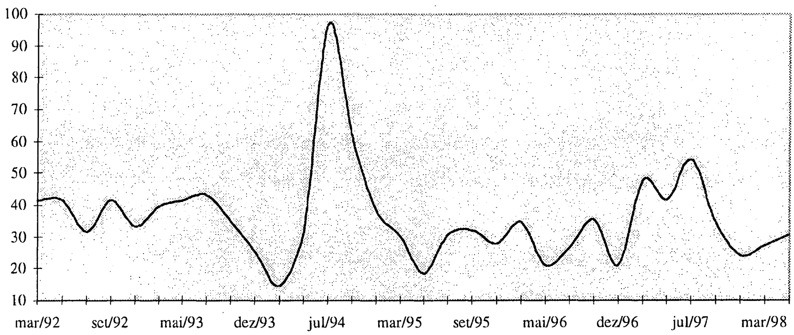
In respect to the behavior of the coffee future prices for different expirations, the data characterized an inverted market in the years 1994, 1996, and 1997, as the more distant future expirations were registered to inferior prices than to the prices of the closest expirations. However, in 1995, the market worked with normal costs of carry: the distant expirations were more valuable than the close ones.

The historical volatility analysis (60 days) of future coffee contracts leads one to make some inferences connected with that market's uncertainty level.[3]. From Figure 2, one observes that there is no distinct pattern of behavior during the period under analysis. In July 1994 (month of release of "Plano Real"), contract volatility was the most extreme found in our study. After that considerable fall, contract volatility remained

[3] Volatility was calculated using the variance of future prices returns for each expiration analyzed. More information on Carvalho (1998).

at low levels, oscillating between 20 and 40%. In the second semester of 1997, a higher tendency toward contract volatility is observed, possibly motivated by the Asian stock markets' crisis.

Figure 2 - Volatility of the future contract of coffee negotiated at the BM&F



Source: Research's Data.

The efficiency analysis of the Brazilian coffee future market proceeded in three stages. First, the existence of unitary root was tested on the twelve suggested series, through the Augmented Dickey-Fuller test (DFA). From the results of that test, it was verified that the variables are not stationary in the level. However, they are stationary in the first difference, in which the cash and future prices are integrated of order one , I(1). The results of the DFA test for first difference can be better visualized in Table 1.

Table 1 - Dickey-Fuller Tests for the Series of Physical and Future Price *

S_0	-4,80	F_5	-4,21
F_0	-5,42	F_6	-3,90
F_1	-4,97	F_7	-3,95
F_2	-4,67	F_8	-4,51
F_3	-4,17	F_9	-4,68
F_4	-3,73	F_{10}	-4,74

* Values calculated from the DFA Test for first difference.
Obs.: Critical values for DFA statistics with 32 observations to the level of 1% significance: -4,29; 5% significance: - 3,56.

Given that the variables are integrated of same order, the next step was to perform a co- integration analysis among variables. According to equation (4), the eleven previous regressions were estimated and their residues obtained.[4] The co-integration hypothesis was then tested between cash price and future prices, applying the Augmented Dickey-Fuller test to the residues of the regressions, without intercept and tendency, and with one gap. For all co-integration regressions, the null hypothesis of non co-integration may be rejected, implying on the co-integration acceptance, consistent with the market efficiency[5]. The results are presented on Table 2.

[4]The multiplicator Lagrange test for self serial correlation (LM Test) was also apllied, through which no problems were verified on the presented estimations.
[5] The Philliphs-Perron Test was applied, for co-integration verification among the series. The results confirm those from the DFA test, demonstrated on Table 2.

Table 2 - Co-integration Regression: Cash and Future Prices

Regressions	R^2	DW	Teste DFA*	Regressions	R^2	DW	Teste DFA*
S_0=0.043 +1,0F_0	0.98	2.2	-5.32	S_0=-0.19 +1.03F_6	0.89	1.58	-4.15
S_0=0.029 +0.98F_1	0.98	1.68	-4.57	S_0=-0.16+ 1.02F_7	0.87	1.53	-4.25
S_0=0.066 +0.98F_2	0.95	1.42	-4.22	S_0=-0.06 +1,0F_8	0.84	1.64	-4.59
S_0=0.049 +0.98F_3	0.94	1.45	-4.29	S_0=0.14 +0.96F_9	0.80	1.56	-4.66
S_0=0.014 +0.99F_4	0.91	1.49	-4.48	S_0=0.24 +0.94F_{10}	0.76	1.48	-4.59
S_0=-0.012+0.99F_5	0.90	1.64	-4.35				

* Values calculated from the DFA Test of residues, at the level.
Obs.: Critical values for DFA statistics with 32 observations to the level of 1% significance: -4,29; 5% significance: - 3,56.

