TESTING EFFICIENCY OF THE COPPER FUTURES MARKET: NEW EVIDENCE FROM LONDON METAL EXCHANGE[a]

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ABSTRACT

This paper investigates the joint hypothesis of market efficiency and unbiasedness of futures prices for the copper futures contract traded on the London Metal Exchange. This contract is of particular importance given the usage and properties of the underlying commodity and its highest share of trading during the last decade, in an exchange which is the centre of the world's trading in copper. The data contain prices from two different copper futures contracts (three and fifteen months maturity) covering the decade of 1990s, a very volatile and turbulent period for the copper market worldwide. Unlike previous studies, it tests for both long-run and short-run efficiency using cointegration and error correction model. Our results show that the market is not efficient and do not provide unbiased estimates of future copper spot prices, which has important implications for the users of this market.

JEL classification: G14; C12; C32

Key words: Copper Futures Market; Market Efficiency; Unbiasedness Hypothesis; London Metal Exchange

I. INTRODUCTION

In this paper we investigate the long-run and short-run efficiency of the copper futures contract traded on the London Metal Exchange (LME). This contract is of particular interest given that the underlying commodity is the world's third most widely used metal, the considerable commercial importance due to its electrical and mechanical properties and the volatile market conditions during 1990s. Furthermore, it had the highest share of trading during the last decade, in an exchange, which is the centre of the world's trading in base metals.

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The 1990s was a very volatile and turbulent period for the world spot and futures copper market and especially in the LME. At the beginning of 1989 the copper spot price in the LME was a little bit above \$3,500 per tonne, while the futures price was \$3,150 per tonne for the three months futures contract and \$2,170 per tonne for the fifteen months futures contract. By 13/2/1990 these prices had fallen to \$2,388, \$2,320.9 and \$2,100 per tonne respectively. After a new spot price fall to \$2,100, it reached close to \$3,400 by September 1990. Since that month the price of copper fell gradually for over two years reaching the lowest point in May 1993 (\$1,730 per tonne). But the situation will change sharply in the years to come. The continuous rising of the demand for copper by the aerospace, electrical and automotive industry, and above anything else the demand from the rapidly growing industry of information systems over the last decade, combined with the investing spring in China and the stable supply of copper, drove its spot price to high levels (\$3,235 in July 1995).

However, in the beginning of June 1996, Sumitomo Corporation of Japan- the leading trader in the copper market- reported a loss of \$1.8 billion on copper trading due to the activities of one of its traders. The market was shocked and the copper spot price reached \$1,830 by the end of June 1996. The market recovered relatively quickly and the copper spot price reached to \$2,720 per tonne by the end of June 1997. However, this rise did not last long. The crisis in the economies of the Far East combined with the rise in the supply of copper and the development of new less costly mining methods drove the price of copper to the level of \$1,415 on 23rd February 1998. The lowest copper spot price for the last decade occurred at 2/3/1999 (\$1,355 per tonne), while reached to \$1,773 per tonne by the end of April 2000.

During the recent years, over 95% of all copper traded in the world terminal market of non-ferrous metals is traded on the LME. The LME is not a cash cleared market. Its clearing system operates between principals based on bank guarantees and other forms of collateral. Both floor and inter-office trading are covered by a matching system run by the London Clearing House (LCH). LCH acts as a counterpart to trades executed between Clearing Members and thereby reduces risk and settlement costs.

If futures markets are to fulfill their price discovery function, in that they provide forecasts of future spot prices, it is necessary that the markets be efficient. Fama (1970, 1991) contends that market efficiency is not testable and that it must be tested jointly with some models of pricing assets. According to the futures markets literature, the model that futures prices are unbiased estimators of future spot prices is the appropriate framework to test efficiency. Using this model, efficiency will necessarily imply that the market price fully reflects available information and so there exists no strategy that traders can speculate in the futures market on the future levels of the spot price exploiting profits consistently. However, if the joint hypothesis is rejected, it is not possible to argue whether the market is inefficient or the asset-pricing model used is inappropriate.

