# UNBIAEDNESS AND COINTEGRATION TESTING: THE CASE OF AFET

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## ABSTRACT

*This paper studies the efficiency in the Agricultural Futures Exchange of Thailand or AFET by means of the unbiased expectation hypothesis of futures. With non-stationarity problem in financial time series leading to unreliable results, this paper applies Cointegration methodology to solve the problem and employs the unbiased expectation hypothesis as the model for the empirical test. Though futures and spot prices are cointegrated, the rejection of the parameters restriction test is found. The final result shows that the futures of Ribbed Smoked Sheet no.3 (RSS3) is the only unbiased predictor, while White Rice 5% (BWR5) and Tapioca Chip (TC) are not.*

## INTRODUCTION

Market Efficiency was first defined by Fama as when the prices of assets fully reflect all available information about the assets themselves, while investors employ this relevant information to form buying or selling decision without a chance of gaining abnormal profit, restated by Jones (2002).

If there is efficiency, futures should be an unbiased predictor. When unbiasednesss exists, the economy, the market and relevant people would obtain benefits. He and Holt (2004) propose that efficient market lessens welfare losses for producers and consumers. This is because when the market is efficient, abnormal profit which leads to speculative opportunity disappears. Thus, when there is no speculation, production or consumption fluctuation caused by speculation should be lesser. Each trader is able to use the right hedging instrument to lock in the price risk.

More specifically, Moholwa and Phukubje (2006) have stated that if efficiency exists in the agricultural futures market, futures will be the most reliable forecaster of the future spot price. For the agents in food chain, the information contained in the futures price provides very important implications for resource allocation.

Wang (2003) confirms that efficient agricultural futures markets are important to governments and producers. Governments can benefit from the efficient market by not having to impose any intervention on the market or introducing policies to stabilize the prices since these have been performed by the efficient futures market. Producers or marketers use futures as an unbiased predictor giving better opportunity to manage risk. The efficiency also eliminates the abnormal profit that can be surely guaranteed, so prices reflect the real equilibrium of supply and demand in that market.

As the existence of the market efficiency is beneficial for the economy, this research seeks to answer: The question Are the futures in AFET or The Agricultural Futures Exchange of Thailand unbiased?

### The Agricultural Futures Exchange of Thailand (AFET)

AFET is an independent juristic person established in 1999 under the provisions of the Act to run the exclusive agricultural futures exchange in Thailand regulated by the Agricultural Futures Trading Commission. The Exchange is aimed to be the marketplace of trading agricultural futures with established rules and regulations offering fairness to all buyers and sellers. AFET is the first, and only, agricultural futures market operating at the present time.

There were six products which were temporarily suspended and later de-listed from the market. Delisting is executed because some are burdened with "unpopularity of the contracts" and some for "contract specification modification". Both reasons are the direct cause of illiquidity. Since the first trading day of AFET, nine products have been listed in this futures market. The details are shown in table 1.

## MARKET EFFICIENCY TESTING AND COINTEGRATION

Numerous papers are found relevant to the efficiency testing in various futures markets. However, there are conflicts among those studies. Adkins & Krehbiel (1994), Antoniou & Holmes (1996), Asche & Guttormsen (2002), Corbae, Lim, & Ouliaris (1992) and Holt & McKenzie (2002) argue for the unbiased prediction of the futures, while Chow (2001), Chowdhury (1991), Ennew, Kellard, Newbold & Rayner (1999), Kenourgios & Samitas (2004) and Raizada & Sahi (2006) propose contradictory arguments.

However, the importance of each paper is the way out of the non-stationarity labyrinth. Non-stationary time series had been resisted in the econometric world for decades because it created difficulty in terms of the market efficiency test by generating two most-found-illusions in the results:

- "Spurious Regression" that causes unrealistic and unreliable statistical value. For example; R2 value between two variables that have no theoretical or explanatory supports, Holt and McKenzie (2002).
- The parameters restriction for those constant and beta in non-stationary data, such as "C = 0 and $\beta = 1$", is no longer appropriate because the standard F-test or t-test fall into bias. Because of no strong inference, the rejection or acceptance of the market efficiency hypothesis seems to be incorrect, Lai and Lai (1991).

Engle and Granger (1987) provided an effective solution by introducing their cointegration approach. Cointegration gives reliable result, understandable application, and the non-stationarity problem has been solved.

The simplest methodology to test for cointegration is the Engle-Granger Methodology. There are two stages to be completed. Firstly, the time series needs to be checked for the same order of I(d); if I(0) or level is stationary, there is no use for cointegration. Secondly, the residual series is tested for the stationarity. If it is found that I(0) is stationary, the existence of cointegrating relationship is confirmed.

