Establishing the presence of a risk premium in the cocoa futures market: An Econometric Analysis

Stephen E Armah
Department of Consumer and Agricultural Economics
University of Illinois at Urbana Champaign
Room 405 Mumford Hall, 1301 West Gregory Dr. Urbana, IL 61801-3605

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Abstract

Previous attempts at identifying and estimating a time-varying risk premium in the cocoa futures market yielded conflicting results. Using a longer series that includes the most recent cash and futures data, the existence of a time-varying risk premium in the cocoa futures market is re-investigated using LM ARCH tests and a Quadratic ARCH in Mean Error Correction Model. In contrast to available research the time series properties of the data are carefully accounted for by employing the most recent econometric techniques in testing for the presence of a risk premium. No evidence is found in support of a positive time-varying [or constant] risk premium in the cocoa futures market at conventional significance levels. The result suggests that cocoa producing countries have one less cost to consider in deciding whether or not to hedge cocoa price risk using futures contracts.

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Contact info: (1) Email: sarmah2@uiuc.edu (2) Office phone 217 333 8538

Introduction

Although the use of futures markets provides practical price risk management opportunities for cocoa exporters in Least Developed Countries (LDC), cocoa exporter participation in futures markets remains low. Reasons offered to explain the limited use of futures contracts by cocoa exporters to hedge price risk include: lack of knowledge about the operations of futures markets on the part of exporters (the so-called ignorant farmer hypothesis), and lack of collateral to meet margin requirements of exchanges (Thompson, 1985)[1]. However, it is also conceivable that LDC governments ignore the use of futures markets for routine hedging operations because it is costly (incorporates a

[1] Employing a positive model of hedging, Collins (1997) argues that the reason farmers in the US do not hedge output price is because the farm income is only a small portion of total assets. By contrast, since cocoa exporters derive almost all income from cocoa exports, the prediction of Collins's positive analysis is that cocoa exporters should hedge output price but they do not do so or do so to a very small degree. One motivation for this research therefore, was to verify if steep risk premiums is the reason why hedging activity remains unpopular among cocoa exporters.

steep risk premium) or because they perceive the cocoa futures markets produce biased and inefficient forecasts of the subsequent commodity cash prices, compromising efficient hedging. Recall that market efficiency implies that futures prices provide an unbiased forecast of subsequent spot prices provided thee are no risk premiums (McKenzie and Holt, 2002 hereafter M&H, 2002; Gray and Tomek, 1970; Kofi, 1973; and Leuthold, 1974). Consequently when futures markets are inefficient futures price forecast of the subsequent cash prices are biased (Sabuhoro and Larue, 1997). It is difficult, however, to discern if this bias in futures market forecasts is due to the inability of the futures markets to incorporate all information available to produce efficient forecasts or if the bias is the consequence of normal backwardation (Frank and Garcia, 2007)[2]. In normal backwardation, risk-averse hedgers pay a risk premium to speculators to bear the spot price risk (Keynes, 1930). Such a risk premium if it exists in the cocoa futures market is yet another cost that will discourage cocoa producers or exporters from using cocoa futures markets to hedge price risk. The primary objective of the paper therefore is to investigate the presence of a time varying risk premium in the New York Board of Trade (NYBOT) cocoa futures market. Beck (1994) Subahuro and Larue (1997) and Manayi and Struthers (1997) have all previously estimated price premiums for cocoa but the research remains relevant as futures market performance and associated risk premiums are often dependent on the period of analysis (M&H, 2002; and Beck, 1994).

The identification of risk premium in agricultural commodities futures market remains a controversial topic (Frank and Garcia, 2007) and its estimation for a typical agricultural commodity futures market such as the as the cocoa futures market is non–trivial. The controversy arises because it is difficult to distinguish between informational inefficiency and the presence of a risk premium, since both cases result in biased futures

[2] The claim that futures markets produce unbiased forecast of the subsequent period cash price is a joint hypothesis of market efficiency and risk neutrality or the absence of a risk premium (M&H, 2002), Beck, 1994). Both assumptions are difficult to justify, as there is evidence to the contrary. Risk premiums can exist both in the long run and the short run. If the risk premium is zero or a non-zero constant in the long run it will likely be zero or constant in the short run so then the main challenge in identifying whether the bias in futures forecast of subsequent period cash prices is caused by informational inefficiency or a risk premium is to identify a time varying risk premium in the short run.

prices. However, if the risk premium is time varying, then QARCH in mean (QARCH-M) type models can be used to detect the presence of a risk premium. On the other hand, if the risk premium is constant, forecast bias due to informational inefficiency couldn't be easily differentiated from forecast bias due to a risk premium Garcia and Frank (2007)[3]. However, in the situation where future price and cash prices are co-integrated, long run but not short forecast bias due to a constant risk premium may be differentiated from forecast bias caused by informational inefficiency[4]. The motivation for testing for the presence of a risk premium in the cocoa futures market at this time is fourfold: (1) There is contrasting evidence in the literature about the existence of a risk premium in the cocoa futures market and this research hopes to resolve some of the ambiguity (2) More time series data is now available and significant improvements have been made recently in those time series techniques (for example, tests of stationarity and structural breaks) necessary to evaluate the efficiency of the cocoa futures market and to identify a risk premium in cocoa futures markets. This implies the conclusions of earlier studies using older data, older statistics and older econometric techniques may not necessarily hold anymore since model selection is driven by correct execution and inference of specification tests (3) There is renewed interest among cocoa producers to hedge cocoa price variability. Ghana, the second largest cocoa producer has started hedging cocoa

[3] The difficulty in differentiating between forecast bias caused by a constant risk premium and bias caused by informational inefficiency arises because when the risk premium is constant instead of time-varying we cannot take advantage of the variability in the variance of cash and futures prices to identify the constant risk premium.