This paper is significant for the following reasons: a) It investigates the efficiency of copper futures contract traded on the LME for the decade of 1990s, a very volatile and turbulent period for the copper market worldwide, which has not been covered by earlier relevant studies; b) Unlike previous studies, this paper tests for both long-run and short-run efficiency; and c) It provides new evidence for the efficiency of London copper futures market, examining its consistency with the main earlier studies on LME during 1970s and 1980s.

In this paper we argue that while markets could be seen as efficient in the long run, there may be substantial deviations from the equilibrium relationship in the short- run. The long-run efficiency of the copper futures market is tested using both Engle-Granger cointegration tests and the Johansen Maximum Likelihood Procedure and short-run efficiency is examined by constructing and investigating an error correction model.

The rest of this paper is organized as follows: Section II discusses market efficiency as it relates to futures trading, while Section III presents a brief literature review, outlining the empirical results of the most significant studies on LME copper futures market. Section IV sets out the methodological issues of our study, involving the cointegration approach and the testing procedure for futures market efficiency. The data used and the empirical results obtained are presented in Section V. Section VI presents the interpretation and implications of the results, while Section VII provides a summary and the conclusions.

II. FUTURES MARKET EFFICIENCY: THEORY AND TESTING

As pointed out by Fama (1970), a financial market can be considered as efficient if prices fully reflect all available information and no profit opportunities are left unexploited. The agents form their expectations rationally and rapidly arbitrage away any deviations of the expected returns consistent with supernormal profits.

Under conditions of risk neutrality, market efficiency implies that

$$S_t = F_{t-n,t} + e_t \qquad (1)$$

This equation states that the futures price, $F_{t-n,t}$ for delivery at time t, is an unbiased predictor of the future spot price, S_t, at contract expiration, given the information set available at time t-n. Therefore, it is the algebraically representation of the Unbiasedness Hypothesis or Simple Efficiency (Hansen and Hodrick, 1980) or Speculative Efficiency (Bilson, 1981). Under this hypothesis, deviations between $F_{t-n,t}$ and S_t should have a mean zero and will be serially uncorrelated. This equation provides a pricing model specification and enables the efficiency of futures markets to be examined.

Fama (1991) supports that market efficiency involves testing a joint hypothesis of efficiency and the asset pricing model. Empirical analysis of Equation (1) allows the examination of the joint hypothesis of market efficiency and unbiasedness in futures prices. Equation (1) can also be written by regressing the spot price at maturity on the futures price some time prior to maturity:

$$S_t = \alpha + bF_{t-n,t} + e_t \qquad (2)$$

Market efficiency requires that α=0 and b=1. It is also normal to assume that futures prices closer to the expiration dates will provide better estimates of the future spot price than do those further away. Rejection of the restrictions imposed to the parameters α and b means that either the market is inefficient or a non-zero risk premium (α≠0) existed in futures markets.

III. LITERATURE REVIEW

A significant number of studies have examined the efficiency of copper futures markets during the last three decades, using different methodological techniques. Goss (1981) examines the hypothesis that futures prices are unbiased predictors of the subsequent spot prices for the markets of copper, tin, lead and zinc, using daily price data from the LME for the period 1971-1978. He rejects the unbiasedness of futures prices for lead and tin, while he reports contrary results for the cases of copper and zinc futures contracts. He revised his paper in 1985 by introducing joint tests for the same metals of the LME extending the sample period to 1966-1984. His results show that the Efficient Market Hypothesis (EMH) is not rejected for lead and tin, while is rejected for copper and zinc.

Canarella and Pollard (1986) test the hypothesis that the futures price is an unbiased predictor of the future spot price using both overlapping and non-overlapping data for the contracts of copper, lead, tin and zinc covering the period 1975-1983. Using three different estimation methods, they confirm the unbiasedness hypothesis. Fama and French (1987) examine whether the futures prices for copper and other metals contain evidence of forecast power or systematic risk premiums for the period 1967-1984. They show that the copper futures price contains suggestive evidence of both systematic risk premiums and forecasting power. Gross (1988) examines unvaried LME prices starting with the first trading day in 1983 till the last one in September 1984 in order to test the EMH. Based on the mean square error criterion, he provides evidence that the EMH is not rejected for the copper futures market. Sephton and Cochrane (1990, 1991) examine the unbiasedness hypothesis in the LME with respect to six metals for the period 1976-1985. They conclude that the unbiasedness hypothesis is rejected and the LME is not an efficient market.