Although, the Engle-Granger Method provides an easy implementation, Enders (2004) has reviewed and stated its shortcomings:

- Because of the two stages, the users' implementing error in stage one could be carried into the later stage.

**Table 1: Summary of Futures Products in AFET**

| Underlying Products | Listed Name | Date of Listing | Status |
|---|---|---|---|
| 1 Ribbed Smoked Sheet no.3 | RSS3 | May 28, 2004 | Listed |
| 2 White Rice 5% Brokens | WR5 | August 26, 2004 | De-Listed |
| 3 Tapioca Starch Premium Grade | TS | March 25, 2005 | De-Listed |
| 4 White Rice 5% Brokens-Mini | WR5-M | August 8, 2005 | De-Listed |
| 5 Tapioca Chip | TC | August 18, 2006 | Listed |
| 6 Concentrated Latex | LATEX | March 31, 2006 | De-Listed |
| 7 Standard Thai Rubber 20 | STR20 | March 31, 2006 | De-Listed |
| 8 White Rice 5% | WR5P | December 1, 2006 | De-Listed |
| 9 White Rice 5% (Re-Specification of WR5P) | BWR5 | April 2, 2007 | Listed |

- It is quite acceptable if the two series concern small sample size, but when the sample size is larger, the cointegration model as "regressing X on Y, giving ($\varepsilon_1$)" and "regressing Y on X, giving ($\varepsilon_2$)" could provide conflicting outcomes.
- In the case where there are more than two series, there will be more problems in choosing the dependent variable. Even more, the method has no systematic process to observe more than one cointegrating vector.

For these reasons, some researches do not apply the Engle-Granger Cointegration. To overcome the three stated problems, VAR Cointegration is employed.

**VAR Cointegration**

Beginning with the simplest bivariate VAR(1) as below:

$$X_t = AX_{t-1} + \varepsilon_t \qquad (1)$$

Where:

$X_t$ = (n*1) vector: $\begin{pmatrix} X_{1t} \\ X_{2t} \end{pmatrix}$

A = (n*n) representing the parameters matrix: $\begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}$

εt = (n*1) vector: $\begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix}$

To test cointegration through VAR, it is analogous to the generalization of the Dickey-Fuller test process (Enders, 2004).

Hence, (1) is subtracted by $X_{t-1}$ from both sides.

$$\Delta X_t = -(I - A)X_{t-1} + \varepsilon_t \qquad (2)$$
$$= (A - I)X_{t-1} + \varepsilon_t$$
$$= \Pi X_{t-1} + \varepsilon_t \ (3)$$

Where: Π in (3) is (A-I)

The two variables are cointegrated when the eigenvalues are 1:

$$\Pi = A - I = \begin{pmatrix} a_{11} - 1 & a_{12} \\ a_{21} & a_{22} - 1 \end{pmatrix}$$

$$|\Pi| = (1 - a_{11})(1 - a_{22}) - a_{12}\, a_{21}$$

The importance of considering the cointegration is the rank of the Π matrix:

*Case A*: If the rank of the Π matrix is equal to zero, each member in Π is zero accordingly (the null matrix). Thus, this will be the case when $X_{1t}$ and $X_{2t}$ are I(1) and not cointegrated.

*Case B*: If Π has the full rank ($|\Pi| \neq 0$), this illustrates "stationary at level" or I(0). So, the cointegration is not necessary.

*Case C*: If Π has the rank equal to $0 < m < n$, $n = 2$, $m = 1$. The rank is 1 ($|\Pi| = 0$) for this case. $X_{1t}$ and $X_{2t}$ are cointegrated and have one long run relationship.

**The Unbiased Expectation Hypothesis**

The joint test of the unbiasedness can be investigated in the Unbiased Expectation hypothesis. Re-stated from He & Holt (2004) and Holt & McKenzie (2002) the expected spot price on maturity date and the rational expectation of the spot price are formed.

$$E_t(ST) = F_{t,T}$$

Where:

$S_T$ is the spot price of a product at time "T".