[4] It is plausible for to have futures forecast of spot prices to be biased or unbiased either in the short or the long run. In the long run, if the cash and futures markets are co-integrated then they are efficient but they may still be a risk premium either time-varying, constant or zero. M&H (2002) derive formal test of short run market efficiency, unbiasedness and the presence of a risk premium in five agricultural commodities, which we also employ in this research. M&H (2002) also try to identify a constant LR risk premium by testing the zero constant restriction of the futures cash cointegration relationship. Beck (1994) investigates long run market efficiency in the presence of a constant risk premium in seven commodity markets including cocoa but ignores the possibility of a time varying risk premium in the long run.

price risk using the cocoa futures markets, and it is conceivable the other cocoa producing West African countries will follow. Policy makers in those countries may appreciate an estimate of the risk premium (if any) to be paid in using futures markets to hedge cocoa prices. (4) Finally, the timing of the research makes sense because no research aimed at identifying a risk premium using post 1991 data is available to my knowledge.

Literature Review

In contrast to the case of "temperate" agricultural commodities such as corn, cattle and soybean meal futures markets that have enjoyed active research, much fewer attempts have been made to identify risk premiums in the cocoa futures markets[5]. Still, the findings of existing research on the identification of a risk premium in cocoa market futures are contentious with no clear consensus having yet been reached. In fact different economists have used different techniques to arrive at varying conclusions using data over different time intervals. To illustrate, Beck (1994) rejects the hypothesis of a positive risk premium in cocoa futures markets using data from 1966 to 1986 and co-integration techniques. Beck ascribes the bias in cocoa futures price to informational inefficiency or the inability of the cocoa futures market to incorporate all available information to produce unbiased forecast of the subsequent cash prices and not to the presence of a risk premium in cocoa futures. However she does not allow for the possibility of the presence of a time varying risk premium but limits her work only to the

[2] Engle et al (1987) is credited with arguing for the testing of a "time varying" risk premium not just a "constant" risk premium in agricultural futures markets as a way of establishing the efficiency of futures markets. However before Engle et al early researchers that tried to detect risk premiums in agricultural futures markets include Houthaker (1957) and Rockwell (1967). More recently, McKenzie and Holt (2002) test for risk premiums and market efficiency in hogs and cattle markets using the autoregressive conditional heteroskedasticty in mean (ARCH-M) error correction (ECM) framework. See Frank and Garcia (2007) for the most recent work in identifying risk premiums in agricultural futures markets as well as a review of past efforts to identify risk premiums in agricultural futures markets.

possibility of a constant risk premium so her conclusions may be incorrect. Sabuhoro and Larue (1997) disagree that a bias exists at all in the cocoa futures market. Using, Johansen and Juselius' co-integration tests, Hansen's test of the stability of co-integration parameters, an error correction model (ECM), and cocoa cash and futures data from 1983 to 1990, they conclude that there is no risk premium in the cocoa futures market. They claim that the absence of the risk premium is not because the bias in cocoa futures market is due to an informational inefficiency but rather because the cocoa futures market provides unbiased and efficient forecasts of subsequent cash prices. When futures prices provide unbiased forecast of subsequent cash prices, the risk premium has a zero value. However Sabuhoro and Larue (1997) use cash and data that terminated in 1990, which calls into question the relevance of the results to present day hedging decisions. By contrast Manayi and Struthers (1997) concluded that cocoa spot and futures prices were not cointegrated and further that the cocoa futures market incorporates a positive risk premium because profitable opportunities still exist for speculators in the cocoa futures market. They use futures and cash data from 1985 to 1991, different cointegration tests, and a GARCH-M (1, 1) model that allows for time varying risk premiums and data from 1985 to 1991 to conclude that the cocoa futures market is inefficient and incorporates a non-trivial time varying risk premium.[6] Manayi and Struthers admit that the GARCH specifications they employed were a bit restrictive and suggested the use of more general ARCH type models. Finally, although M&H (2002) do not use cocoa market data, they make methodological contribution to the problem of identifying a risk premium in

[6] I acknowledge that the notion of efficiency is a complicated one. Grossman and Stigilitz (1980) argued against the idea that because an efficient market incorporates all relevant information, the incentive to collect information in order to earn a premium is nonexistent. They conclude that it must be profitable for someone to make profits or else there would be no incentive to collect information.

agricultural commodities by analyzing and deriving expressions to test (i) unbiasedness of futures forecasts (ii) futures market efficiency and (ii) the presence of a risk premium in both the short run and the long run. Using data for cattle, hogs, corn and soybean meal from 1959 to 2000 and Quadratic Garch in Mean Error Correction Models (QGARCH-M-ECM), they conclude the futures markets for all four agricultural commodities were unbiased in the long run. However some commodities futures were biased and inefficient in the short run. The methodology used in this research to identify risk premiums builds on the M&H (2002) methodology described above.

Given the resurgence in cocoa producer demand for hedging output price variability and the preponderance of contrasting evidence in the literature concerning the presence of a risk premium in cocoa futures, a contribution that this research hopes to make to the existing literature is to help resolve the controversy surrounding the existence of a risk premium in the current cocoa futures market by carefully accounting for the time series properties of the data[7]. We also utilize a long series that incorporates the most recent data. Similar to M&H (2002) we employ the (Q) ARCH-M-ECM model as it nests other models capable of identifying a risk premium in cocoa futures markets.

Data, Empirical Tests and Estimation Procedure

To detect the presence of a time-varying risk premium in cocoa futures, NYBOT cocoa futures and cash prices from 1980 to 2007 were obtained from University of Illinois's Office for Futures and Options Research (OFOR). The cash and futures series were constructed to circumvent two main difficulties often encountered in routine analysis of commodity futures markets: "the expiration date problem" and the "forecast horizon