Each of the above studies employs a traditional hypothesis testing procedure, but the issue of the non-stationary behavior of various spot and futures price series raised concern regarding the use of conventional statistical procedures. Among the first studies that suggested the use of Engle-Granger cointegration test is that of Shen and Wang (1990) coming as a response to the remarks of Elam and Dixon (1988). Some of the studies provide evidence of accepting the EMH, supporting that the futures prices are unbiased predictors of the future spot prices for the case of copper futures contact. For example, MacDonald and Taylor (1988a) test the EMH for four metals in the LME covering the period 1976-1987. Their basic conclusion is that the copper and lead futures markets can be considered as efficient, whilst the EMH is rejected for tin and zinc. MacDonald and Taylor (1988b) support the EMH for the same metals in the LME for the period 1976-1985. Moore and Callen (1995) examine the Speculative Efficiency of the LME for six base metals between 1985 and 1989. They show that the long-run speculative efficiency cannot be rejected for the copper and other three metals. On the other hand, the same hypothesis is rejected for the copper futures contract traded on the LME according to Chowdhury (1991) and Beck (1994).

IV. METHODOLOGICAL ISSUES: COINTEGRATION AND FUTURES MARKET EFFICIENCY

Standard statistical techniques of parameter restrictions as those presented in relation to equation (2) are not reliable in circumstances where data are non-stationary. However, cointegration provides a satisfactory means to investigate (2), in the presence of non-stationary series.

When two price series, such as the future and the spot price series, are both integrated of the same order d, a linear combination of two I(d) series can be integrated of an order lower than d. More specifically, it is possible that two series that are non-stationary and contain a unit root, for example I(1), can generate a linear combination that is stationary, I(0). These two series are said to be cointegrated with a cointegrating relationship of the following form:

$$S_t - \alpha - bF_{t-n} = e_t \qquad (3)$$

Cointegration of two price series is a necessary condition for market efficiency, since the Efficient Market Hypothesis implies that the future price is an unbiased predictor of the future spot price. If the two series are cointegrated, S_t and F_{t-n} move together and will not tend to drift apart over time. If this is the case, then the futures price is an unbiased predictor of the future spot price.

In order to test for cointegration between the two markets, both the ADF test on the cointegrating regression residuals as described by Engle and Granger (1987) and the Johansen Maximum Likelihood Procedure (Johansen, 1988) are implemented. The latter is a preferred method of testing for cointegration as it provides a unified framework of estimating and testing the cointegration relationships in a VAR error correction mechanism, which incorporate different short-run and long-run dynamic relationships in a system of variables.

The Johansen cointegration procedure firstly specifies the following unrestricted N-variable VAR:

$$x_t = \mu + \sum_{i=1}^{k} \Pi_i x_{t-i} + \varepsilon_t \qquad (4)$$

where $x_t^{'} = [f_t^{'} , s_t^{'}]$, μ is a vector of intercepts terms and ε_t is a vector of error terms. Johansen (1988) and Johansen and Juselius (1990) re-parameterized equation (4) in the form:

$$\Delta x_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \varepsilon_t \qquad (5)$$

Equation (5) is now a VAR re-parameterized in error correction form, where $\Pi = -(\Pi - \Pi_1 - \ldots - \Pi_k)$ represents the long response matrix. Writing this matrix as $\Pi = \alpha\beta^{'}$, then the linear combinations $\beta^{'} x_{t-k}$ will be I(0) in the existing of cointegration, with α being the adjustment coefficients, and the matrix Π will be of reduced rank. The Johansen approach can be used to test for cointegration by assessing the rank (r) of the matrix Π. If r = 0 then all the variables are I(1) and there are no cointegrating vectors. If $0<r<N$ there will be r cointegrating vectors. Last, if r = N then all of the variables are I(0) and, given that any linear combinations of stationary variables will also be stationary, there are N cointegrating vectors.