$E_t$ is the expectation at time "t"

$F_{t,T}$ is the futures price of an underlying product at time "t" matured at time "T"

As stated, the rational price expectation is also assumed. Thus, it becomes:

$$S_T = E_t(S_T \,|\Omega_t) + \mathbf{u}_T$$

Where:

$\Omega_t$ is the information set available in period "t"

$\mathbf{u}_T$ is a rational expectations error and orthogonal to all elements in $\Omega_t$

This model is re-defined for empirical purpose by replacing the realized spot prices based on expectation with the futures price at time "t - n". This is an imposition of the rational expectation to the empirical model because the expectation cannot be measured:

$$S_T = \beta_0 + \beta_1 F_{t,T} + \mathbf{u}_T \quad (2.6)$$

Where:

$S_T$ and $F_{t,T}$ are the same specification as in (2.4)

$\mathbf{u}_T$ is the same specification as in (2.5)

In the unbiasedness and the efficiency condition under the unbiased expectation hypothesis, the uT opponent needs to be stationary. If not, the futures and the spot prices are going to show deviation from each other without bound. This indicates "biasedness of prediction" and "market inefficiency" since the futures price has only little or no power of predictability.

Empirically, not only must the condition of ut be stationary, to succeed the joint hypothesis, the restriction of $\beta_0 = 0$ and $\beta_1 = 1$ must be true also. However in reality, the risk premium at time t may occur because of the condition of non-zero risk premium; $\beta_0 < 0$: Normal Backwardation, and $\beta_0 > 0$: Contango, resulting in $\beta_0 \geq 0$. So, if only $\beta_1 = 1$ is not rejected, the futures is not an effective spot predictor but the market is still efficient with the presence of the risk premium.

**DATA**

However, there is flexibility for data pairing in this study. For more elaboration, the data matching example from Adkins and Krehbiel (1993) who have done the unbiasedness testing and demonstrated the data matching, can support why the flexibility of this data matching method should be accepted.

Adkins and Krehbiel (1993) tested the copper futures in the Commodity Exchange Inc. (COMEX). The futures data is from the period January 1960 - May 1992 (32 years). They matched the four-month-futures and the spot price by pairing the price of the May futures contract observed on the first trading day in January with the spot price of the metal observed on the first trading day of May.

The longest contract in AFET is RSS3 (Ribbed Smoked Sheet no.3) which started trading on May 28, 2004. That means there are about only four years to collect the data. So, if the daily data is transformed to any longer specific interval similar to Adkins and Krehbiel (1993), the problem of the observation size would occur. Matching the data with daily interval could lessen the problem of the observation size and the nearest month to maturity of the futures price will be paired with the spot price. This is to avoid the serial corre-

**Table 2: Data Information**

| Product | Period | Source: Futures | Source: Spot |
|---|---|---|---|
| Ribbed Smoked Sheet no.3 | May 28, 2004 - June 30, 2008 | AFET's Office Website http:// www.afet.or.th | CEIC database provided by Assumption University Library |
| White Rice 5% | April 2, 2007 - June 30, 2008 | | Office of Agricultural Economics |
| Tapioca Chip | August 18, 2006 - May 30, 2008 | | (http://www.oae.go.th) |

**Table 3: Data Pairing**

| | Futures Prices | | Spot Prices | |
|---|---|---|---|---|
| BWR5 07/08 | 16/7/2007 | 10.70 | 1/8/2007 | 1037.50 |
| BWR5 07/08 | 17/7/2007 | 10.70 | 2/8/2007 | 1037.50 |
| BWR5 07/08 | 18/7/2007 | 10.70 | 3/8/2007 | 1037.50 |
| BWR5 07/08 | 19/7/2007 | 10.70 | 6/8/2007 | 1027.50 |
| BWR5 07/08 | 20/7/2007 | 10.70 | 7/8/2007 | 1027.50 |

lation problem.

Since the delivery date is not a requisite for the specific day as the forward agreement, this result indicates only for "prediction" which covers a two weeks horizon. The data pairing for this research is shown in the following example (Table 3):

## DATA ANALYSIS

### Stationarity Test

Firstly, the stationarity of the data need to be confirmed. If the data are all non-stationary, the cointegration method needs to be employed. The stationarity testing process is carried out by the Augmented Dickey Fuller test (ADF). The futures and the spot prices for the three products are transformed to logarithm form and tested. The number without the parenthesis is the test statistic to be compared with MacKinnon one-sided p-values following by the optimal lag(s) chosen by Schwarz Information Criterion (SIC) written on the same line. The value in the parenthesis on the second line is the probability. The results in table 4 show that all the spot and futures prices series are stationary at the first difference level as the null hypotheses have been rejected. The non-stationarity requires that cointegration be the method.

### VAR Cointegration

VAR cointegration test will be processed from the most suitable number of lag(s) and data trend chosen by the lowest SIC value. From $S_t = \beta_0 + \beta_1 F_{t-n} + \mathbf{u}_T$, the first condition of Market Efficiency is that the spot and the futures prices need to be cointegrated. Secondly, the null hypothesis of $\alpha = 0$ and $\beta = 1$ must not be rejected.