[7] In the light of the success of the Guatemala National Coffee Association (ANACAFE) which makes cheap loans to coffee growers on conditions that they appropriately hedge their price exposure with futures, there are calls for the IMF to require cocoa producers hedge their output price variability Malone (2005)

problem". The expiration date problem arises because futures contracts expire around the third week of the contract month even though delivery can occur starting the first business day of the maturity month. It is therefore unclear if the researcher should use the first business day or the expiration day to represent the final cash price. The forecast horizon problem involves the tendency to have overlapping data in the forecast horizon. In particular, if the frequency of observation of the futures price is larger than the forecast horizon, the forecast horizon problem is manifest as residual correlation due to overlapping intervals (Granger and Newbold, 1977, Beck 1994). For this research, we resolve the expiration date problem by using the expiration day settlement price to represent the final cash price. We limit the research to a 2-month horizon forecast because it coincides with the highest level of futures trading activity in terms of both volume and open interest (M&H, 2002). For the two-month horizon, we count back two months from expiration (approximately 40 trading days), and use the futures settlement price as the two-month forecast. As Table 1 illustrates there are five contract months for cocoa (March, May, July, September and December) and therefore there are five observations per year. To avoid the problem of introducing a moving average process into the residuals, spot price observations were taken on a bimonthly basis (except for the December contract) to match the observation frequency for the futures contracts M&H (2002). The time series dataset was developed to guarantee evenly spaced observations and to minimize the forecast horizon problem. Since the NYBOT cocoa contracts do not expire every other month it is impossible to build a dataset with equal forecast horizons and spacing. Following McKenzie and Holt (2002), Beck (1994) and Frank and Garcia (2007), equal spacing between contracts was achieved by using a longer forecast horizon in December (approximately 60 days). Table 1 also displays contract months and forecast horizon lengths used in the empirical exercise as well as the mean and standard deviation of the cash and futures prices. The mean cash price is clearly bigger on average than the mean future price so *ex ante* we expect futures market forecasts to incorporate a downward bias.

Structural break and Unit Root Tests

The choice of an appropriate model that can adequately identify a time varying risk premium in cocoa futures often depends on the underlying characteristics of the data. It is therefore essential to verify the degree of integration of both the cash and futures price data. Guaranteeing that regressions are always carried out on stationary series is pertinent because if ordinary least square (OLS) regression is performed using non-stationary data; it yields spurious regression results (Granger and Newbold, 1974). Furthermore, the results of standard test of stationarity such as the Augmented Dickey Fuller (ADF) test can be influenced by structural breaks. When structural breaks are not properly accounted for in testing for unit roots, incorrect conclusions regarding the stationarity of the data will likely be drawn (Perron, 1989). Figure 1 in the Appendix displays the futures and subsequent period cash prices for NYBOT cocoa contrast for a 2-month horizon from 1980 to 2007. From the graph there is no indication of a well-defined structural break. To confirm there is indeed no structural break, we perform the Zivot-Andrews (1992) or the ZA test in order to determine possible structural break points[8]. The null hypothesis in

[8] Although not reported since the ZA test does not identify the 2001 War in CIV as a structural break, we perform structural break test using non-parametric methods, which make no distributional assumptions. In particular we employ the Fligner-Policello test, which is sensitive to differences in the median and does not assume equal variance before and after the break to test for differences in the mean before and after the structural break. Next Changes in the variance of prices before and after the 2001 CIV war was assessed using the Miller jackknife test, which does not assume an equal median in the two periods. The tests reject the hypothesis of a structural break in 2001 either in the mean or the variance

the ZA test is that the variable under investigation contains a unit-root with a drift that excludes any structural break. The alternative hypothesis is that the series is a trend stationary process with a one-time break in the trend variable occurring at an unknown point in time[9]. Results from Table 2 fail to give evidence of a substantial structural break in the data over the range of analysis using the ZA test. In the light of our findings we test for stationarity of the cash and futures prices using the ADF test over the entire range of the data[10]. Three distinct models were accounted for in executing the ADF test: with constant only, with constant and trend and with no constant and no trend while incorporating lags ranging from 1 to 5. We restrict the number of lags to 5 because there are only 5 contract months for cocoa futures. The Akaike Information Criterion (AIC) was used to determine lag structure (Enders, 2004). Table 3 contains the results of the ADF test of stationarity and table 3.1 contains results of the Perron stationarity test. Clearly the levels of NYBOT cocoa cash and lagged futures prices are both integrated of order 1 but their first differences are stationary. In other words both series are non-stationary in levels but stationary in first difference at the five percent significant level. Since the cocoa cash and futures prices are both I (1) it is possible that they are *cointegrated* (Enders, 2004, p.336). If the spot and futures price are *cointegrated* then the futures market is efficient in the long run because identical factors determine the spot and futures price so they should not diverge from each other (Beck, 1994)[11]. To establish *co*

[9] The ZA test is preferred to the Chow test because it does not assume the break point *ex ante*, so unlike the Chow test, the results of the test of structural break is not biased towards non-rejection of the null of structural break *ex post*.

[10] Perron tests of stationarity give identical results to the ADF tests (Table 3 and 3.1)

[11] Co-integration implies futures market efficiency in the long run but not necessarily the short run. Co-integration does not also inform us about the absence or presence of a time –varying risk premium although we can test the null hypothesis of zero intercept in the error correction model to detect the presence of a constant risk premium. Furthermore, even if the lagged futures prices and current cash prices are co-

integration, we regress the cash series on the lagged futures series and test the residuals of that regression for stationarity. Since the residuals are stationary (Table 3 and Table 3.1) we conclude that the cash and futures prices are *cointegrated.* Given cointegration, an Error Correction Model (ECM) can be specified to investigate both long run and short run relation between current cash prices and previous period futures prices. Before estimating the ECM we confirm the co integration relationship between cash and futures price by performing Johansen's test of co-integration (results of cointegration test are in Table 3.2 and are discussed in the results section) Note however that the existence of a co-integrating relationship between the log futures and log of subsequent cash price does not rule out *short run inefficiencies and pricing biases* such that past information may improve futures market forecasts of future cash prices M&H (2002). As M&H (2002) point out, the ECM in its basic form has several limitation: (i) It does not allow for the possibility of a time varying risk premium (ii) it can only account for linear price dynamics in the conditional mean of spot price changes but an appropriate model should be flexible enough to accommodate potential nonlinear and linear dynamics in the conditional variance of the spot price changes and (iii) despite evidence to the contrary especially from the finance literature, OLS estimation of ECM assume that the distribution of spot prices is characterized by a constant variance. A better way to proceed may be to allow for time variation in the conditional second moment of spot prices M&H (2002). To this end, Engle (1987), Domowitz and Hakkio (1985), Diebold and Pauly (1988) have all used ARCH-M type models to test for risk premiums in financial data but the theoretical justification is due to Keynes (1930). By contrast, M&H

integrated residual correlation where previous spot prices contain information useful for predicting the current spot price is still possible.

