Price efficiency and speculative trading in cocoa futures markets

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Abstract

In recent years a number of market participants called into question the efficiency of the price discovery mechanism in commodity futures markets. They believe that speculators move commodity futures markets away from their fundamentals by distorting prices and exacerbating volatility. The smoking gun of these allegations is the empirical observation that speculative buying (selling) precedes movements in the cocoa futures markets. Among soft commodities, the cocoa futures market represents an interesting case study. In the last decades, speculators' open interest is increased by nearly 4 times, fuelling the apprehension of practitioners and market analysts. This paper evaluates the efficiency of the price discovery mechanism in cocoa futures markets. Results show that the price discovery mechanism in both LIFFE and NYBOT cocoa futures markets is efficient. In addition, they rule out the existence of any casual relationship between speculative activity and cocoa prices (i.e. level and volatility) at the least for the NYBOT. This evidence supports the hypothesis that successful speculators are reacting quicker than any other market participant to new information emerging from the market. That is why profitable speculative buying (selling) occurs just before the market makes a move.

Keywords: futures markets, efficient market hypothesis, speculation.

1. Introduction

Commodity futures markets are markets featuring "paper" transactions, that is, trade of financial standardized contracts. In general, these contracts are not exchanged to secure the procurement or the sale of a commodity at their expiration. Rather, they are traded to provide a centralized price discovery mechanism and a price insurance function to market participants.

In recent years a number of market participants called into question the efficiency of the price discovery mechanism in commodity futures markets. Two major factors fuelled this apprehension. Firstly, investors diverted large amount of money from traditional equity markets to commodity futures markets at unprecedented rate. Secondly,

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according to some practitioners, speculators' "herd behaviour" exacerbates price movements in commodity futures markets[2] [De Long, *et al. 1990*].

From a market microstructure perspective, price movements are caused by the release of new market information which is then incorporated by trading processes into prices. If futures markets are efficient, their prices should react instantaneously to release of new market information (i.e. Fama's efficient market hypothesis, EHM) [Fama, 1970].

Aim of this paper is to investigate the efficiency of the price discovery mechanism in both the London Financial Futures and Options Exchange (LIFFE) and the New York Board of Trade (NYBOT) cocoa futures markets. Specific objectives are:

a) to highlight the main characteristics of cocoa futures contracts listed in both LIFFE and NYBOT;
b) to evaluate whether both LIFFE and NYBOT cocoa futures markets adhere to EMH; and
c) to assess the effect of speculative trade activity on prices and volatility of NYBOT cocoa futures contracts.

Cocoa futures markets represent an interesting case study. In the past years speculative activity is increased steadily. According to the US Commodity Futures Trading Commission, the share of open interest held by non-commercial traders (i.e. speculators) in the New York cocoa futures market is increased by more than 400 percent from 1986 to 2005.

Recently the literature has focused its interest on the effect of speculative behaviour in financial markets [Holt and Irwin, 2000; Irwin and Yoshimaru, 1999; Chang, Pinegar and Schachter, 1999]. However, results are mixed and do not provide a conclusive answer to this issue. Holt and Irwin [2000] assessed the impact of futures trading by hedge funds on market volatility. Their findings suggested the existence of a positive relationship between hedge funds' trading volume and market volatility. However, hedge funds' trading decisions were not driven by technical analysis (i.e. analysis of past price changes). This result indicates that speculators base their trading decisions on fundamentals, even though they exacerbate market volatility. Irwin and

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[2] The 'herd behaviour' is referring to the empirical observations that large number of market participants are simultaneously long after a price increase or short after a price decrease.

Yoshimaru [1999] evaluated the impact of commodity funds' trading activity on futures contracts' prices and volatility. Results suggested the existence of a positive feedback trading, that is, commodity funds were long when prices increased and short when prices declined. Nonetheless, further statistical tests indicated the absence of a causal relationship between market volatility and commodity funds' trading. Finally, Chang, Pinegar and Schachter [1997] examined interday trading patterns of large speculators and their impact on prices and volatility. Results suggested the existence of a positive relationship between large speculators' trading volume and price volatility. Thus, speculative activity exacerbated volatility in financial markets.

Single equation approach is the dominant econometric strategy in these empirical investigations. Specifically, these analyses are based on the strong assumption that volume and open interest are exogenous with respect to price and volatility. Furthermore, they do not disentangle the short- and the long-run effect of speculative trading on prices and volatility.

This paper intends to contribute to the ongoing debate about the efficiency of futures markets by appraising the impact of speculative activity in futures markets. The focus is on the cocoa futures markets where in recent years speculative buyings and sellings are increased at an astonishing rate. A vector of autoregression approach is employed to tackle methodological weaknesses of previous studies.

This paper is constituted of 5 sections. The first section provides a short background on the characteristics of cocoa futures contracts. The second section develops the econometric strategy to assess the efficiency of the price discover mechanism and the impact of speculative trading on prices and volatility. The third section describes the data used in this investigation. The forth section discusses the empirical results. Finally, some concluding remarks end the paper.

2. The LIFFE and NYBOT cocoa futures contracts

A cocoa futures contract is an agreement to buy (or to sell) a specified quantity of cocoa beans at a future date, at a price agreed upon when entering into the contract. Cocoa futures contracts are traded only in two exchanges: LIFFE and NYBOT. Figure 1 and

Figure 2 shows respectively the monthly average total volume and open interest in these two cocoa terminal markets.

In determining the fair cocoa futures prices, market participants compare the current futures price to the spot price that can be expected to prevail at the maturity of the futures contract. As a result, futures prices represent the consensus reached by a large number of market participants, given all available information on crop outlook, level of stocks and their geographical distribution, and demand prospects.

A cocoa futures contract calls for delivery a lot size of 10 tonnes of cocoa beans in the months of March, May, July, September and December. Two major differences stand out when comparing the LIFFE and NYBOT cocoa futures contracts: (1) the New York contract is traded in US dollar, the London contract in pounds sterling; and (2) the New York contract calls for slightly lower grade cocoa than the London contract.

In general, cocoa futures contracts are not exchanged to secure the procurement or the sale of cocoa beans at their expiration, being LIFFE and NYBOT buyers or sellers of last resort. Rather, they are traded to provide a centralized price discovery mechanism and a price insurance function to market participants. The price discovery mechanism is the process through which buyers and sellers negotiate the terms of contract (i.e. price, quality, delivery time, delivery place, payment conditions). In futures markets this process is highly standardized, visible and transparent compared to spot markets. In fact, to enter into a transaction, futures market participants place their orders through authorized floor traders who in turn pass all this information to the exchange clearinghouse. The exchange clearinghouse, apart from assuring the market clearing conditions –correspondence between the numbers of futures contracts sold and bought–, discloses in real time information on futures contract prices, number of the exchanged contracts (i.e. volume) and number of the outstanding contacts (i.e. open interest). This is in contrast with the spot markets, where the terms of contracts are unknown to most market participants. Another function performed by futures markets is the price insurance function. The futures markets provide a mechanism, commonly indicated as futures hedging, with which the spot price risk is mitigated.

The legal principles underlying the monitoring activities of futures and options trading in LIFFE and NYBOT follow two different approaches. In accordance with the

Financial Services and Markets Act 2000 (FSMA) part XVIII, not only the LIFFE is exempt from the Financial Services Authority (FSA) handbook, but it has a regulatory obligation to be front-line regulator of itself. As a result, the LIFFE has put in place market monitoring controls and procedures to monitor and detect abusive or manipulative behavior as outlined in the Market Abuse Handbook. Emphasis of these controls is during the weeks prior to contract expiration when there is a greater potential for abusive squeezes[3].

Contrary to the LIFFE, futures and options trading in the NYBOT are monitored by a third party, the US Commodity Futures Trading Commission (CFTC). The CFTC identifies potential concentrations of market power within the cocoa futures market through its market surveillance program: the Large-Trader Reporting System (LTRS). The CFTC uses the adjective "commercial" and "non-commercial" to classify commodity futures traders. A reportable trader gets classified as "commercial" if he/she is engaged in business activities hedged by the use of the futures and options markets. The adjective "non-commercial" is used to identify speculators. Non-reportable position (NRP) participants are those traders whose commercial and non-commercial classifications are not known, because they hold a number of contracts below the reportable position threshold. For the cocoa futures market, this limit is set at 100 contracts per delivery month. Finally, it is worth noting that the CFTC is also responsible for the enforcement of speculative position limits, which are set to no more than 750 cocoa futures contracts for each delivery month.

For this study the only relevant implication deriving from these two different regulatory approaches is that data on open interest broken down by type of traders is available only for the NYBOT cocoa futures and options markets and not for the LIFFE.

3. Methods

The investigation of the impact of speculative activities on price levels and volatility requires the evaluation of the causal relationships among open interest, trading volume, prices and volatility. The single equation approach proposed by Holt and Irwin [2000],

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[3] An abusive squeeze occurs when a market participant is able to deliberately dry up liquidity in a particular security so as to be able to resell the security to other market participants when the price rises due to the lack of liquidity.

Irwin and Yoshimaru [1999], and Chang, Pinegar and Schachter [1999] is flawed. First, these analyses are based on the strong assumption that volume and open interest are exogenous with respect to prices and volatility. However, this is not often the case. For instance, trading activity in commodity option markets is driven by expectations on volatility. As a result, volatility is the cause of trading volume and not the opposite. Secondly, in futures markets, speculative buying (selling) would eventually distort the price discovery mechanism in the short run. In fact, in the long run, arbitrage forces will assure that market fundamentals will be fully reflected in futures prices. However, the econometric approach adopted by previous studies does not allow to disentangle the alleged short-run distortional impact from the long-run one.

A vector of autoregression (VAR) can address effectively the weaknesses of previous studies. In fact, all variables entering in the VAR are considered endogenously determined. Furthermore, by estimating the impulse response function, it is possible to evaluate firstly, whether both LIFFE and NYBOT cocoa market are efficient “a’ la Fama”; and secondly, whether, in the NYBOT cocoa markets, non-commercial traders distort prices from their competitive levels and exacerbate volatility.