However, Hakkio and Rush (1989) demonstrate that, while cointegration is a necessary condition for market efficiency, is not a sufficient one for two reasons. First, it is necessary to consider the values of the parameters α and b in the equation (2). For the futures price to be an unbiased predictor of the future spot price it is required that α=0 (for zero expected profits) and b=1 (the only value that implies stationary excess return)[1] Furthermore, along with the restricted-cointegration test, a test for serial correlation of $S_t - F_{t-n}$ is needed to infer about the efficient market hypothesis (Liu and Maddala, 1992). The acceptance of the above restrictions imposed to α and b (both jointly and individually) and the serial independence of e_t is a second necessary condition for market efficiency.

If both necessary conditions were met, according to Hakkio and Rush (1989), the short- run efficiency of the futures market (third condition) has to be tested, since in the short- run it is possible that there will be considerable departures from the long-run equilibrium relationship (implied by the first two conditions). This can be tested by using an error-correction model (ECM) in the following form:

$$\Delta S_t = \alpha - \rho U_{t-1} + b\Delta F_{t-1} + \sum_{i=1}^{m} \beta_i \Delta S_{t-i} + \sum_{i=1}^{n} \gamma_i \Delta F_{t-1-i} + \varepsilon_t \qquad (6)$$

where α is the intercept, ΔS_t the changes in copper spot prices, ΔF_{t-1} the changes in futures copper prices, and $U_{t-1} = S_t - c_1 F_{t-1} + c_0$ is the error-correction term (ECT). In equation (6) cointegration implies only that ρ›0 because spot price changes respond to deviations from the long- run equilibrium as this is described in equation (3). Short-term efficiency can be investigated by testing the following restrictions in equation (6); $b \neq 0$ (this way all new information concerning future spot price changes is immediately reflected in a change in the current spot price), $\beta_i = \gamma_i = 0$ (this way past information is already completely incorporated in the current futures price) and $\rho = 1$ and $\rho c_1 = b$. If restrictions $\rho = 1$ and $\rho c_1 = b$ do not hold then the efficient market hypothesis is violated as past futures and spot prices (and not only the futures price of the last period F_{t-1}) contribute useful information for the formation/prediction of the spot price of the present period.

Having in mind that c_1 is the coefficient of F_{t-1} in the cointegrating relationship and that for the market efficiency to hold this should be equal to 1, it can be finally concluded that the restrictions imposed for testing market efficiency are the following: $\beta_i = \gamma_i = 0$, $\rho = 1$, $b = 1$ and $\alpha = 0$ (not allowing for the presence of a risk premium according to the unbiasedness hypothesis) [2].

If the above restrictions hold, then equation (6) can be simplified to equation (3). These restrictions constitute the third condition for efficiency. If the three conditions are met, then the copper futures market is efficient and futures prices provide unbiased estimates of future spot prices both in the long-run and the short-run.

V. DATA AND EMPIRICAL RESULTS

The data consist of three time series: daily copper spot prices (LCOPSP) and daily prices for the copper futures contract with maturity three months (LCOP3M) and fifteen months (LCOP15M), for the period between 3rd of January 1989 and 30th April 2000. The size of the lot in copper futures contract is 25 tonnes and the minimum price movement is 50 American cents per tonne. The LME uses U.S. dollars as its major currency for each contract, even if Sterling, Deutschmarks and Japanese Yen also constitute currencies for clearing purposes regarding all LME metals. Delivery dates are daily for 3 months forward and then every Wednesday for the next 3 months and then every third Wednesday of the month for the next 21 months (a total of 27 months forward). The data are collected from the London Metal Exchange archives. The spot and futures prices are converted to logs.

To formally test the price series for stationarity Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981) and non-parametric Phillips- Perron (PP) (Phillips and Perron, 1988) unit root tests are employed. Table I reports the results of the unit roots tests. Since the null hypothesis of a unit root in the series is not rejected in the level by both tests, they are non-stationary. However, they are stationary in the first difference, i.e. original price series are integrated of first order I(1).