(2002) utilize these models to test for a risk premium in "temperate" agricultural commodities futures market such as corn, hogs and soybean meal. However, no research has applied the QARCH-M-ECM model to finding a time-varying risk premium in the futures market of cocoa[12]. Following M&H (2002) we test for long and short run market efficiency, unbiasedness and risk premiums in the cocoa futures market using LM ARCH tests and a QARCH-M-ECM model. To account for seasonal variations in the data we also define a dummy variable for each contract month and include the dummies in the QARCH-M-ECM. We elect to use the QARCH-M-ECM because it nests many of the other forms of the QARCH-type models. We next discuss the procedure used in selecting the ARCH-M-ECM in the context of tests of market efficiency and risk premiums.

Model Selection, Market Efficiency and Risk premium Tests

The link between a positive (constant or time-varying) risk premium and futures market inefficiency is that they can both cause biased futures markets forecasts. In the presence of a risk premium, the lagged futures prices cannot produce unbiased forecasts of current cash prices even if the futures market is efficient (there is no informational inefficiency so expectations are rational). The risk premium in futures forecasts may also have a temporal dimension to it as it can exist only in the short run and disappear in the long run, or it may be present in both the long and short run. Furthermore, the risk premium may be time varying or constant in the long run or the short run. Recall that in the absence of a risk premium, arbitrage will force current futures price to equal the expected future cash price for the same commodity at contract maturity (McKenzie and Holt, 2002). This is illustrated in equation (1) below:

[12] I acknowledge the contribution of Beck (1994) but she does not allow for the risk premium to be time varying. Manayi and Struthers allow the risk premium to be time varying but they strangely find that the cash and futures prices are not co-integrated and so do not apply the QARCH-M-ECM.

$$E_{t-1}S_t = F_{t-1} \quad (1)$$

Where $E_{t-1}S_t$ is the expectation of the current cash price conditional on information available in the previous period, F_{t-1} is the price of the futures contract that will mature in period t and the futures price refers to the NYBOT-specified delivery point price[13]. Assuming a linear rational expectations framework, (1) can be rewritten as (2)

$$S_t = \alpha_0 + \alpha_1 F_{t-1} + \mu_t \quad (2)$$

However S_t in (2) is a non-stationary series so we can define a first difference version (3)

$$\Delta S_t = \alpha_0 + \alpha_1 \Delta F_{t-1} + \Delta \mu_t \quad (3)$$

Given the specification in (3) the joint hypothesis of market efficiency and unbiased forecast is given by Ho: $\alpha_0 = 0$ and $\alpha_1 = 1$. However, the transformation in (3) is mis-specified when the cash and futures prices are co-integrated M&H (2002); Beck (1994). When the cash and futures prices are co-integrated as is the case for this research, an ECM must be estimated to account for the (stationary) long-run equilibrium relationship between the respective cash and futures series. The structure of the ECM is given as

$$\Delta S_t = - \rho\mu_{t-1} + \psi_1 \Delta F_{t-1} + \sum_{i=1}^{I} \Omega_i \Delta S_{t-i} + \sum_{j=2}^{j} \psi_j \Delta F_{t-j} + \mu_t$$

$$\mu_t \,|\, \mu_{t-q} \sim N(0, \sigma_t^2) \quad (4)$$

Where ΔS_t is the first difference operator such that, $\Delta S_t = S_t - S_{t-1}$, μ_t is the error term conditional on the amount of volatility observed in recent periods (μ_{t-q}), $\mu_{t-1} = S_t - \alpha_0 + \alpha_1 - F_{t-1}$ is the stationary error correction term and the magnitude of the estimated coefficient on the error correction term (ρ) indicates the speed of adjustment of any dis-equilibrim towards the long-run equilibrium state (M&H, 2002; Beck, 1994). Results of

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13 We assume zero basis risk for simplicity.

long run test of unbiasedness and market efficiency performed on the ECM is found in Table 3.3

Although The ECM in (4) is correctly specified to test the long run market efficiency condition, it is not appropriate for testing for a time-varying risk premium in cocoa futures. To test the hypothesis that there is a risk premium (time-varying or constant) in the NYBOT cocoa futures market we must employ a model that allows us to identify a "time varying risk premium." This is because if the risk premium is constant rather than time varying, the bias in futures market prices cannot be easily decomposed into separate biases due to informational inefficiency and normal backwardation especially in the short run. In the spirit of Hendry et al (2005)'s general to specific model selection strategy, we initially employ a ARCH-M-ECM model in this paper to identify a time varying risk premium for several reasons: (i) the cash and futures prices are co-integrated so by definition an ECM defined by the long-run co-integration relation between cash and futures prices applies, (ii) there may be short run bias (despite possible LR unbiasedness) in futures forecasts which cannot be investigated in the context of just an ECM but can be analyzed within the context of an ARCH-M-ECM. We find that ARCH effects at long lags are insignificant and so ignore GARCH specifications since GARCH is a concise representation of an ARCH with many terms especially at long lags (iii) the chosen model allows us to identify time-varying volatility in the conditional mean. The structure of the ARCH-M-ECM is:

$$\Delta S_t = -\rho\mu_{t-1} + \psi_1 \Delta F_{t-1} + \theta\sigma_t + \sum_{i=1}^{I}\Omega_i \Delta S_{t-i} + \sum_{j=2}^{j}\psi_j \Delta F_{t-j} + \mu_t + D_3 + D_5 + D_7 + D_9$$