A VAR is a linear model with *n*-equations and *n*-variables, where the dynamics of each variable are explained by its own lagged values, plus current and past values of the remaining variables. Equation [1] is a primitive VAR of order one[4]:

$$\mathbf{B X_t} = \mathbf{\Gamma_0} + \mathbf{\Gamma_1 X_{t-1}} + \boldsymbol{\varepsilon}_\mathbf{t} \qquad [1]$$

where $\mathbf{B}$ is a $(n \times n)$ matrix with ones along the main diagonal (i.e. n^2-n unknown parameters); $\mathbf{X_t}$ is a $(n \times 1)$ vector of endogenous variables; $\mathbf{\Gamma_0}$ is $(n \times 1)$ vector of unknown parameters; $\mathbf{\Gamma_1}$ is a $(n \times n)$ matrix of unknown parameters; and $\boldsymbol{\varepsilon}_\mathbf{t}$ is a $(n \times 1)$ vector of error terms. Equation [1] cannot be estimated as it is, because regressors are correlated with the error terms. An estimable form is a reduced form VAR, which is obtained by multiplying both sides of [1] by $\mathbf{B}^{-1}$:

$$\mathbf{X_t = A_0 + A_1\, X_{t\text{-}1} + e_t} \qquad [2]$$

where $\mathbf{A_0} = \mathbf{B}^{-1}\mathbf{\Gamma_0}$, $\mathbf{A_1} = \mathbf{B}^{-1}\mathbf{\Gamma_1}$ and $\mathbf{e_t} = \mathbf{B}^{-1}\boldsymbol{\varepsilon}_\mathbf{t}$. However, the estimation of the reduced form VAR only yields $3/2n^2+1/2n$ parameters: n^2+n coefficients and $(n^2-n)/2$ parameters

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[4] The order of VAR indicated the number of lag of $\mathbf{X_t}$ on the right-hand side of the equation.

from the variance-covariance matrix. On the contrary, the primitive system is constituted of $2n^2+n$ parameters: $2n^2$ coefficients and n parameters from the variance of the error terms. Therefore, an identification issue arises. To deal with this issue, it is common practice to place restrictions on **B**, such that the error terms in each regression equation are uncorrelated with the errors in the preceding equation (i.e. Choleski decomposition of the error terms) [Enders, 2004].

The formal derivation of the impulse response function follows. The starting point is to re-arrange the reduced form VAR in a vector moving average (VMA), in which the current values of the variables entering in the VAR depend on the error terms. This can be done solving [2] backward, then, after n iterations it can be expressed as:

$$\mathbf{X_t} = (\mathbf{I} + \mathbf{A_1} + \ldots + \mathbf{A_1^n})\mathbf{A_0} + \sum_{\mathbf{i=0}}^{\mathbf{n}} \mathbf{A_1^i e_{t-i}} + \mathbf{A_1^{n+1} X_{t-n-1}} \qquad [3]$$

If the elements of $\mathbf{X_t}$ are stationary, as n approaches to infinity, one gets

$$\mathbf{X_t} = \boldsymbol{\mu} + \sum_{\mathbf{i=0}}^{\infty} \mathbf{A_1^i e_{t-i}} \qquad [4]$$

where $\boldsymbol{\mu}$ is a vector of means of the elements in $\mathbf{X_t}$. At this point, [4] is re-written so that $\mathbf{X_t}$ depends on $\boldsymbol{\varepsilon}_\mathbf{t}$. Substituting $\mathbf{e_t}$ with $\mathbf{B}^{-1}\boldsymbol{\varepsilon}_\mathbf{t}$:

$$\mathbf{X_t} = \boldsymbol{\mu} + \sum_{\mathbf{i=0}}^{\infty} \mathbf{A_1^i B^{-1}} \boldsymbol{\varepsilon}_\mathbf{t-i}$$

and setting $\mathbf{A_1^i B^{-1}}$ equal to $\boldsymbol{\varphi}_\mathbf{1}^\mathbf{i}$, one gives:

$$\mathbf{X_t} = \boldsymbol{\mu} + \sum_{\mathbf{i=0}}^{\infty} \boldsymbol{\varphi}_\mathbf{1}^\mathbf{i} \boldsymbol{\varepsilon}_\mathbf{t-i} \qquad [5]$$

The elements of the matrix $\boldsymbol{\varphi}_\mathbf{1}^\mathbf{i}$ represent the impact multipliers. $\frac{\partial \mathbf{X_{t+1}}}{\partial \boldsymbol{\varepsilon}_\mathbf{t}}$ is the simulated impulse response of the elements of **X** at time t+1 arising from a realization of the random element at time t [Hamilton, 1992]. These unexpected changes are modeled through shocks or impulse in one of the elements of the vector $\boldsymbol{\varepsilon}_\mathbf{t}$. The value of the impulse, which is often chosen to be one standard error, is nonzero in the initial impact period (t=1) and zero elsewhere ($t \neq 1$). However, because of the identification restrictions previously placed on **B**, the impulse response functions are not robust to the re-ordering of the variables entering in the VAR [Lutkenpohl, 1991]. In particular, the error terms of the first variable, $\{\varepsilon_{1t}\}$, are affected by the error terms of all remaining variables, $\{\varepsilon_{2t}\}$, $\{\varepsilon_{3t}\}$, …, $\{\varepsilon_{nt}\}$. On the other hand, the error terms of the last variable entering the VAR, $\{\varepsilon_{nt}\}$, are exogenous to the system [Enders, 2004].

A possible solution to this issue is to derive the generalized impulse response function. The generalized impulse response function is invariant to any re-ordering of the variables entering in the VAR. Moreover, because orthogonality is not imposed, it allows a meaningful interpretation of impact responses. Defining $E(\mathbf{e_t}\mathbf{e_t}^{'}) = \mathbf{\Omega_e}$ such that shocks are contemporaneously correlated. The generalized impulse response function of X_i to one unit (one standard deviation) shock in X_j is given by:

$$\Psi_{ij,h} = (\rho_{ii})^{-1/2}\, \mathbf{e_j^{'}}\mathbf{\Omega_e}\mathbf{e_i} \qquad [6]$$

where ρ_{ii} is the i^{th} diagonal element of $\mathbf{\Omega_e}$, $\mathbf{e_i}$ is a selection element vector with the i^{th} element equal to one and all other elements equal to zero, and h is the time horizon [Koop, Peasaran and Potter, 1996].

4. Data

Four different datasets have been used in this investigation. The first dataset contains information on LIFFE prices, open interest and volumes for the 5 nearest cocoa futures contracts. Observations range from the 2nd January 2002 to the 31st January 2006, with a total of 1012 daily observations.

The second dataset contains information on NYBOT prices, open interest and volumes for the 5 nearest contracts. This latter dataset is larger than the LIFFE one. Observations range from the 3rd of January 1989 to the 28th of February 2006, with a total of 4287 daily observations.

The third dataset contains the NYBOT aggregate open interest for the 5 nearest cocoa futures contracts broken down by types of traders. Observations range from the 15th of January 1986 to the 27th of December 2005, with a total of 851 observations. It is worth noting that from the 6th of October 1992 to the 27th of December 2005, observations have a weekly frequency. On the contrary, from the 15th of January 1986 to the 30th September 1992, observations have a bi-weekly frequency. As a result, a resampling has been performed to have thoroughly the dataset a bi-weekly frequency. Source of information is the Commitment of Traders (COT) report which is released every Friday at 3:30 p.m. Eastern Time by the CFTC.

Finally, the fourth database is obtained by merging the third database with the second, after some data adjustments. The characteristics of this forth dataset follow the discussion about these data adjustments.

Since 5 cocoa futures contracts are exchanged every trading day in both futures markets, the following average prices are calculated to have representative minimum, maximum and closing prices:

$$P_t^{\min,K} = \sum_{j=1}^{5} op_{j,t}^{k} P_{j,t}^{\min,k} \qquad [7]$$

$$P_t^{\max,K} = \sum_{j=1}^{5} op_{j,t}^{k} P_{j,t}^{\max,k} \qquad [8]$$

$$P_t^{closing,K} = \sum_{j=1}^{5} op_{j,t}^{k} P_{j,t}^{closing,k} \qquad [9]$$

where *P* stands for price; *k* indicates either the LIFFE or NYBOT cocoa futures market; $op_{j,t}^{k}$ is the open interest of the j^{th} cocoa futures contract at time *t* in the *k* exchange[5].

The daily volatility in the *k* cocoa futures market is then calculated using the 'corrected' Parkinson scaled range measure [Parkinson, 1980; Wiggins, 1991]:

$$\sigma_t^{k} = 0.601 \ln\left(\frac{P_t^{\max,k}}{P_t^{\min,k}}\right) \qquad [10]$$

where *ln* is the neperian logarithm and $P_t^{\max,k}$ and $P_t^{\min,k}$ are calculated in accordance with equations [7] and [8]. Historical developments in LIFFE and NYBOT cocoa futures markets are reported in Figure 3 and Figure 4, respectively.

As mentioned before, at least for the NYBOT it is possible to gain some insights on who is trading cocoa futures contracts. Following the procedure outlined in Chang, Pinegar and Schachter [1999] the trading volume for each market participant is calculated

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[5] Another possible representative price is the price of the nearby futures contract, being the most traded contract. Here, the representative cocoa futures price is calculated as weighted average of the 5 nearest contracts to be consistent in matching observations on prices and volatility and observations on the NYBOT aggregate open interest broken down by types of traders.

as follows. First, it has been estimated the bi-weekly changes in the trader's long and short positions between the Tuesday of week *t* and the Tuesday of the previous two weeks *t-1*. These changes are represented as follows:

$$\Delta LP_{i,t} = LP_{i,t} - LP_{i,t-1} \tag{11}$$

$$\Delta SP_{i,t} = SP_{i,t} - SP_{i,t-1} \tag{12}$$

where $LP_{i,t}$ is the Tuesday's long position of trader *i* for all delivery months in the cocoa futures markets on week *t*, and $SP_{i,t}$ is the corresponding short position. If a trader initially has a long position and decreases the size of the long position over the period [*t-1, t*], then $\Delta LP_{i,t}$ will be negative and $\Delta SP_{i,t}$ will be zero. For a trader who initially has a long position and changes to a short position over [*t-1, t*], $\Delta LP_{i,t}$ will be negative (and equal to $-LP_{i,t-1}$) and $\Delta SP_{i,t}$ will be positive (and equal to $SP_{i,t}$). Once the changes in long and short positions have been determined, the long and short trading volume for trader *i* over the period [*t-1, t*] can be calculated as follows:

$$LongVOL_{i,t} = +\max[0, \Delta LP_{i,t}] - \min[0, \Delta SP_{i,t}] \tag{13}$$

$$ShortVOL_{i,t} = -\min[0, \Delta LP_{i,t}] + \max[0, \Delta SP_{i,t}] \tag{14}$$

Usually, either $LongVOL_{i,t}$ or $ShortVOL_{i,t}$, but not both, will be non zero. The sum of these terms is the minimum volume during the two-week period to arrive at the change in the *i* trader's reported long and short positions from the previous two-week period:

$$VOL_{i,t} = LongVOL_{i,t} + ShortVOL_{i,t} \tag{15}$$

Finally, these estimated trading volumes have been matched with the NYBOT average prices and volatility previously calculated. This fourth dataset has only 434 bi-weekly observations ranging from January 1989 to December 2005. It is worth noting, however, that these estimates understate the actual trading volume. In fact, intraday round-trip transactions are not taken into account.