Synchronization between the markets cash and future prices is the first requirement of an efficient market. The efficiency hypothesis still requests that the co-integration parameter (β) equal one. In order to test that condition, W variable is defined as follows:

$$W_t = S_t - F_{t-i} \quad (8)$$

Verification that the variable W_t is stationary, from the application of the Augmented Dickey-Fuller test, implies that S_t and F_{t-i} are co-integrated with their parameter equal to the unit. For all W_t series, the null hypothesis of non-stationarity is rejected, as may be observed on the following Table:

Table 3 - Dickey-Fuller Test increased for W_t variable (*)

$_0$= S_0 - F_0	-5,11	W_6= S_0 - F_6	-4,01
W_1= S_0 - F_1	-4,26	W_7= S_0 - F_7	-4,10
W_2= S_0 - F_2	-4,20	W_8= S_0 - F_8	-4,40
W_3= S_0 - F_3	-4,17	W_9= S_0 - F_9	-4,52
W_4= S_0 - F_4	-4,31	W_{10}= S_0 - F_{10}	-4,49
W_5= S_0 - F_5	-4,14		

(*) Values calculated from the DFA Test, at the level.
Obs: Critical values for DFA statistics with 32 observations to the level of 1% significance: -4,29; 5% significance: - 3,56.

It can be inferred from the results obtained by this study that the Brazilian Commodities & Futures Exchange's coffee futures market is weakly efficient (weak form). Alternatively, it can be affirmed that coffee cash and future prices found at the BM&F are co-integrated and synchronized, with a parameter equal to one, and that the future prices are unbiased estimators of cash prices. The results also suggest that, over the ten weeks previous to the first week of the contract's due date month, future prices registered at the BM&F efficiently reflect the cash price that will in effect on their due date. Agreeing with the theoretical referent, future prices set nearer to the contract settlement date are more efficient unbiased estimators of the cash price, which is the effect of the agents' accumulated information.

Two other studies of the Brazilian coffee futures market show similar results to the ones found in the present study. Using a like method, differing only in the period analyzed and the number and periodicity of the gaps, Morgan et al. (1994) analyzed the period from March 1984 to December 1993, gapping the series of future prices by one and two months to test the efficiency hypothesis. That study's results also suggest that the coffee cash and future prices are co-integrated and that the market is weakly efficient.

Campos (1996) set up two tests for the Brazilian coffee future market, which were presented by Nordhaus (1987). The first test determines that forecast revisions are not correlated to the previous ones, while the second determines that forecast mistakes are independent of the revisions of previous forecast. For the period from August 1991 to March 1996, the author concludes that it is not possible to reject the efficiency hypothesis for the Brazilian coffee futures market and that it shows no evidences of inefficiency. The results of our work, supported by those obtained in the studies referred to above, support acceptance of the hypothesis of efficiency of the coffee futures market negotiated in Brazil's Commodities & Futures Exchange.

CONCLUSIONS

The obnoxious distortions found in the futures market's prices were a result of continuous Brazilian currency inflation allied with excessive State regulation and interference in agricultural markets. These problems inhibited the development of the country's agricultural derivative markets. However, the arrival of economic stability and free market mechanisms marked the emergence of a new business context, favorable to creation and expansion in the economy, including agribusiness, and employing the modern instruments of price risk management.

Besides their basic function of providing a means of risk transfer between investors, futures markets also work as important indicators of assets price expectations. The futures markets must act as good forecasters of future prices as a necessary condition for the effective reduction of risks in those markets. That ability is known in the literature as the hypothesis of futures markets efficiency.

The results suggest that the Brazilian futures market is weakly efficient. Although cash and future prices are not stationary at specific levels, they are co-integrated, indicating that there exists a long term relationship between them. Moreover, the co-integration parameter equals the unit, which denotes that futures prices are unbiased estimators of cash prices. The results also suggest that the coffee futures market properly carries out its price function; therefore, it may facilitate and optimize the agents' decisions in respect to production, commercialization [marketing], and storage. The adoption of efficient price risk-reduction instruments may also translate into increased stability in the rural economy.

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