$\mu_t | \mu_{t-q} \sim N(0, \sigma_t^2)$ and

Where D_3, D_5, D_7 and D_9 = March, May, July and September and D_{12} = December and D_{12} is intentionally omitted to avoid the dummy variable trap. Furthermore

$$\sigma_t^2 = \pi_0 + \sum_{q=1}^{Q} \pi_{qq} \ \mu^2_{t-q} + \sum_{q=1}^{Q} \pi_q \ \mu_{t-q}$$

$$\pi_0, \pi_{qq,} > 0, \sum \pi_{qq} < 1, \qquad (5)$$

Also, μ_t is the error term conditional on the amount of volatility observed in recent periods (μ_{t-q}), $\mu_{t-1} = S_t - \alpha_0 + \alpha_1 F_{t-1}$ is the stationary error correction term and the magnitude of the estimated coefficient on the error correction term ρ indicates the speed of adjustment of any disequilibrim towards the long-run equilibrium state (&H (2002). For meaningful results ρ must be signifiant différent from zero at 5% signifiance Note also that σ_t is a measure of volatility, the standard deviation, of μ_t while π_0, π_q, and π_{qq} are estimated coefficients of the variance and D_3 to D_9 are the cocoa contract dummies accounting for seasonality. Diagnostic tests performed to establish model validity for both the ECM-ARCH-ECM and the ECM included Ljung-Box Portmanteau (Q) test for white noise of the errors (the Q test has a null hypothesis of white noise), Breusch-Pagan / Cook-Weisberg test for heteroskedasticy which has a null of constant variance, the Breusch Geoffrey test of serial correlation and the Ramsey test of functional form or omitted variables which has a null hypothesis of no omitted variables. The results of these tests are presented in Table 5 and discussed in the results section.

Summary of Market Efficiency and Risk premium Hypothesis

Recall that M&H (2002) showed that in the context of the ECM, Short run market efficiency implies:

Hypothesis 1. $\rho = 1$; $\rho\,\alpha_1 = 1$; $\boldsymbol{\psi_1} = 1$; $\boldsymbol{\Omega}_i = \boldsymbol{\psi_j} = 0$; and $\theta = 0$ (6)

Short-run unbiased ness implies:

Hypothesis 2. $\alpha_1 = 1, \psi_1 = 1$; $\Omega_i = \psi_j = 0$; and $\theta = 0$ (7)

The sufficient condition for identifying a time varying risk premium is the rejection of

Hypothesis 3. Ho: $\theta = 0$. (8)

The identification of a positive risk premium is evidence that at least some of the bias in futures markets is due to a risk premium. Note however that the sign of θ, the coefficient on σ_t, can only be determined empirically (Frank and Garcia, 2007). If θ turns out to be positive then the market is experiencing normal backwardation where the market is dominated by short hedgers who pay a risk premium to long speculators to bear the spot price risk. On the other hand, if θ turns out to be negative and statistically significant then the market is under conditions of contango where the market is dominated by long hedgers paying a risk premium to short speculators Keynes (1930). In the special case where θ turns out to be statistically insignificant, a time varying risk premium does not exist in the cocoa futures market in the long run or the short run in the cocoa futures market. In this case, a possible explanation of biased long run futures market forecast is a constant non-zero risk premium because co-integration excludes informational inefficiency in the long run. The hypothesis of a long run constant risk premium can be explicitly tested as in Beck (1994) and MH (2002) by performing LR tests to determine if the constant in the ECM model is significantly different from zero (See Table 3.3). Alternatively one can test the restriction of a zero constant using by testing the appropriateness of cointegration restrictions (0, 1) on the VECM using the Johansen procedure. With regards to the short run, we can employ the conditions for testing short run market efficiency derived by M&H (2002) and described above. If we reject the null of short run market efficiency then the forecast bias in the short run is caused by either a constant or a time varying risk premium. We can test for a time varying risk premium in the short run by testing for ARCH effects, which are short run variations in the variance with LM ARCH tests. Rejection of the null hypothesis of a time-varying risk premium implies that the biased futures market forecast is likely due to a constant risk premium or market inefficiency. However, it is impossible to identify which of the two factors constant risk premium or market inefficiency caused the bias in the short run futures forecast of cash prices. This is because unlike the case for a time-varying risk premium, we cannot take advantage of the changes in the underlying uncertainty in the futures market (measured by the changing variance or ARCH effects) to identify a constant risk premium in the cocoa futures markets.

Methodology for identifying the lag-structure and "time-varying risk premium":

Econometric provides little guidance about the correct number of lags of the cash and futures price to include in (4). Econometric theory is also not forthcoming regarding the structure of conditional variance term in (4). To decide how many lags of the futures and cash prices to include in (4), we minimize the AIC for lags one to 5[14] after adding both cash and futures prices to the first difference specification in (3). The results of the empirics dictate the addition of one lag of the first difference of the cash price to the ECM so the actual form of the ECM in (4) estimated is given in (9)

$$\Delta S_t = \alpha_0 + \rho\mu_{t-1} + \psi_1 \Delta F_{t-1} + \Omega_1 \Delta S_{t-1} + \Delta \mu_t \qquad (9)$$

All variables in (9) have been previously defined. Since the lagged cash price is necessary for forecasting subsequent cash prices, the futures market is clearly biased. For the purposes of determining the presence and form of the conditional volatility in the cash

[14] We limit the number of lags to five because the NYBOT has five cocoa contract months in a year.

equation, we perform LM ARCH and QARCH tests. The LM ARCH test involves regressing the squared OLS residual from (8) on an intercept and the lagged residuals of (8). The test statistic (the sample size N * R^2) has a chi-square distribution with degrees of freedom equal to the number of lags, p.

$NR^2 \sim \chi^2_{p,}$ p = 1, 2, 3 etc. LM QARCH tests (results not reported but available upon request) are performed by regressing the squared OLS residual on an intercept, the lagged residuals and the cross product residuals of lags of different lengths. The test statistic is distributed $\chi 2$ distribution with p (p+3)/2 degrees of freedom (Sentana, 1995).[15] From the results of the LM tests of ARCH type heteroskedasticity tests (see Table 4), none of the lags in the conditional variance specification is significant so we re-parameterized the ARCH-M-ECM as a parsimonious ECM-M specification by eliminating all insignificant terms in the conditional variance expression. For completeness, we also estimated an ARCH (1)-M-ECM to check for a time-varying risk premium.[16] Table 5, column 1 reports the results of the ECM model while Table 5 columns 2 reports the results of the ARCH (1)-M-ECM. The tests of short run market efficiency and unbiasedness and the test for a risk premium (equations 5, 6 and 7 respectively) are applied sequentially to the ARCH (1)-M-ECM and are presented in Table 6 columns, 1 and 2 and respectively.