5. Empirical results

In accordance with the objectives of this paper, empirical results are discussed in two distinct subsections. The first discusses results on the EMH for both LIFFE and NYBOT, while the second outlines the results on effect of speculation on the NYBOT cocoa prices and volatility.

5.1 Efficient market hypothesis.

A natural way to evaluate the hypothesis of market efficiency is to examine the revisions in the forecasts of prices, volatility and trading activity after new information is released. If those revisions are equal to zero then the EMH holds.

Cocoa price returns, volatility and trading activity (i.e. volume de-trended by the open interest) in both LIFFE and NYBOT are modeled through a VAR. The VAR for LIFFE has been estimated using 1012 daily observations raging from the 2nd January 2002 to the 31st January 2006. While a total of 4287 of daily observations have been used to estimate the VAR for the NYBOT; these observations range from the 3rd of January 1989 to the 28th of February 2006. The order of the VAR has been selected by minimizing the AIC [Harvey, 1990]. Annex 1 and Annex 2 report estimated VARs for LIFFE and NYBOT, respectively.

Figure 5 illustrates the revisions in forecasts of prices, volatility, and trading activity in the LIFEE cocoa futures markets after new market information is released. Unequivocally, empirical results suggest that LIFFE cocoa market adheres to the EMH. In the econometric exercise, the release of a “bullish” news, e.g. a one-day delay in major shipment ports in producing countries, has been simulated by a price shock of +1.8% at time t=0. Then, revisions in the forecast of prices, volatility and trading activity have been calculated from time t=1 to t=15. Results suggest that those revisions are substantially equal to zero (see Figure 5). This result implies that LIFFE has incorporated instantaneously the new market information. As a result, nobody can forecast LIFFE cocoa prices using all public available information.

Figure 6 illustrates the revisions in forecasts of prices, volatility, and trading activity in the NYBOT cocoa futures markets after “bullish” news emerge in the market. Results suggest that also the NYBOT has reacted instantaneously to the release of new market information. In fact, revisions in the forecast of prices, volatility and trading activities are substantially equal to zero. As a result, also in the NYBOT cocoa market traders cannot forecast NYBOT cocoa prices using all the available public information.

These empirical evidences suggest that both LIFFE and NYBOT react instantaneously to the release of new market information. Consequently, traders cannot profit from any trading mechanism attempting to forecast prices. The major implication of this result is that the price discovery mechanism in these centralized exchanges is efficient and that futures prices are unbiased forecasts of spot market prices.

5.2 Speculators activity in NYBOT cocoa futures markets.

Table 1 shows the averages of daily open interest, trading volume, and the turnover ratio by type of traders in the NYBOT cocoa futures markets from 15th of January 1994 to the 27th of December 2005. The turnover ratio is defined as the ratio of the average volume to the average open interest. It quantifies the share of the open interest that is settled at the end of the daily trading session. In addition to hedgers (i.e. commercial traders) and speculators (i.e. non-commercial traders), Table 1 reports statistics for another category of futures market participants: “other traders”. They are market participants with a non-reportable position, e.g. less than 100 cocoa futures contracts.

On average, hedgers have an open interest higher than speculators and “other traders”. They account for 69% of all “open” cocoa futures contracts in the NYBOT. However, their relative trading activity is rather low. In fact, on average, they are expected to settle only eight per cent of their open positions at the end of the trading session. Speculators are more active traders than hedgers. On a daily basis, they settle 24% of their open positions. However, speculators’ open interest accounts for only 16% of all “open” cocoa futures contracts in the NYBOT.

Figure 7 illustrates the monthly average of the daily open interest for all traded contracts broken down by type of traders from January 1986 to December 2005. A high correlation exists between hedgers’ open interest and the total open interest. Not surprisingly, hedgers account for more than two out of three of all open positions in the cocoa futures markets. Finally, speculators and “other traders” contribute to the remaining part with an equal share.

Figure 8 compares the trade activity of hedgers and speculators over time, by plotting the monthly average of the daily volume for all traded contracts broken down by type of traders from January 1986 to December 2005. Interestingly, speculators’ and hedgers’ average daily volume follow similar patterns and have approximately similar sizes. As a result, there are no differences in absolute terms between hedgers’ and speculators’ trade activity.

Figure 9 depicts the monthly average of the daily net positions of hedgers and speculators in the NYBOT cocoa futures markets from January 1986 to December 2005. On the vertical axis, a positive value indicates a net “long” position (i.e. traders are net buyers of cocoa futures contracts), whereas a negative value corresponds to a net “short” position. Interestingly, the average net positions of hedgers and speculators always have opposite signs. This evidence suggests that speculators facilitate risk transfer in the NYBOT cocoa futures markets.

A VAR has been estimated to capture the dynamics interrelationships among price level, price volatility and trading activities of different types of traders. The order of the VAR has been selected by minimizing the AIC [Harvey, 1990]. The dataset ranges from January 1989 to December 2005, with a total of 434 bi-weekly observations. Exogenous shocks in trading activities have been simulated to assess how price levels and volatility would react if either commercial or non-commercial or other types of traders increased their trading volume. The impact of these exogenous shocks has been evaluated in term of forecast revisions with respect to a baseline scenario (i.e. no shocks`). Finally, for completeness we have traced out also the effect of price shocks on volatility and vice versa. Econometric results are in Annex 3.

Concerning the impact of speculation activity on price volatility, two competitive hypotheses can be formulated. On the one hand, speculative activity increases price volatility by exacerbating the price movements in one direction or in the other. On the other hand, speculation reduces price volatility, by increasing market liquidity. Figure 10 illustrates the revisions in forecasted volatility because of shocks in trading activity of commercial, non-commercial and “other” traders and in prices. According to our results, shocks in trading activities of commercial, non-commercial and “other” traders reduce instantaneously price volatility by -0.18, -0.13 and -0.03%, respectively. As a result, speculation does not increase price volatility in the NYBOT cocoa markets. On the contrary, speculation reduces price volatility by increasing market liquidity. Finally, results suggest that volatility is expected to increase by 0.48% in response to a positive price shock. However, this initial impact will gradually decline and disappear after six weeks.

Concerning the impact of trading activity on price levels, one expects the existence of correlation between the two. However, it is not possible to set a benchmark by specifying the direction of such correlation, because of a lack of a satisfactory theoretical framework for price-volume relationship in futures markets; see Karpoff [1987] for a review of the issues. Figure 11 illustrates the revisions in forecasted price level because of shocks in trading activity of commercial, non-commercial and "other" traders and volatility. Shocks in trading volume of commercial, non-commercial and non-reportable positions will decrease trading prices in the range of 0.2 to 0.4%. Then, they will disappear in four weeks. This result indicates that in our sample the volume of transactions in which the price change is negative is larger than the volume of transactions in which the price change is positive. As a result, on average, "bear" traders have outnumbered "bulls" in the NYBOT cocoa markets[6]. Finally, a positive shock in volatility (i.e. an increase in the spread between the maximum and minimum price) will raise the price initially by 0.77%. Afterwards, revisions in forecasted prices will converge toward zero in four weeks. This result is confirming the existence of a positive relationship between price and volatility.

6. Concluding remarks

A competitive speculative market is typically asserted to be "efficient à la Fama" when the current market prices always "fully reflects" all available information. The major implication of the Fama-efficient hypothesis is that it is increasingly difficult for any single investor to outperform the overall market for an extended period of time. In recent year, however, this hypothesis has been questioned by a number of market participants who believe that speculators are distorting futures markets from their fundamentals.

Speculators are inclined to buy or to sell futures contracts according to whether the contact prices are high or low with respect to their expected levels. If the prevailing price is greater (less) than the expected price, speculators would sell (buy) futures

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[6] This suggests that during the sample period a pessimistic view (i.e. negative price trend) has prevailed the on NYBOT cocoa futures market.

contracts planning to make offsetting purchases (sales) at later date. If their expectations are corrects, speculation make profits equal to the differences between purchase (sale) price and the re-sale (re-purchase) price.

Often it is associated a causal relationship between speculative buying (selling) and prices. However, the observed "causal" relationship is only due to the different speed with which market participants react to new market information. Since speculators react quicker than any other futures market participant, it seems that speculators have triggered that particular market event. Indeed, speculators have just anticipated an event which would have occurred in any case. By using a metaphor, one would say that speculators catch "the wave" before any other surfers, but this has nothing to do with what creates the wave itself. Moreover, it is worth noting that if futures prices moved away from fundamentals, the speculative activity of arbitrageurs would soon restore the efficient conditions in futures markets.

Empirical results of this paper suggest that both LIFFE and NYBOT react instantaneously to the release of new market information. This means that traders cannot profit from any trading mechanism attempting to forecast prices. As a result, the price discovery mechanism in these centralized exchanges is efficient and futures prices are unbiased forecasts of spot prices.

Results from the analysis of the impact of non-commercial traders in the NYBOT cocoa futures market indicate that non-commercial traders do not exacerbate the volatility of cocoa futures contract prices. Indeed, their trade activity seems to have a stabilizing effect. This evidence supports the hypothesis that successful speculators are reacting quicker than any other market participant to new information emerging from the market. That is why profitable speculative buying (selling) occurs just before the market makes a move. However, caution has to be exercised in the interpretation of these last findings. In fact, these tests have been carried out using only the speculators' reportable positions recorded on each Tuesday by the US Commodity Futures Trade Commission. As a result, this investigation does not account for intraday round-trip transactions.

Finally, a negative relationship is observed between shocks in trading volume and cocoa futures prices. This result suggests that a "bearish" view has prevailed in the NYBOT cocoa futures markets.

The econometric framework presented here addresses effectively the weakness of previous studies, which were mainly based on a single equation approach. A VAR analysis and the derivation of the generalized impulse response function assess the extent of causal relationship among price, volatility and trading volume by disentangling both short-run and long-run effects. One major limitation of this framework is represented by the requirement of a large data set.

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Table and Figures

Table 1. Averages of daily open interest, trading volume, and turnover ratio by type of traders in the NYBOT cocoa futures markets from 4 January 1994 to 30 December 2005.