In table 5, the lowest SIC value indicates the proper data trend for each cointegration test. Ribbed Smoked Sheet no.3 and White Rice 5% are chosen as "No Intercept and No Trend", while Tapioca Chip are chosen as "Intercept and No Trend".

The cointegration test is presented in table 6. For all the products, it is proved that the futures and spot prices are cointegrated. As per the hypothesis testing, the null hypothesis of zero rank is rejected, but "the rank is equal to 1" is

**Table 4: Stationarity Test of the three Spot and the Futures Prices by ADF**

| Product | Level | | First Difference | |
|---|---|---|---|---|
| | Spot | Futures | Spot | Futures |
| **Ribbed Smoked Sheet no.3 (RSS3)** | 1.1695 [2] | 1.37295 [1] | -14.7094 [1] | -27.4646 [0] |
| | *(0.9381)* | *(0.9578)* | *(0.0000)* | *(0.0000)* |
| **Tapioca Chip (TC)** | -2.6277 [0] | -3.3146 [0] | -20.0595 [0] | -22.4587 [0] |
| | *(0.2681)* | *(0.0651)* | *(0.0000)* | *(0.0000)* |
| **White Rice 5% (BWR5)** | 1.2237 [1] | 1.2950 [1] | -10.9363 [0] | -12.4154 [0] |
| | *(0.9436)* | *(0.9507)* | *(0.0000)* | *(0.0000)* |

accepted by Trace and Maximum Eigenvalue Statistics for all the three products.

### Parameters Restriction

The final proof of the unbiasedness testing is shown in table 7. The futures of Ribbed Smoked Sheet no.3 is the unbiased predictor because the null hypothesis $\beta_1 = 1$ is not rejected. Intercept as zero or no risk premium is also valid since there is no intercept found in the cointegrating model. In contrast, Tapioca Chip futures is not unbiased as the null hypothesis of $\beta_1 = 1$ and $\beta_0 = 0$ are simultaneously rejected by the significant t-Stat at 0.01 critical level. White Rice 5% is not different to its previous peer. As its cointegrating model provides no intercept but only the coefficient, there is only one hypothesis to be proved. Nevertheless, the null hy-

**Table 5: Schwarz Information Criteria by Rank and Model of "$S_T = \beta_0 + \beta_1 F_{t,T} + uT$"**

| Data Trend: Rank or No. of CEs | None No Intercept No Trend | None Intercept No Trend | Linear Intercept No Trend | Linear Intercept Trend | Quadratic Intercept Trend |
|---|---|---|---|---|---|
| **Ribbed Smoked Sheet no.3 [3 lags] Schwarz Criteria by Rank (rows) and Model (columns)** | | | | | |
| 0 | -12.22463 | -12.22463 | -12.21461 | -12.21461 | -12.20038 |
| 1 | -12.30029 | **-12.29323** | -12.28753 | -12.28033 | -12.27321 |
| 2 | -12.27282 | -12.26029 | -12.26029 | -12.24987 | -12.24987 |
| **Tapioca Chip [1 lags] Schwarz Criteria by Rank (rows) and Model (columns)** | | | | | |
| 0 | -12.08835 | -12.08835 | -12.06906 | -12.06906 | -12.04070 |
| 1 | -12.05522 | -12.05609 | **-12.05079** | -12.04302 | -12.02915 |
| 2 | -12.00630 | -11.99287 | -11.99287 | -11.99087 | -11.99087 |
| **White Rice 5% [6 lags] Schwarz Criteria by Rank (rows) and Model (columns)** | | | | | |
| 0 | -9.759325 | -9.759325 | -9.722752 | -9.722752 | -9.679344 |
| 1 | -9.990868 | **-9.973261** | -9.952080 | -9.938932 | -9.916773 |
| 2 | -9.900728 | -9.869956 | -9.869956 | -9.850175 | -9.850175 |

**Table 6: Cointegration Test of "$S_t = \beta_0 + \beta_1 F_{t-n} + u_t$"**

| Product | Hypothesis | Cointegration Test | | | |
|---|---|---|---|---|---|
| | Ho: | Trace Statistic | Prob. | Max-Eigen Statistic | Prob. |
| Ribbed Smoked Sheet no.3 | $r \leq 0$ | 100.8038*** | 0.0001 | 99.54085*** | 0.0001 |
| | $r \leq 1$ | 1.262973 | 0.3048 | 1.262973 | 0.3048 |
| Tapioca Chip | $r \leq 0$ | 20.65717** | 0.0441 | 16.75384** | 0.0366 |
| | $r \leq 1$ | 3.903333 | 0.4267 | 3.903333 | 0.4267 |
| White Rice 5% | $r \leq 0$ | 78.13108*** | 0.0001 | 77.98933*** | 0.0001 |
| | $r \leq 1$ | 0.141744 | 0.7560 | 0.141744 | 0.7560 |