Results

The ZA test results (Table 2) provided no evidence of a structural break point. The Augmented Dickey Fuller (ADF) and Perron's test of stationarity were therefore

[15] The QARCH tests and their conditional specifications were analyzed to determine nonlinear behavior in the time-varying volatility (McKenzie and Holt, 2002).
[16] To provide a check for our result from the LM ARCH test, we also estimated the ARCH (1)–M-ECM model in order to confirm or dispel the presence of time varying volatility which is an indicator of a time-varying risk premium

applied to the whole range of the data[17]. From the results of the tests of both the ADF and the Perron test of stationarity (See Table 3 and 3.1 respectively), the previous period futures price and the current cash price are both integrated of order one and hence are non-stationary. Since the error from a regression of the cash price on lagged futures price was found also to be stationary (able 3 and Table 3.1), we conjectured that the cash and futures price are *co-integrated* and therefore an ECM applies to forecast next period spot prices using current futures data[18]. We next devised and executed a step-wise Strategy to achieve our objective of establishing the presence (or absence) of a risk premium (time-varying or constant) in the cocoa futures markets. Specifically, we first employed Johansen's co-integration procedure to test for co-integration of the cash and futures price which, guaranteed long run futures market efficiency. The results of the cointegration test were confirmed first by testing for the stationarity of the I (1) cash and futures prices and the I(0) error of the regression of cash price on lagged futures price with the ADF and Perron tests and by using Johansen's method. From Table 3.2 we can see that both the trace statistic and the maximum eigen-value statistics confirm the presence of only one co-integrating vector at 1 percent significance level. Both the trace statistic and maximum eigen-value statistics of Johansen's cointegration test reject the null of zero cointegration vectors and accepts the null of one cointegration one vector. This result was independent of lag length which was determined by minimizing AIC. Table 3.3 contains

[17] The KPPS test which has a null hypothesis of stationarity (in contrast to the ADF and Perron tests) was also used to test for stationarity. The conclusions regarding stationarity is consistent with the ADF and Perron's tests are not reported.

[18] Recall that it is inappropriate to use the original ADF test t-values to make conclusions on stationarity of the errors of the cash and futures. The appropriate critical values are available are due to Engle and Granger (1987) and are reproduced in Enders (2004).

the results of the test the non-zero long run constant risk premium restriction on the intercept and slope of the ECM i.e. α = 0 in (4). Since the intercept was not found to be significantly different from zero there is no non-zero, constant and positive risk premium in the long run.

Next, we tested for a time varying risk premium in both the short run and the long run using LM ARCH tests and an ARCH-M-ECM. Tables 4.1 and d 4.2 and Table 5 confirm the absence of time varying risk premiums in the short run since there is no significant error variability in the ECM captured by the LM ARCH tests and the θ term in the QARCH-M-ECM is not significantly different from zero. Finally we tested for and rejected short run market efficiency and bias using tests derived by M&H (2002). We fail to confirm the presence of a risk premium in futures markets. Although the finding of *co-integration* of the cash and futures price suggests long-run unbiased futures forecasts of subsequent prices, there is evidence of short-run market inefficiency (most likely informational information) and bias in the context of the ECM.

There is however no evidence of a time varying-risk premium or a constant risk premium either in the long run or the short run. From Table 6, column 3, the joint null hypothesis of short run futures market efficiency and unbiasedness are both rejected at 5 % significance level. We also find no evidence of ARCH effects using LM ARCH tests (Table 4). A positive identification of ARCH effects by the LM ARCH tests indicates time-varying volatility, which is a necessary condition for establishing the presence of a time-varying risk premium. For completeness, we also estimate a parsimonious ARCH (1)-M-ECM model the results of which are in Table 5. From Table 5, the magnitude or absolute value of the coefficient of the error correction term ρ is significantly different from zero as it a well-defined ECM. Notice that the magnitude of ρ in both the ECM and ARCH-M-ECM similar. The coefficient (θ) from Table 5 is not significantly different from zero, which means there is no risk time varying premium in the cocoa futures market confirming the result of the LM ARCH tests. Since the futures market is biased in the short run (See table 6), it is likely that the bias is coming from an informational inefficiency. Confirmation that this is in fact the case is provided by the test of short run market inefficiency. From the results in Table 6, the null hypothesis that the futures market is efficient in the short run is rejected at conventional significance levels.

Section 5: Conclusion

The futures market is one way by which LDC producer of cocoa can hedge output price risk. However, efficient hedging is compromised if futures markets are inefficient and costly if speculators demand a significant risk premium to bear spot price risk. Previous attempts to identify a risk premium in cocoa futures markets yielded contrasting results. One reason for the contrasting evidence is the literature is that the identification of a risk premium depends on the range of data used and longer series give more consistent results. Another important reason for the lack of consensus is the difficulty in disentangling bias in futures price forecasts caused by the presence of a positive risk premium from that due to informational inefficiency. By focusing on data from the more liquid NYBOT futures market, by using a long series incorporating the most recent data, and by using models that can identify a time-varying risk (as well as constant risk premium either in the long run or the short run and that is also relevant to forecasting cash prices) this decomposition can be achieved. In this paper we have employed LM ARCH tests as well as an ARCH-M-ECM model to confirm the absence of a time varying risk premium. Our main result is consistent with the results of Beck (1994) but is in disagreement with Manayi and Struthers (1997). We concede that the conclusion that there is no significant risk premium in cocoa futures markets is subject to alternative interpretations. On one hand it can be argued that risk premium is insignificant because there is very little and sporadic hedging activity being generated because cocoa producers are not using the futures markets to stabilize price. There is therefore little need for speculators to charge a risk premium to bear spot price risk. A more debatable argument is that the underlying uncertainty in using futures markets is too small to command a significant measurable risk premium. Further research may investigate the effect of basis adjustment on the risk premium. We agree that the futures market is biased, at least in the short run, but contrary to initial speculation, it is likely that the bias is not coming from a positive risk premium but rather it is due to an information bias, albeit only in the short run. Still the conclusion that there is no significant risk premium in the cocoa futures market should be welcome news to LDC governments desiring to use the futures markets for hedging operations.