	Open Interest (no. of contracts)	Volume (no. of contracts)	Turnover ratio
Hedgers	54,518	4,386	8%
Speculators	12,924	3,061	24%
“Other traders”	12,145	1,941	16%

Figure 1. Monthly average of the daily total open interest in LIFFE and NYBOT from 2 January 2002 to 31 January 2006.

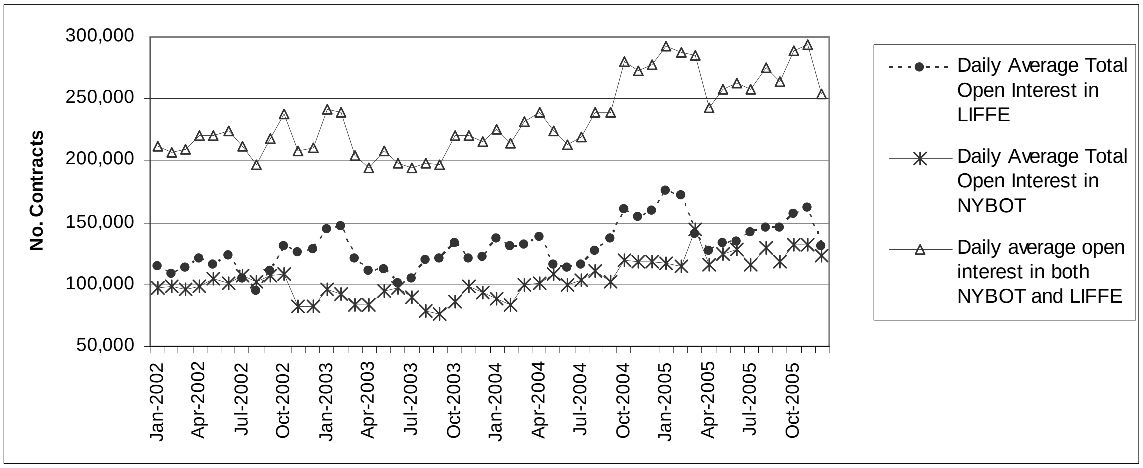


Figure 2. Monthly average of the daily total volume in LIFFE and NYBOT from 2 January 2002 to 31 January 2006

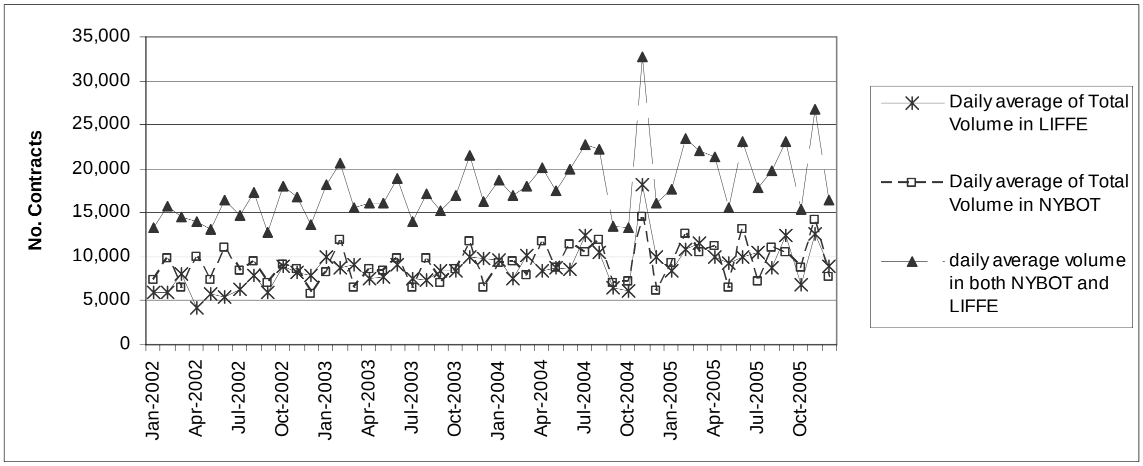


Figure 3. LIFFE average closing prices and average daily volatility from 2 January 2002 to 31 January 2006.

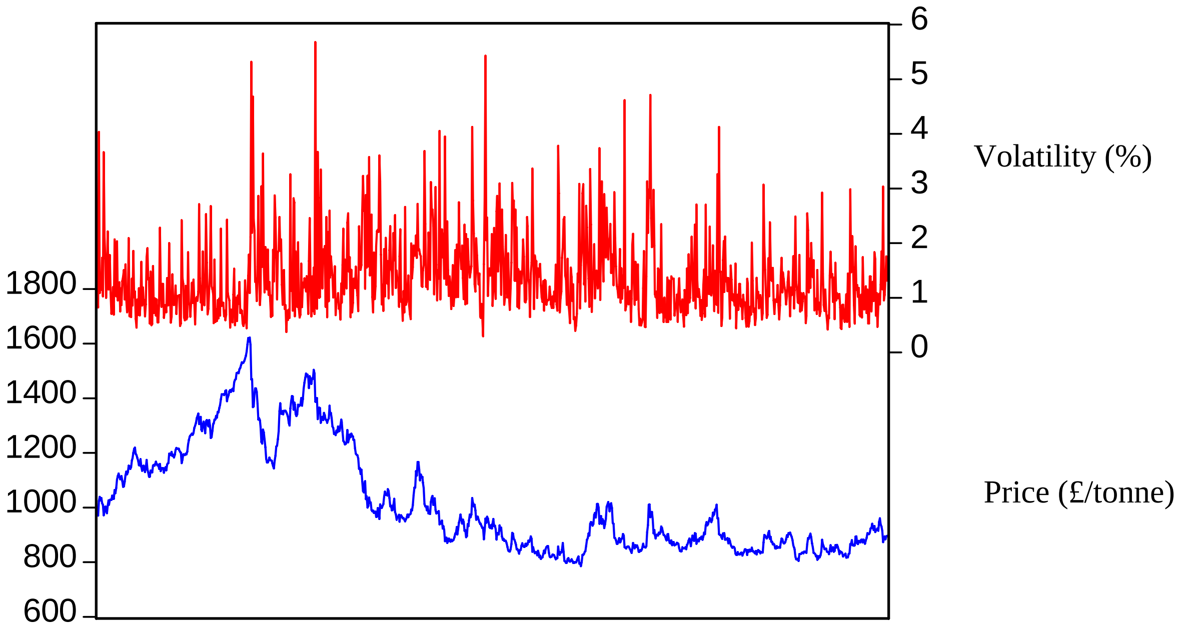


Figure 4. NYBOT average closing prices and average daily volatility from 3 January 1989 to 28 February 2006.

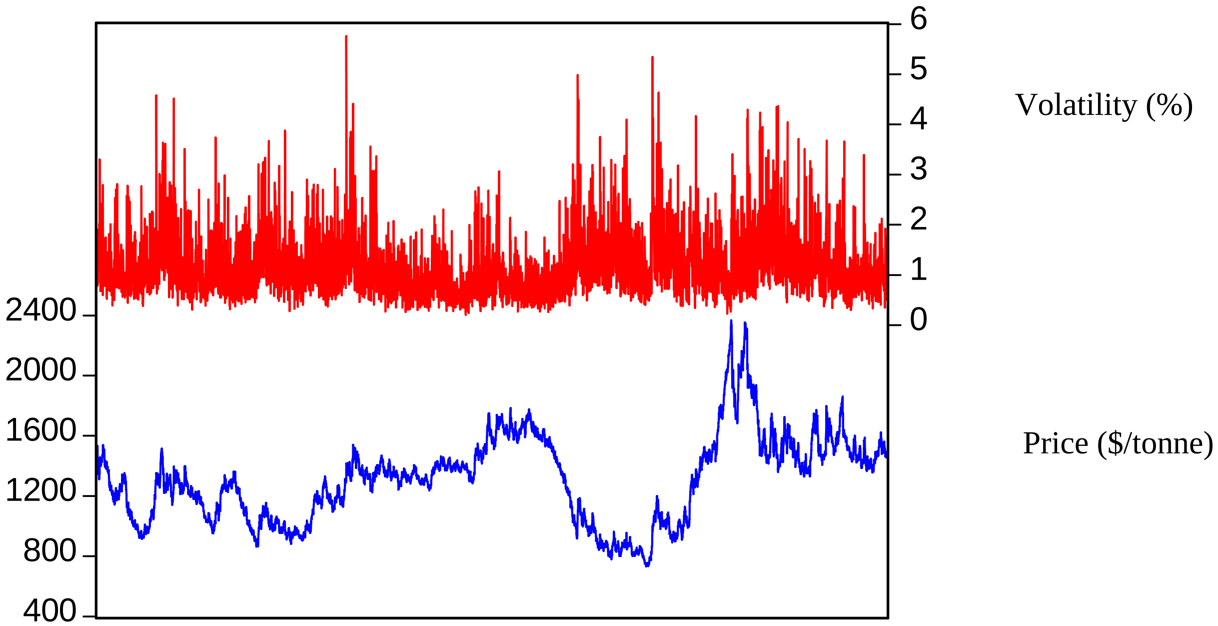


Figure 5. Revisions in the forecast of closing prices, volatility and trading activities in the LIFFE cocoa futures market after the release of new market information.

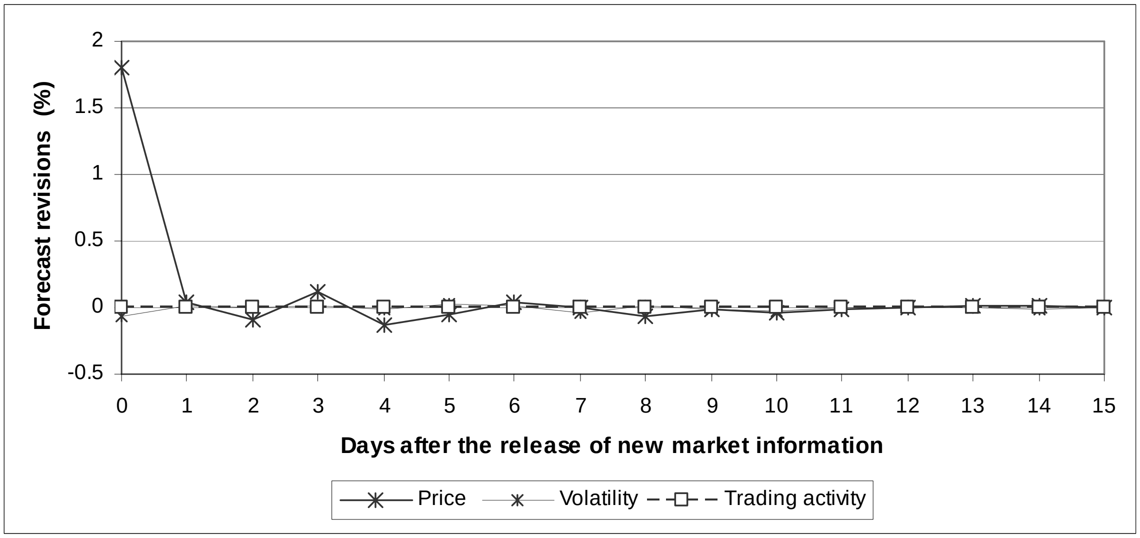


Figure 6. Revisions in the forecasts of LIFFE and NYBOT cocoa closing prices after new information on the exchange rate market are released.