Table I **Unit Roots Tests on Spot and Futures Prices**			
Statitic tests	LCOPSP	LCOP3M	LCOP15M
ADF levels	-2.6712	-2.4233	-2.3057
PP levels	-2.4268	-2.0896	-2.0780
ADF first differences	-54.7310*	-57.8185*	-64.2737*
PP first differences	-38.3179*	-38.2323*	-41.5815*

LCOPSP denotes the log of copper spot prices
LCOP3M and LCOP15M denote the log of three months and fifteen months copper futures prices respectively.
MacKinnon (1991) critical values are –2,864 and -2.568 at the 5% and 10% level respectively.
* Indicates statistical significance at the 5% and 10% level.

Table II reports the ADF test results on the cointegrating regression residuals as proposed by Engel and Granger (1987). The null hypothesis of no cointegration between the copper spot prices (LCOPSP) and the fifteen months futures prices (LCOP15M) is accepted at the 5% level. However, Market Efficiency implies that LCOPSP and LCOP3M should have been at least cointegrated. Cointegration implies that the same factors that determine the spot price are reflected in the futures price, so the two should not drift apart if there is any chance for market efficiency in the long-run. For this reason any further investigation for the existence of market efficiency in the case of the fifteen months copper futures contract has been abandoned. On the contrary, the null hypothesis of no cointegration between the copper spot prices (LCOPSP) and the three months futures prices (LCOP3M) is rejected at the 5% level[3].

Table II **Engle-Granger Unit Roots Tests Between Spot and Futures Prices**		
System	DF	ADF
LCOPSP-LCOP15M	-2.1224	-1,8680
LCOPSP- LCOP3M	-4.1838*	-3,6342*

LCOPSP denotes the log of copper spot prices
LCOP3M and LCOP15M denote the log of three months and fifteen months copper futures prices respectively.
The critical value is –3,3407 at the 5% level .
*: Indicates significance at the 5% level.

Departing now from the bi-variant cointegration regressions in the Engle-Granger framework, the Johansen procedure test for cointegration between the copper spot prices (LCOPSP) and the three months futures prices (LCOP3M) is implemented in order to cross check the existence of cointegration between them. Hall (1991) has demonstrated that in using this procedure to test for cointegration it is necessary to establish the appropriate order of the VAR. For the choice of the lag order k, the Akaike Information Criterion (AIC) is applied. The results of the AIC established that a lag length of 3 is appropriate for both series[4].

Having established the appropriate lag length we proceed to test whether the copper spot and futures prices cointegrate. Table III reports the test statistics by Johansen and Juselius (1990) for the number of cointegrating vectors. The null hypothesis of zero cointegrating vectors is rejected, whilst the null of one cointegrating vector cannot be rejected at the 5% level. Thus, the spot and futures prices are I(1), with linear combinations being I(0), so the two price series are CI(1,1). The existence of cointegration between the copper spot prices and the three months futures prices, using both the Engle-Granger and Johansen tests, confirms the first necessary condition for long-term market efficiency.

Table III
Johansen tests for cointegration of spot and future prices
$LCOPSP_t = a + b\ LCOP3M_{t-n} + e_t$

Futures' maturity	Null	Alternative	Test for cointegration vectors based on			
			Maximal eigenvalue Statistic	Critical values (5%)	Trace statistic	Critical values (5%)
LCOP3M	r=0 r≤1	r≤1 r=2	34.7666 7.5057	15.8700 9.1600	42.2723 7.5057	20.1800 7.1600

LCOPSP and LCOP3M denote the log of spot and three months futures prices respectively. The critical values are from Johansen and Juselius (1990), Table A3.

However, the problem of autocorrelation on the residuals was detected in the long-run relationship between the copper spot prices and the three months futures prices. Given that our data are daily and the futures contracts have three months and fifteen months time to maturity respectively, this problem was due to overlapping observations: two futures contracts that the time distance among them is less than the time to maturity of the older of the two will use at least one common spot observation to get formed[5]. So, to avoid overlapping observations the futures prices must be chosen at a forecast horizon less than or equal to the observation interval (Beck, 1994).

The problem of autocorrelation due to overlapping observations is overcome during the construction of the final regression of the error correction model (ECM) using the following differences for the spot and three months futures prices, taking as given that there exist 22 working days per month and so 66 in three months:

DLCOPSP = LCOPSP – LCOPSP (-66)

(7)

DLCOP3M = LCOP3M - DLCOP3M (-66)

Table IV demonstrates all the significant ECM coefficient variables (p value<0.050) and the diagnostic tests. The model is highly significant, with negative coefficient for the ECT, high R^2, and absence of serial correlation on residuals.