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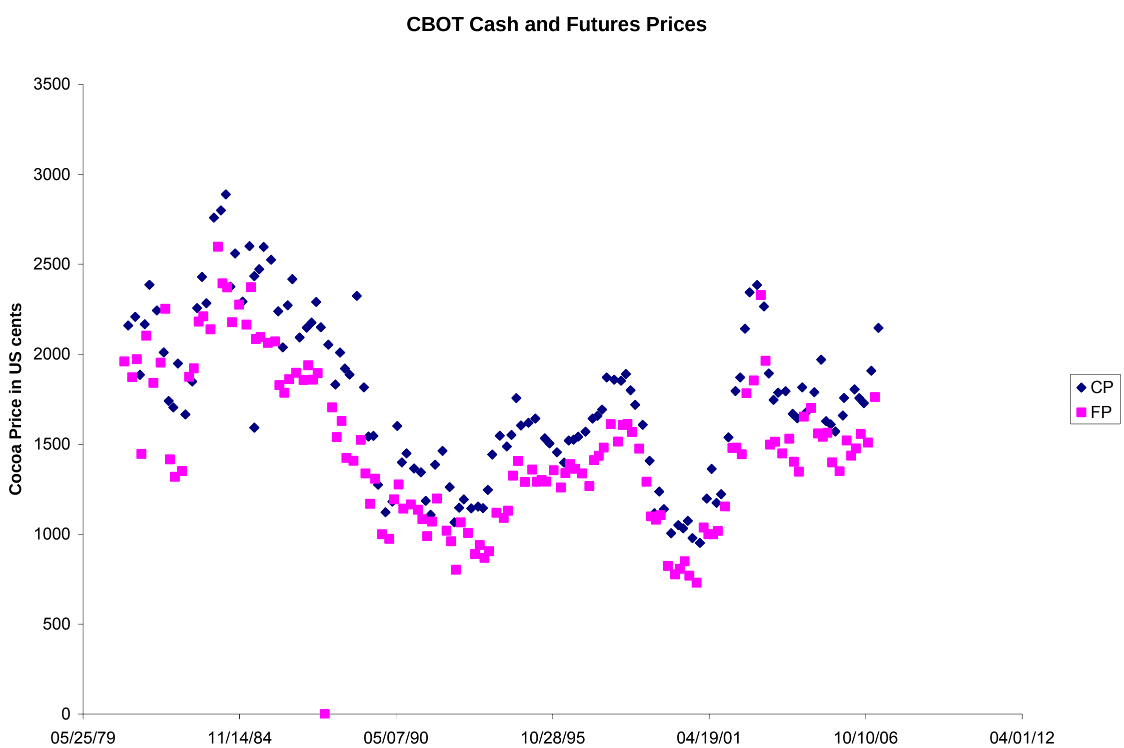
Appendix

Figure 1: No Evidence of a structural break in the cash and futures prices



Note that in the figure, CP is cash price and FP is futures price. Note also the apparent downward bias in the futures prices

Table 1: NYBOT cocoa contract months and futures price forecast horizon

Series Name	Contract Month
NYBOT Cocoa Cash Price	*March May July September and December*
	Two Month Forecast Horizon
NYBOT Cocoa Futures Price	*40 days prior to contract expiration (60 days for December contract)*

Variable	Mean and Standard Deviation in Bracket
NYBOT Cocoa Cash Price	1483.63
	(418.60)
NYBOT Cocoa Futures Price	1748
	(444.4)

Table 2: Zivot and Andrews (1992) test of Structural Break

Variable	Description	TB	K	t_{MIN}	Decision	Inference
CP	Log cash price	1984:May	0	-4.089 at	Accept H0	No Break. CP is I(1)
FP	Log futures price (previous period)	1984:July	0	-3.415 at	Accept H1	No Break. FP is I(1)

(1) Critical Values at 1, 5 and 10 percent levels of significance are -5.57, -5.08 and -4.82 respectively Zivot and Andrews (1992)
(2) *, **, and *** indicate that the corresponding null is rejected at 1%, 5 % and 10 percent respectively
(3) The ZA test endogenizes the selection of the break point (Zivot and Andrews, 1992). The null hypothesis (Ho) is that the series is non-stationary with no break in the trend/intercept. The alternate hypothesis is that the series is stationary with a break each in the trend or intercept.
(4) K is the minimum number of lags chosen by AIC, T_B is the break point suggested by t_{MIN} and is the break point selected to be the least favorable to the null hypothesis of unit root without a break. Therefore t_{MIN} is the minimum t-value that gives a unit root given that the break point is T_B

Table 3: ADF test of stationarity (level and 1st difference) of cocoa cash & futures prices

Variable	Description	Number of Lags (AIC)	Is trend significant	5% critical value = -2.88	$H_{o:}$ series is Non-Stationary
CP	Cash price	4	No	-1.75*	ACCEPT H_o
DCP	1st difference of log cash price	4	No	-4.75**	REJECT H_o
FP	Futures price	4	No	-2.63	ACCEPT H_o
DFP	1st difference of futures price	4	No	-3.03**	REJECT H_o
Error	Error of CP = FP + b = u	4	No	-3.45**	REJECT H_o

Since the null hypothesis (H_o) implies the presence of a unit root, rejection of H_o implies the series is stationary. Furthermore, *** indicates rejection of H_o at 1 % significance level, ** indicates rejection of H_o at 5 % significance level, and ** indicates rejection of H_o at 1 % significance level respectively. Column 5 contains the test statistic of the ADF test. Critical values are available in Enders (2004)

Table 3.1: Perron test of stationarity (level and 1st difference and error) of cocoa cash & futures prices