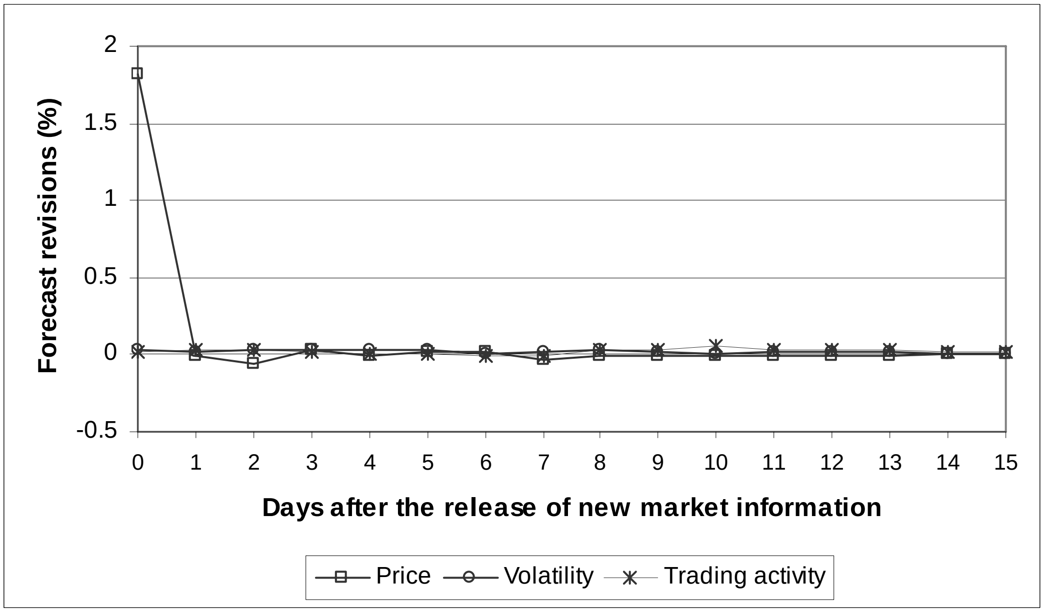


Figure 7. Monthly average of the daily open Interest broken down in non-commercial (NonComm), commercial (Comm) and non reportable (NonRept) positions in the NYBOT cocoa futures markets.

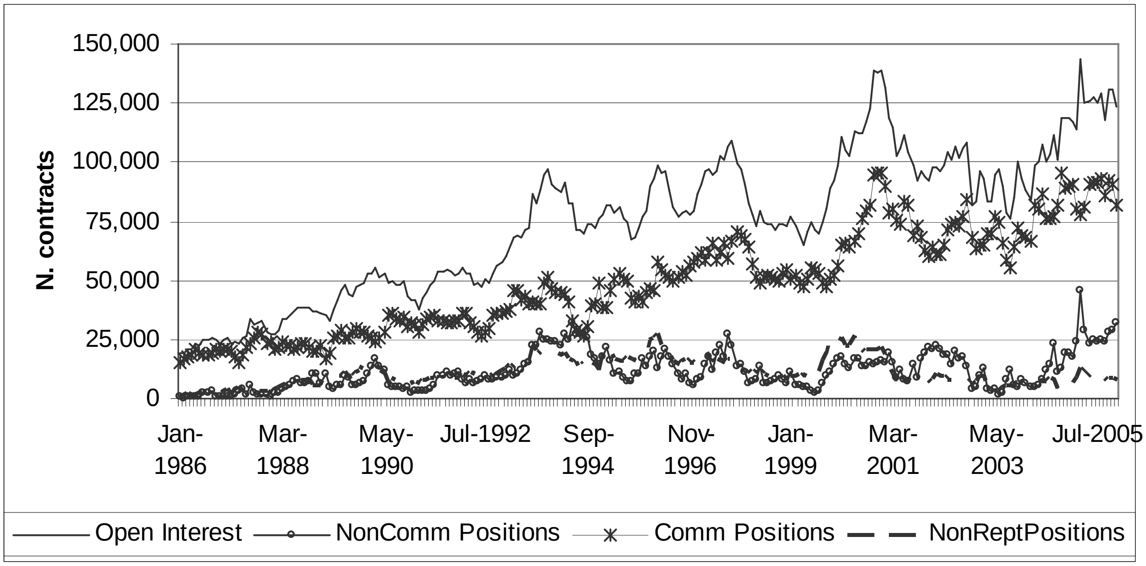
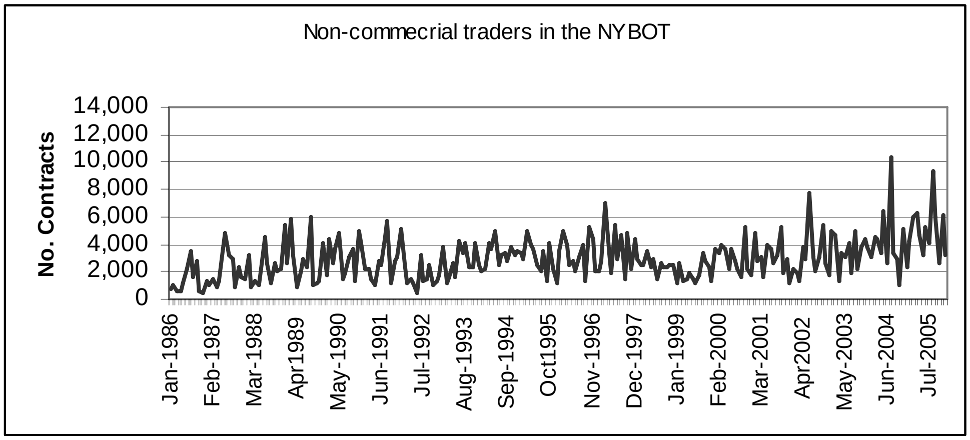
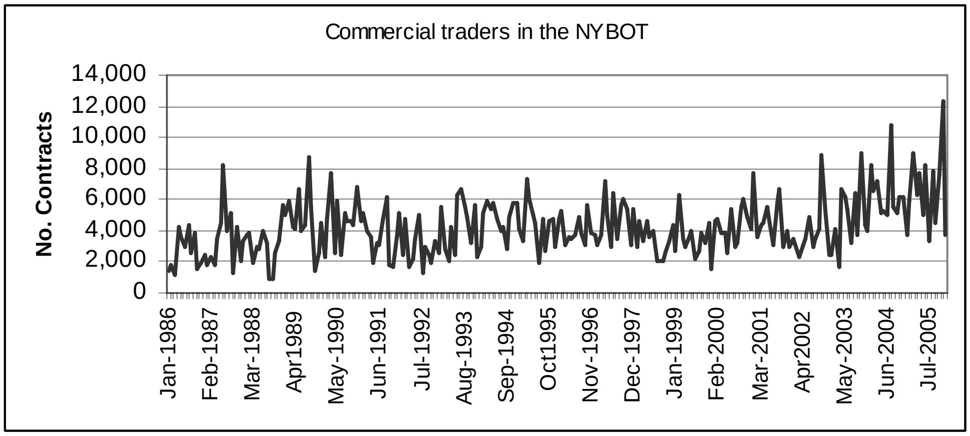


Figure 8. Monthly average of daily volume broken down in non-commercial, commercial and non-reportable-position trading in the NYBOT cocoa futures markets.





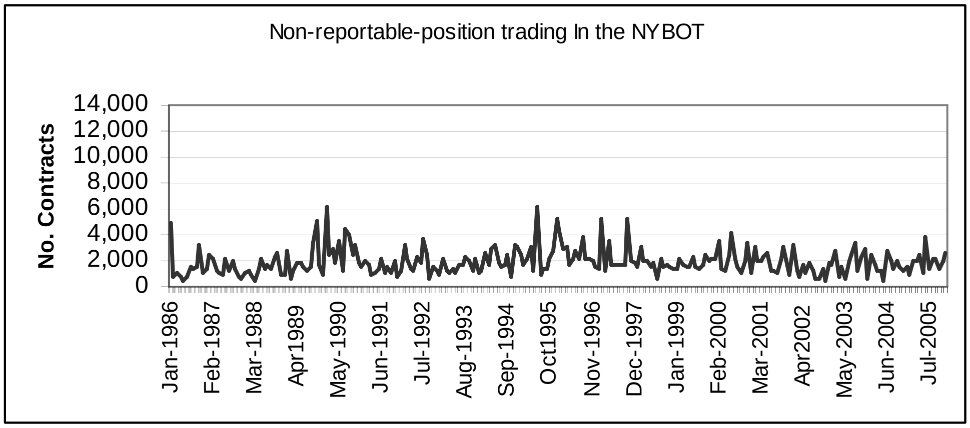


Figure 9. Commercial and Non-Commercial net positions in the NYBOT cocoa futures markets from January 1986 to December 2005

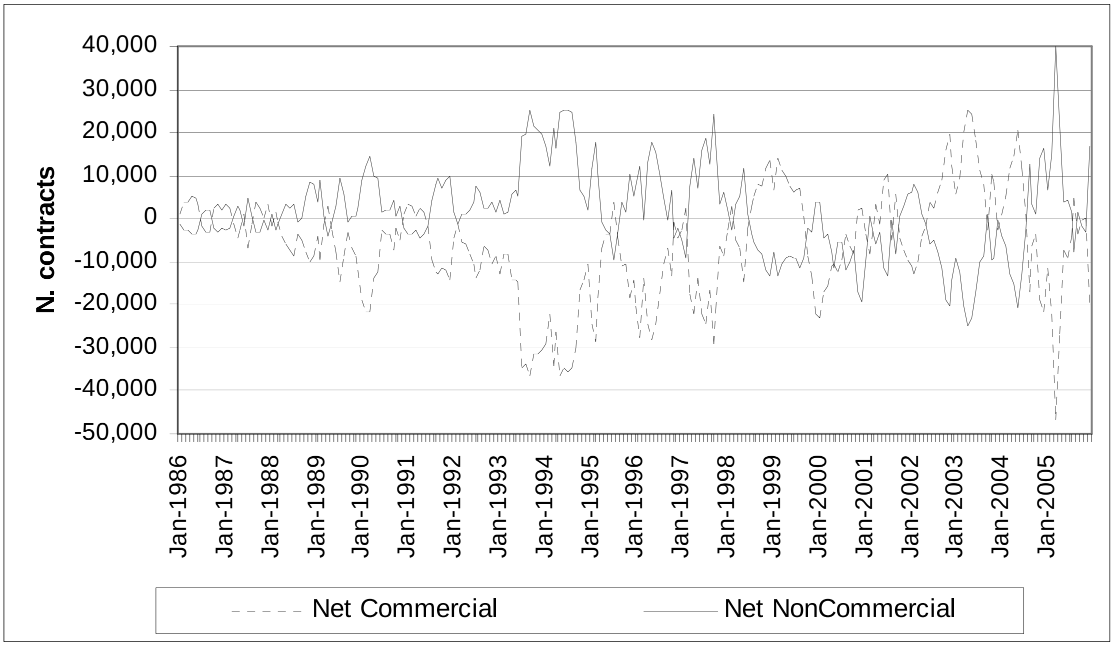


Figure 10. . Revisions in forecasted volatility as a result of shocks in the volume of non-commercial (VOL NON COMM), commercial (VOL COMM), non-reportable positions (VOL NON REPT) and price levels.