*** and ** denote the significance at 1% and 5% level respectively

**Table 7: Parameters Restriction Test of "$S_T = \beta_0 + \beta_1 F_{t,T} + u_T$"**

| Product | Cointegrating Model | Null Hypothesis | t-Stat Value |
|---|---|---|---|
| Ribbed Smoked Sheet no.3 (RSS3) | $S_T = 1.003\ F_{t,T} + u_T$ | Ho: $\beta_0 = 0$ | No Intercept |
| | (0.00184) | Ho: $\beta_1 = 1$ | 1.399 |
| Tapioca Chip (TC) | $S_T = -0.37 + 1.207\ F_{t,T} + u_T$ | Ho: $\beta_0 = 0$ | -2.873*** |
| | (0.129) (0.086) | Ho: $\beta_1 = 1$ | 2.407*** |
| White Rice 5% (BWR5) | $ST = -0.988F_{t,T} + u_T$ | Ho: $\beta_0 = 0$ | No Intercept |
| | (0.01188) | Ho: $\beta_1 = 1$ | 2.794*** |

*** denotes the significance at 1%

pothesis $\beta_1 = 1$ is rejected at 0.01 critical level. This rejection shows that White Rice 5% futures is the biased predictor.

## CONCLUSION

Market Efficiency of futures market is very beneficial to the economy as it can lessen welfare losses, be an unbiased predictor of the spot price, and help governments to stabilize the spot market. Numerous researchers have tried to investigate the efficiency of their country's futures market. AFET or The Agricultural Futures Exchange of Thailand which has been recently established is studied in this research.

Using the unbiased expectation hypothesis as a framework to represent "unbiased prediction" in the market, the hypothesis will be true as long as the null hypothesis of "$\alpha = 0$ and $\beta = 1$" from the model $S_t = \beta_0 + \beta_1 F_{t-n} + u_t$ are valid. The data are the three products which are still trading in AFET; Ribbed Smoked Sheet no.3 (RSS3), Tapioca Chip (TC), and White Rice 5% (BWR5).

However, Non-Stationarity of the data has proved difficult for testing because it can lead to unreliable results. This paper employs Cointegration to solve the problem and has found that all three products' futures and spot prices are cointegrated. Though the first condition of being efficient is passed as they are all cointegrated, Ribbed Smoked Sheet no.3 (RSS3) is the unbiased predictor, while Tapioca Chip (TC), and White Rice 5% (BWR5) are not because each of them has the null hypothesis rejected.

One point to be noted is that the futures would be the unbiased predictor when the trading volume is large or more liquid. RSS3 is the one which is the unbiased predictor, the table below shows that RSS3 is also the one which receive highest volume compared to its peers. This finding is in agreement with Fink and Feduniak (1988) who suggest that higher liquidity creates more stability in futures market, and Garcia and Mattos (2004) who found similar results in the Brazilian Futures Market. More futures volume does provide a better equilibrium between the futures and the spot price.

**Table 8: AFET's Products Volume**

| Month | Contract Volume | | |
|---|---|---|---|
| | RSS3 | BWR5 | TC |
| Oct-07 | 5,917 | 4,041 | 400 |
| Nov-07 | 8,856 | 4,344 | 60 |
| Dec-07 | 4,691 | 2,381 | 16 |
| Jan-08 | 6,340 | 2,082 | 110 |
| Feb-08 | 6,808 | 1,880 | 140 |
| Mar-08 | 6,286 | 2,074 | 128 |
| Apr-08 | 5,297 | 6,658 | - |
| May-08 | 7,054 | 8,529 | - |
| Jun-08 | 9,990 | 7,036 | - |
| Jul-08 | 8,943 | 3,678 | - |
| Aug-08 | 12,311 | 1,381 | - |
| Sep-08 | 13,119 | 1,428 | - |
| Oct-08 | 12,103 | 562 | - |
| **Total** | **107,715** | **46,074** | **854** |

The reason behind those biased predictors emerge from "Agricultural Price Guaranteed by the Government". The government intervention still has

a large impact on the economy, hedgers see no necessity to enter AFET for using the futures to serve their hedging purpose. On the other hand, speculators are also affected; they are not willing to take risks in the futures market because they are most likely to get lower returns from being risk bearers since the price would go within the boundary that is created by the price guaranteed. It can be concluded that one important burden for the efficiency between AFET futures and the Thai spot market is government intervention.

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