	Description	Is Constant significant	Is trend significant	5% critical value = -3.446	H_o: series is Non-Stationary
CP	Cash price	No	No	-2.383	ACCEPT H_o
DCP	1st difference of cash price	No	No	-11.735 **	REJECT H_o
FP	Futures price	No	No	-2.485	ACCEPT H_o
DFP	1st difference cash price	No	No	-14.244***	REJECT H_o
	Error of CP = FP + b = u	No	No	-10.029 **	REJECT H_o

Since the null hypothesis (H_o) implies the presence of a unit root, rejection of H_o implies the series is stationary. Furthermore, *** indicates rejection of H_o at 1 % significance level, ** indicates rejection of H_o at 5 % significance level, and ** indicates rejection of H_o at 1 % significance level respectively. Column 5 contains the test statistic of the Perron test. Critical values were provided by STATA

Table 3.2: Johansen Test of Cointegration (Trace test and Max Eigen value Test)

# of cointegrating vectors	Trace Statistic	1 %critical Value	Max Statisitc	1 %critical Value	Decision
0	31.8092	20.04	26.8357	18.63	REJECT
1	4.9735	6.65	4.9735	6.65	ACCEPT
2					

Table 3.3: Results of Test of Restriction on Cointegration Relationship

	$\alpha_0 = 0$	p-values	$\alpha_1 = 1$	p-value	$\alpha_0 = 0$, $\alpha_1 = 1$; p-value
ECM Results	20	0.61	0.5	0.0	0.0

The null hypotheses are shown in the tables: A likelihood ratio test statistic p-value for the various restrictions is shown and has a $\chi 2$ distribution with the degrees of freedom equal to the number of restrictions placed on the parameters.

Table 4a LM test for Conditional Volatility of ARCH type (Manual Computation)

Conditional Volatility Model	p-Value of N^*R^2	Hypothesis tested	p-value
1 lag	0.93	ut-1 = 0	0.93
2 lags	0.96	ut-1 = 0 ut-2= 0	0.96
3 lags	0.79	ut-1 = 0 ut-2 = 0 ut-3 = 0	0.8

Lags refer to the number of n umbers lagged squared residuals (p) used in the test. In the LM ARCH test, p-values of the $\chi 2$ distribution with p degrees of freedom are reported. The LM QARCH test was performed using lagged residuals, their corresponding squares, and cross-product terms. P-values of the $\chi 2$ distribution with p (p+3)/2 degrees of freedom are reported

Table 4b LM test for Conditional Volatility of ARCH type (STATA computation)

lags(p)	Chi-square	df	Prob > chi2
1	0.007	1	0.93
2	0.074	2	0.96
3	1.01	3	0.8
4	6.289	4	0.18
5	6.289	5	0.28
6	7.129	6	0.3

Lags refer to the number of n umbers lagged squared residuals (p) used in the test. In the LM ARCH test, p-values of the $\chi 2$ distribution with p degrees of freedom are reported. The LM QARCH test was performed using lagged residuals, their corresponding squares, and cross-product terms. P-values of the $\chi 2$ distribution with p (p+3)/2 degrees of freedom are reported

Table 5. Results of the ECM and ARCH-ECM estimation

	ECM	ARCH-M-ECM
Columns	(1)	(2)
α_0	18.05	481.5
	(0.50)	(0.90)
ψ_1	0.32	0.263
	(2.96)	(3.23)**
Ω_1	-0.24	-0.14
	(-2.23)	(-1.15)
ρ	-0.84	-0.94
	(-1.90)**	(3.00)**
π_0		24120
		(5.37)
θ		-0.01
		(0.79)
π_{11}		-1.13
		(0.80)
D3	-24.78	-8.87
	(-0.48)	(-0.07)
D5	-60.7	-82.7
	(-1.18)	(-1.78)
D7		19.6
		(0.45)
D9		-26.3
		(-0.70z)

Stationary series are indicated at the 1% (***), 5% (**), and 10% (*) significant level.
ARCH –M-ECM Diagnostics: Ljung-Box Portmanteau (Q) test for white noise of the errors, the Q test has a null hypothesis of white noise Portmanteau Q-Statistic = 29.1969. P-value = 0.8979. Error is white noise. Breusch-Pagan / Cook-Weisberg test for heteroskedasticy which has a null of constant variance. P-value = 0.3772. Breusch-Geoffrey Lm test of autocorrelation, which has a null hypothesis of no serial correlation. P-value = 0.217. Ramsey test of functional form or omitted variables, which has a null hypothesis of no omitted variables. P-value = 0.409
Although all the analysis in this paper was performed with data over the whole range of data available (1980-2007), the data was also divided into 2 halves (1980-1994 and 1994-2007) halves and used to analyze within sample predictive accuracy. The Mean Square Error (MSE) and Mean Square proportional Error (MSPE) obtained are respectively 21664.701 and 16.1735 compared to a MSE and MSPE of 25202.758 and 16.2 when using the lagged futures contract prices for prediction of current cash prices over the same range.

Table 6: Tests of Hypothesis: Short-run market efficiency, bias and positive Risk Premium

	Hypothesis 1	Hypothesis 2	Hypothesis 3
	Efficient in SR	Unbiased in SR	No RP present
	$\rho = 1$	$\alpha_1 = 1$	in SR
	$\rho\,\alpha_1 = 1$	$\boldsymbol{\psi}_\mathbf{1} = 1$	Ho: $\theta = 0$
	$\boldsymbol{\psi}_\mathbf{1} = 1$	$\boldsymbol{\psi}_\mathbf{j} = 0$, for j not = 1	
	$\boldsymbol{\Omega}_i = \boldsymbol{\psi}_\mathbf{j} = 0$; i, j not = 1	$\boldsymbol{\Omega}_i = 0$	
	$\theta = 0$	$\theta = 0$	
Chi (q) = j	q =8, j = 74	q =4, j = 17.5	q =1, j = 1.48
Prob > chi2 =	0	0.0015	0.224
Conclusion	Reject H_o	Reject H_o	Do Not Reject H_o