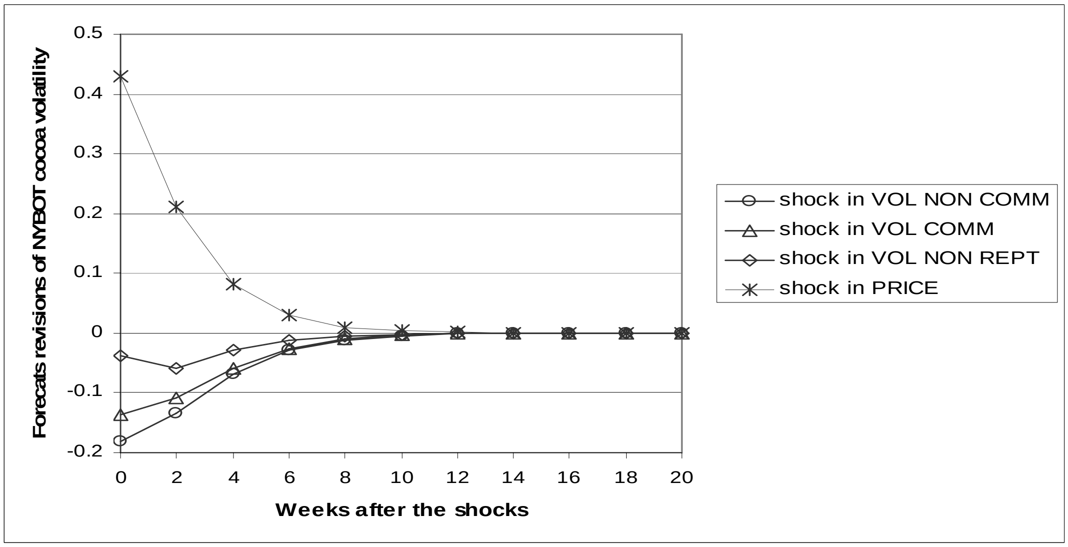
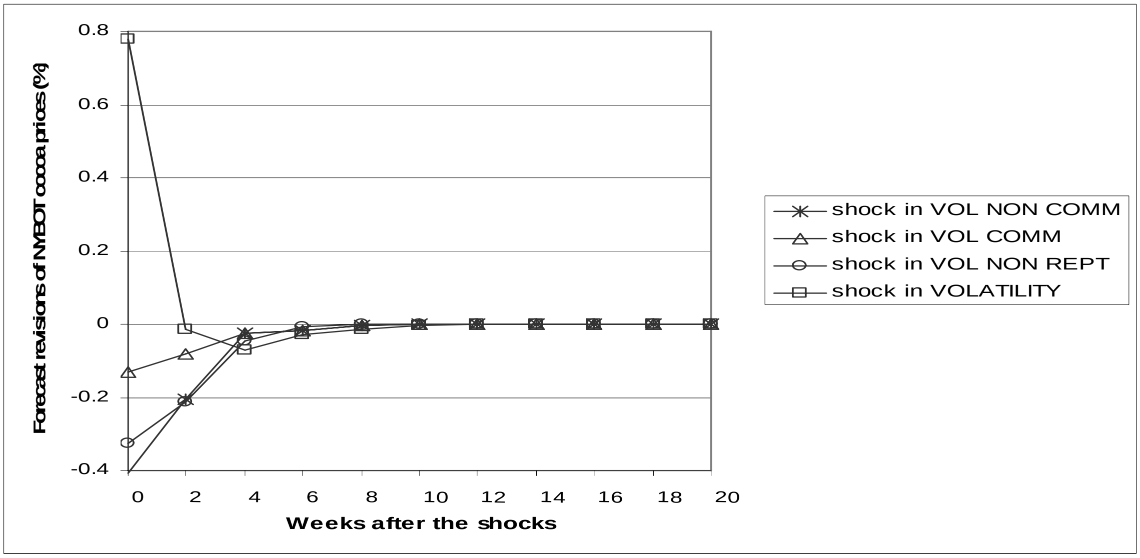


Figure 11. Revisions in forecasted price changes as a result of shocks in volatility and in the volume of non-commercial, commercial, non-reportable positions and volatility.



ANNEX 1. LIFFE-VAR: price, volatility, volume

DEFINITION OF VARIABLES

Cocoa prices $\left(R = 100 \times \ln \frac{P_t^{clo\sin g,LIFFE}}{P_{t-1}^{clo\sin g,LIFFE}} \right)$;

Volatility $\left(VOLATILITY = 0.601 \ln \frac{P_t^{\max,LIFFE}}{P_t^{\min,LIFFE}} \right)$;

Volume $\left(VOLUME\_ST = \frac{Volume_t}{Open\ Interest_t} \right)$ of the 5 nearest cocoa futures contacts in LIFFE;

C constant; and

T time trend.

VAR ESTIMATES

```
 Dependent variables: VOLATILITY R VOLUME_STD
 Number of lags = 10
 Exogenous variables: C  T

                          Residual covariance matrix

              VOLATILITY             R    VOLUME_STD
 VOLATILITY       0.50525
 R               -0.12342       3.22660
 VOLUME_STD      0.011736     0.0075523     0.0027180

 Schwarz B.I.C. = 1556.71  Log likelihood = -1232.16

                  Estimated    Standard
 Variable         Coefficient     Error       t-statistic   P-value
 VOLATILITY(-1)   .182788       .036806       4.96630       [.000]
 VOLATILITY(-2)   .121636       .037519       3.24198       [.001]
 VOLATILITY(-3)   .050174       .037784       1.32793       [.185]
 VOLATILITY(-4)   .085474       .038063       2.24559       [.025]
 VOLATILITY(-5)   .035158       .038323       .917408       [.359]
 VOLATILITY(-6)   .028272       .038225       .739621       [.460]
 VOLATILITY(-7)   .051960       .037957       1.36891       [.171]
 VOLATILITY(-8)   -.014505      .038134       -.380375      [.704]
 VOLATILITY(-9)   -.053006      .037338       -1.41962      [.156]
 VOLATILITY(-10)  .030734       .036772       .835785       [.404]
 R(-1)            .012835       .013823       .928460       [.353]
 R(-2)            .348955E-02   .013914       .250793       [.802]
 R(-3)            .762295E-02   .013926       .547396       [.584]
 R(-4)            -.649596E-02  .013967       -.465094      [.642]
 R(-5)            .012857       .013988       .919109       [.358]
 R(-6)            .940772E-02   .014029       .670589       [.503]
 R(-7)            -.025944      .014037       -1.84825      [.065]
 R(-8)            .416556E-02   .013818       .301451       [.763]
 R(-9)            -.012282      .013580       -.904444      [.366]
 R(-10)           -.803206E-02  .013481       -.595792      [.551]
 VOLUME_STD(-1)   .171489       .498461       .344036       [.731]
 VOLUME_STD(-2)   .766386       .503352       1.52256       [.128]
 VOLUME_STD(-3)   .242063       .527809       .458619       [.647]
 VOLUME_STD(-4)   .749144       .528570       1.41731       [.157]
 VOLUME_STD(-5)   -.357165      .521622       -.684719      [.494]
 VOLUME_STD(-6)   -.548106      .516397       -1.06141      [.289]
 VOLUME_STD(-7)   .527920       .517620       1.01990       [.308]
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VOLUME_STD(-8)   .542103       .519378       1.04376       [.297]
VOLUME_STD(-9)   -.276900      .522250       -.530207      [.596]
VOLUME_STD(-10)  -.546235      .514067       -1.06258      [.288]
C                 .623366       .112931       5.51988      [.000]
T                -.707831E-04  .887985E-04   -.797120      [.426]
VOLATILITY(-1)   .129688       .093011       1.39433       [.164]
VOLATILITY(-2)   -.273579      .094814       -2.88543      [.004]
VOLATILITY(-3)   -.270634      .095483       -2.83438      [.005]
VOLATILITY(-4)   .081447       .096189       .846747       [.397]
VOLATILITY(-5)   .075848       .096846       .783180       [.434]
VOLATILITY(-6)   -.120965      .096597       -1.25226      [.211]
VOLATILITY(-7)   -.260225      .095921       -2.71292      [.007]
VOLATILITY(-8)   -.898201E-02  .096369       -.093204      [.926]
VOLATILITY(-9)   .013359       .094357       .141577       [.887]
VOLATILITY(-10)  -.090838      .092926       -.977529      [.329]
R(-1)             .026526      .034933        .759332      [.448]
R(-2)            -.076381      .035162       -2.17225      [.030]
R(-3)            .058953       .035192       1.67517       [.094]
R(-4)            -.070317      .035296       -1.99221      [.047]
R(-5)            -.011383      .035350       -.322015      [.748]
R(-6)            -.125056E-02  .035453       -.035274      [.972]
R(-7)            -.275327E-02  .035474       -.077615      [.938]
R(-8)            -.034759      .034920       -.995395      [.320]
R(-9)            -.017020      .034317       -.495964      [.620]
R(-10)           -.039568      .034069       -1.16142      [.246]
VOLUME_STD(-1)   -.394588      1.25966       -.313251      [.754]
VOLUME_STD(-2)   5.51172       1.27202       4.33306       [.000]
VOLUME_STD(-3)   -1.42553      1.33382       -1.06875      [.285]
VOLUME_STD(-4)   -.614085      1.33574       -.459733      [.646]
VOLUME_STD(-5)   .498288       1.31819       .378010       [.706]
VOLUME_STD(-6)   -.351989      1.30498       -.269727      [.787]
VOLUME_STD(-7)   1.14730       1.30807       .877094       [.381]
VOLUME_STD(-8)   .100905       1.31251       .076879       [.939]
VOLUME_STD(-9)   .709683       1.31977       .537732       [.591]
VOLUME_STD(-10)  -.059520      1.29909       -.045816      [.963]
C                 .807942       .285387      2.83104       [.005]
T                -.288898E-03  .224402E-03   -1.28741      [.198]
VOLATILITY(-1)   .358134E-02   .269952E-02   1.32666       [.185]
VOLATILITY(-2)   -.246902E-02  .275185E-02   -.897220      [.370]
VOLATILITY(-3)   -.317911E-02  .277126E-02   -1.14717      [.252]
VOLATILITY(-4)   .157707E-02   .279175E-02   .564905       [.572]
VOLATILITY(-5)   -.194069E-02  .281082E-02   -.690436      [.490]
VOLATILITY(-6)   .207532E-02   .280361E-02   .740233       [.459]
VOLATILITY(-7)   .273293E-02   .278397E-02   .981664       [.327]
VOLATILITY(-8)   -.808872E-03  .279698E-02   -.289195      [.773]
VOLATILITY(-9)   -.445015E-02  .273860E-02   -1.62497      [.105]
VOLATILITY(-10)  .876435E-02   .269706E-02   3.24960       [.001]
R(-1)            .888450E-03   .101389E-02   .876279       [.381]
R(-2)            -.660712E-03  .102053E-02   -.647419      [.518]
R(-3)            -.154119E-03  .102140E-02   -.150890      [.880]
R(-4)            .129558E-02   .102441E-02   1.26470       [.206]
R(-5)            -.315566E-03  .102598E-02   -.307575      [.758]
R(-6)            .183848E-02   .102897E-02   1.78673       [.074]
R(-7)            .348066E-03   .102958E-02   .338068       [.735]
R(-8)            .212048E-02   .101351E-02   2.09221       [.037]
R(-9)            -.504363E-03  .995997E-03   -.506390      [.613]
R(-10)           -.695358E-03  .988793E-03   -.703239      [.482]
VOLUME_STD(-1)   .155279       .036560       4.24726       [.000]
VOLUME_STD(-2)   .146942       .036919       3.98016       [.000]
VOLUME_STD(-3)   .037410       .038712       .966347       [.334]
VOLUME_STD(-4)   -.380360E-02  .038768       -.098111      [.922]
VOLUME_STD(-5)   -.013612      .038259       -.355802      [.722]
VOLUME_STD(-6)   -.026845      .037875       -.708768      [.479]
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VOLUME_STD(-7)   -.026418      .037965       -.695844      [.487]
VOLUME_STD(-8)   .014363       .038094       .377039       [.706]
VOLUME_STD(-9)   .017750       .038305       .463387       [.643]
VOLUME_STD(-10)  -.050161      .037704       -1.33038      [.184]
C                 .038099       .828298E-02   4.59971       [.000]
T                .108233E-04   .651297E-05   1.66180       [.097]

Dependent variable: VOLATILITY

       Mean of dep. var. = 1.40112           R-squared = .142788
  Std. dev. of dep. var. = .753814  Adjusted R-squared = .110849
Sum of squared residuals = 420.366        LM het. test = 3.19246 [.074]
   Variance of residuals = .505247       Durbin-Watson = 2.01548
Std. error of regression = .710807     F (block exog.) = .983368 [.480]

Dependent variable: R

       Mean of dep. var. = .131676E-02           R-squared = .077803
  Std. dev. of dep. var. = 1.83661      Adjusted R-squared = .043443
Sum of squared residuals = 2684.53            LM het. test = .373972 [.541]
   Variance of residuals = 3.22660           Durbin-Watson = 2.00883
Std. error of regression = 1.79627         F (block exog.) = 2.77878 [.000]

Dependent variable: VOLUME_STD

       Mean of dep. var. = .068949               R-squared = .093093
  Std. dev. of dep. var. = .053753      Adjusted R-squared = .059302
Sum of squared residuals = 2.26138            LM het. test = 10.7671 [.001]
   Variance of residuals = .271800E-02       Durbin-Watson = 2.02249
Std. error of regression = .052134         F (block exog.) = 1.28265 [.182]
```

ANNEX 2. NYBOT-VAR: price, volatility, volume

DEFINITION OF VARIABLES

Cocoa prices $\left(R = 100 \times \ln \frac{P_t^{clo\sin g,NYBOT}}{P_{t-1}^{clo\sin g,NYBOT}}\right)$;

Volatility $\left(VOLATILITY = 0.601 \times \ln \frac{P_t^{\max,NYBOT}}{P_t^{\min,NYBOT}}\right)$;

Volume $\left(VOLUME\_ST = \frac{Volume_t}{Open\ Interest_t}\right)$ of the 5 nearest cocoa futures contacts in NYBOT;

C constant; and

T time trend.

VAR ESTIMATES

```
 Dependent variables: VOLATILITY R VOLUME_STD
 Number of lags = 10
 Exogenous variables: C T


 Number of observations:  4222

                          Residual covariance matrix

               VOLATILITY             R    VOLUME_STD
 VOLATILITY       0.33213
 R               0.062513       3.28777
 VOLUME_STD     0.0026454      0.027510       0.85369

 Schwarz B.I.C. = 18168.5  Log likelihood = -17767.7

                   Estimated    Standard
 Variable         Coefficient     Error       t-statistic   P-value
 VOLATILITY(-1)   .152920       .015451       9.89729       [.000]
 VOLATILITY(-2)   .079676       .015606       5.10544       [.000]
 VOLATILITY(-3)   .085202       .015628       5.45200       [.000]
 VOLATILITY(-4)   .061735       .015666       3.94073       [.000]
 VOLATILITY(-5)   .060357       .015695       3.84570       [.000]
 VOLATILITY(-6)   .021156       .015698       1.34766       [.178]
 VOLATILITY(-7)   .065014       .015668       4.14941       [.000]
 VOLATILITY(-8)   .053026       .015635       3.39141       [.001]
 VOLATILITY(-9)   .055341       .015594       3.54882       [.000]
 VOLATILITY(-10)  .067832       .015431       4.39570       [.000]
 R(-1)            .947793E-02   .491771E-02   1.92731       [.054]
 R(-2)            .015890       .491710E-02   3.23149       [.001]
 R(-3)            .010578       .491965E-02   2.15014       [.032]
 R(-4)            .012799       .491632E-02   2.60331       [.009]
 R(-5)            .934362E-02   .492244E-02   1.89817       [.058]
 R(-6)            -.136431E-02  .492099E-02   -.277243      [.782]
 R(-7)            .286818E-02   .492229E-02   .582693       [.560]
 R(-8)            .604456E-02   .492206E-02   1.22805       [.219]
 R(-9)            .156674E-02   .491848E-02   .318542       [.750]
 R(-10)           -.425018E-02  .490910E-02   -.865777      [.387]
 VOLUME_STD(-1)   -.010875      .961597E-02   -1.13089      [.258]
 VOLUME_STD(-2)   -.653741E-02  .011208       -.583305      [.560]
```

```
VOLUME_STD(-3)    .012044        .011335        1.06252         [.288]
VOLUME_STD(-4)    -.545527E-02   .011342        -.480993        [.631]
VOLUME_STD(-5)    -.016827       .011225        -1.49912        [.134]
VOLUME_STD(-6)    .012277        .011229        1.09333         [.274]
VOLUME_STD(-7)    -.674368E-02   .011347        -.594326        [.552]
VOLUME_STD(-8)    .852685E-03    .011336        .075219         [.940]
VOLUME_STD(-9)    .012320        .011209        1.09913         [.272]
VOLUME_STD(-10)   .895059E-02    .962565E-02    .929869         [.352]
C                 .334608        .033806        9.89791         [.000]
T                 .427010E-05    .720018E-05    .593055         [.553]
VOLATILITY(-1)    .501388E-02    .048612        .103141         [.918]
VOLATILITY(-2)    .055052        .049101        1.12120         [.262]
VOLATILITY(-3)    -.036703       .049169        -.746467        [.455]
VOLATILITY(-4)    .035615        .049289        .722570         [.470]
VOLATILITY(-5)    .081530        .049380        1.65110         [.099]
VOLATILITY(-6)    -.040043       .049391        -.810730        [.418]
VOLATILITY(-7)    -.030088       .049296        -.610349        [.542]
VOLATILITY(-8)    -.365010E-03   .049193        -.742002E-02    [.994]
VOLATILITY(-9)    -.091326       .049063        -1.86140        [.063]
VOLATILITY(-10)   -.035690       .048552        -.735089        [.462]
R(-1)             -.653990E-02   .015472        -.422681        [.673]
R(-2)             -.032408       .015470        -2.09486        [.036]
R(-3)             .018301        .015479        1.18236         [.237]
R(-4)             -.875074E-02   .015468        -.565730        [.572]
R(-5)             .980180E-02    .015487        .632892         [.527]
R(-6)             .561371E-02    .015483        .362578         [.717]
R(-7)             -.022169       .015487        -1.43149        [.152]
R(-8)             -.280725E-02   .015486        -.181276        [.856]
R(-9)             -.655015E-02   .015475        -.423278        [.672]
R(-10)            -.330143E-02   .015445        -.213750        [.831]
VOLUME_STD(-1)    .174476E-02    .030254        .057670         [.954]
VOLUME_STD(-2)    -.019439       .035262        -.551275        [.581]
VOLUME_STD(-3)    .339637E-02    .035664        .095232         [.924]
VOLUME_STD(-4)    .146745E-02    .035684        .041124         [.967]
VOLUME_STD(-5)    .047608        .035316        1.34804         [.178]
VOLUME_STD(-6)    .024773        .035329        .701215         [.483]
VOLUME_STD(-7)    .014778        .035700        .413953         [.679]
VOLUME_STD(-8)    -.082050       .035666        -2.30049        [.021]
VOLUME_STD(-9)    -.036842       .035267        -1.04466        [.296]
VOLUME_STD(-10)   .030796        .030285        1.01689         [.309]
C                 .054051        .106362        .508173         [.611]
T                 .975764E-05    .226536E-04    .430731         [.667]
VOLATILITY(-1)    .010453        .024771        .421976         [.673]
VOLATILITY(-2)    .930509E-02    .025020        .371906         [.710]
VOLATILITY(-3)    .018378        .025055        .733518         [.463]
VOLATILITY(-4)    -.254917E-02   .025116        -.101497        [.919]
VOLATILITY(-5)    .017395        .025162        .691306         [.489]
VOLATILITY(-6)    .127388E-02    .025168        .050615         [.960]
VOLATILITY(-7)    -.043395       .025120        -1.72753        [.084]
VOLATILITY(-8)    .313789E-02    .025067        .125181         [.900]
VOLATILITY(-9)    -.029244       .025001        -1.16973        [.242]
VOLATILITY(-10)   -.046295       .024740        -1.87125        [.061]
R(-1)             .012500        .788421E-02    1.58546         [.113]
R(-2)             .129957E-02    .788322E-02    .164852         [.869]
R(-3)             -.348382E-02   .788731E-02    -.441700        [.659]
R(-4)             -.650616E-02   .788198E-02    -.825448        [.409]
R(-5)             -.252969E-02   .789180E-02    -.320547        [.749]
R(-6)             -.010630       .788947E-02    -1.34733        [.178]
R(-7)             -.233021E-02   .789154E-02    -.295279        [.768]
R(-8)             .018545        .789117E-02    2.35004         [.019]
R(-9)             .665047E-02    .788544E-02    .843386         [.399]
R(-10)            .016738        .787040E-02    2.12675         [.033]
VOLUME_STD(-1)    .602407        .015417        39.0753         [.000]
```

```
 VOLUME_STD(-2)   .177486       .017968       9.87777       [.000]
 VOLUME_STD(-3)   -.074851      .018173       -4.11878      [.000]
 VOLUME_STD(-4)   .149296       .018183       8.21064       [.000]
 VOLUME_STD(-5)   .207025       .017996       11.5040       [.000]
 VOLUME_STD(-6)   -.223141      .018003       -12.3950      [.000]
 VOLUME_STD(-7)   .053685       .018191       2.95113       [.003]
 VOLUME_STD(-8)   -.100286E-02  .018174       -.055180      [.956]
 VOLUME_STD(-9)   .078823       .017971       4.38621       [.000]
 VOLUME_STD(-10)  -.050549      .015432       -3.27557      [.001]
 C                .068852       .054199       1.27037       [.204]
 T                .111713E-04   .115435E-04   .967756       [.333]


 Dependent variable: VOLATILITY
        Mean of dep. var. = 1.15569           R-squared = .173293
   Std. dev. of dep. var. = .631509  Adjusted R-squared = .167177
 Sum of squared residuals = 1391.64        LM het. test = 88.8061 [.000]
    Variance of residuals = .332133       Durbin-Watson = 2.00615
 Std. error of regression = .576310     F (block exog.) = 2.08217 [.003]

Dependent variable: R
        Mean of dep. var. = .513678E-02           R-squared = .798626E-02
   Std. dev. of dep. var. = 1.81381      Adjusted R-squared = .646776E-03
 Sum of squared residuals = 13775.8            LM het. test = 17.6492 [.000]
    Variance of residuals = 3.28777           Durbin-Watson = 1.99894
 Std. error of regression = 1.81322         F (block exog.) = 1.22561 [.222]

Dependent variable: VOLUME_STD
        Mean of dep. var. = .270123           R-squared = .764203
   Std. dev. of dep. var. = 1.89575  Adjusted R-squared = .762458
 Sum of squared residuals = 3576.98        LM het. test = 329.081 [.000]
    Variance of residuals = .853693       Durbin-Watson = 1.98844
 Std. error of regression = .923955     F (block exog.) = 1.31788 [.155]
```

ANNEX 3. NYBOT-VAR: price, volatility, volume of commercial traders, volume of non-commercial traders, volume of non-reportable positions.

DEFINITION OF VARIABLES

Cocoa prices $\left(R = 100 \times \ln \frac{P_t^{closing,NYBOT}}{P_{t-1}^{closing,NYBOT}} \right)$;

Volatility $\left(VOLATILITY = 0.601 \times \ln \frac{P_t^{\max,NYBOT}}{P_t^{\min,NYBOT}} \right)$;

Volume commercial traders $\left(VOLCOMM = \frac{Volume_t^{Commercial}}{Open\ Interest_t} \right)$ of the 5 nearest contacts in NYBOT;

Volume non-commercial traders $\left(VOLNONCOMM = \frac{Volume_t^{Non-Commercial}}{Open\ Interest_t} \right)$ of the 5 nearest contacts in NYBOT;

Volume non-reportable traders $\left(VOLCOMM = \frac{Volume_t^{Non-reportable}}{Open\ Interest_t} \right)$ of the 5 nearest contacts in NYBOT;

$Volume_t^{Commercial}$, $Volume_t^{Non-Commercial}$ and $Volume_t^{Non-reportable}$ are defined in accordance with equation [15] in the text;

C constant; and

T time trend.

```
 Dependent variables: VOLNONCOMM VOLCOMM VOLNONREPT VOLATILITY R
 Number of lags =  1
 Exogenous variables: C T


                           Residual covariance matrix

               VOLNONCOMM       VOLCOMM    VOLNONREPT    VOLATILITY       R
 VOLNONCOMM      0.019393
 VOLCOMM         0.014218      0.013780
 VOLNONREPT     0.0029918     0.0025315     0.0012336
 VOLATILITY     -0.025374     -0.016001    -0.0013493       6.00619
 R              -0.056663     -0.015450     -0.011434       1.90476    19.66550

 Schwarz B.I.C. = 523.268  Log likelihood = -417.398

                  Estimated    Standard
 Variable        Coefficient     Error       t-statistic   P-value
 VOLNONCOMM(-1)  .099396       .095897       1.03649       [.301]
 VOLCOMM(-1)     .352091       .109367       3.21937       [.001]
 VOLNONREPT(-1)  -.604336      .243261       -2.48431      [.013]
 VOLATILITY(-1)  .481459E-02   .265777E-02   1.81151       [.071]
 R(-1)           -.280464E-03  .154680E-02   -.181319      [.856]
 C               .787997E-02   .020101       .392012       [.695]
 T               .691412E-04   .587285E-04   1.17730       [.240]
 VOLNONCOMM(-1)  .308076       .080835       3.81116       [.000]
 VOLCOMM(-1)     .334478       .092189       3.62816       [.000]
 VOLNONREPT(-1)  -1.08969      .205055       -5.31415      [.000]
 VOLATILITY(-1)  .306469E-02   .224035E-02   1.36796       [.172]
 R(-1)           -.134964E-02  .130386E-02   -1.03511      [.301]
 C               .057547       .016944       3.39627       [.001]
```

```
 T               -.166329E-04  .495046E-04   -.335986      [.737]
 VOLNONCOMM(-1)  .036876       .024186       1.52468       [.128]
 VOLCOMM(-1)     .138565       .027584       5.02341       [.000]
 VOLNONREPT(-1)  -.253971      .061354       -4.13946      [.000]
 VOLATILITY(-1)  .641414E-03   .670328E-03   .956866       [.339]
 R(-1)           -.695342E-04  .390123E-03   -.178236      [.859]
 C               .036885       .506984E-02   7.27546       [.000]
 T               -.707385E-04  .148121E-04   -4.77571      [.000]
 VOLNONCOMM(-1)  -.447174      1.68764       -.264971      [.791]
 VOLCOMM(-1)     -.068751      1.92469       -.035721      [.972]
 VOLNONREPT(-1)  .024726       4.28103       .577582E-02   [.995]
 VOLATILITY(-1)  .332642       .046773       7.11186       [.000]
 R(-1)           .014244       .027221       .523267       [.601]
 C               3.06896       .353754       8.67541       [.000]
 T               .206964E-02   .103353E-02   2.00249       [.046]
 VOLNONCOMM(-1)  -2.41174      3.05374       -.789768      [.430]
 VOLCOMM(-1)     2.72395       3.48268       .782142       [.435]
 VOLNONREPT(-1)  -4.40493      7.74643       -.568641      [.570]
 VOLATILITY(-1)  -.060408      .084634       -.713747      [.476]
 R(-1)           .160510       .049256       3.25868       [.001]
 C               .404145       .640109       .631370       [.528]
 T               .188900E-03   .187016E-02   .101007       [.920]

 Dependent variable: VOLNONCOMM
        Mean of dep. var. = .066221           R-squared = .123125
   Std. dev. of dep. var. = .147656  Adjusted R-squared = .110508
 Sum of squared residuals = 8.08692        LM het. test = 9.91714 [.002]
    Variance of residuals = .019393       Durbin-Watson = 2.08844
 Std. error of regression = .139259     F (block exog.) = 3.91600 [.004]

Dependent variable: VOLCOMM
        Mean of dep. var. = .084875           R-squared = .247275
   Std. dev. of dep. var. = .134338  Adjusted R-squared = .236444
 Sum of squared residuals = 5.74615        LM het. test = 85.9252 [.000]
    Variance of residuals = .013780       Durbin-Watson = 1.97426
 Std. error of regression = .117387     F (block exog.) = 9.93257 [.000]

Dependent variable: VOLNONREPT
        Mean of dep. var. = .030847               R-squared = .216227
   Std. dev. of dep. var. = .039391      Adjusted R-squared = .204949
 Sum of squared residuals = .514424            LM het. test = 187.759 [.000]
    Variance of residuals = .123363E-02       Durbin-Watson = 2.05811
 Std. error of regression = .035123         F (block exog.) = 23.6496 [.000]


Dependent variable: VOLATILITY
        Mean of dep. var. = 5.23636           R-squared = .133685
   Std. dev. of dep. var. = 2.61433  Adjusted R-squared = .121220
 Sum of squared residuals = 2504.58        LM het. test = 9.31365 [.002]
    Variance of residuals = 6.00619       Durbin-Watson = 2.13265
 Std. error of regression = 2.45075     F (block exog.) = .175015 [.951]

Dependent variable: R
        Mean of dep. var. = .074526           R-squared = .030055
   Std. dev. of dep. var. = 4.47071  Adjusted R-squared = .016099
 Sum of squared residuals = 8200.52        LM het. test = .107969E-03 [.992]
    Variance of residuals = 19.6655       Durbin-Watson = 1.97676
 Std. error of regression = 4.43458     F (block exog.) = .429517 [.787]
```