However, heteroskedasticity and Autoregressive Conditional Heteroskedasticity (ARCH) are extremely persistent problems. The existence of ARCH errors could be explained by the presence of a time varying risk premium, given that the latter was assumed to be linear and constant over time. These problems are overcome by developing an ARCH model[6]. A dumping factor of 0.0100 has been used for its construction. The ARCH specification equation is of the following form:

$$h_t^2 = 0.0003351 + 0.23915\varepsilon_{t-1}^2 \quad (8)$$

and the coefficient of ε_{t-1}^2 is significant[7]. The model proved highly significant with high R^2 (0.97208), negative coefficient for the ECT and corrected ARCH.

Table IV Estimates of ECM Coefficients and Diagnostic Tests		
Variables	Coefficient	T-Ratio[Prob.]
CONSTANT	.1318E–3 [.4699E –3]	.28047 [.779]
ECT (-1)	-.039241 [.017063]	-2.2998 [.022]
DLCOP3M	-.51533 [.022248]	-23.1631 [.000]
DLCOPSP(-1)	.87412 [.021925]	39.8696 [.000]
DLCOPSP(-3)	.095290 [.016082]	5.9252 [.000]
DLCOPSP(-13)	-.094877 [.019753]	-4.8032 [.000]
DLCOPSP(-14)	.075358 [.018924]	3.9820 [.000]
DLCOP3M(-1)	.46092 [.028834]	15.9849 [.000]
DLCOP3M(-2)	.046591 [.022980]	2.0275 [.043]
R^2	.97219	
F- stat	9701.9 [.000]	
Serial Correlation	X^2 =3.7857 [.052]	
Heteroskedasticity	X^2 = 11.8837 [.001]	
ARCH	X^2 = 114.8908 [.000]	

DLCOPSP and DLCOP3M denote price changes in spot and three months futures prices respectively.
In the second column, figures in parentheses are standard errors.
The serial correlation and ARCH were tested by Langrage multiplier statistic.
Heteroskedasticity test was based on the regression of squared residuals on squared fitted values.

Table V reports the Wald tests on parameters restrictions of the final ECM relating to the second and third necessary condition for market efficiency. The first test (column 1) investigates the Efficient Market Hypothesis, imposing the restrictions ρ = b = 1, βi = γi = 0, and no restriction to the intercept, allowing the existence of a risk premium (consistent with the definition of futures market efficiency). The test rejects the imposed restrictions not accepting thus market efficiency. The second test (column 2) refers to the unbiasedness hypothesis, imposing to the above restrictions the additional of α = 0. The result again rejects the hypothesis. The third test (column 3) on the imposed restrictions a = 0 and b = 1 is rejected, where b is the coefficient of ΔF_{t-1}, measuring the speed/ extent that changes in S_t produce changes in F_t. The restriction b = 1 (column 4) is also rejected, a result that supports the rejection of market efficiency and the unbiasedness hypothesis. The restriction $\alpha = 0$ (column 5) is not rejected, supporting the non- existence of a risk premium conditional to the form that has been assumed for it. Such a result means that a risk premium could exist but in any case will not be of a linear form. A non- linear or time varying risk premium is very possible to exist, which is advocated by the existence of ARCH in the initial data. Finally, the last test (column 6) rejects the hypothesis $\beta i = \gamma i = 0$, which means that the past information is not incorporated immediately and completely in the current futures prices.

Table V.
Wald Tests on ECM Parameters Restrictions

$\rho=1$ $b=1$ $\beta_i=\gamma_i=0$ (1)	$\alpha=0$ $\rho=1$ $b=1$ $\beta_i=\gamma_i=0$ (2)	$\alpha=0$ and $b=1$ (3)	$b=1$ (4)	$\alpha=0$ (5)	$\beta_i=\gamma_i=0$ (6)
463152.6 [.000]	464956.7 [.000]	40573.6 [0.000]	3565.2 [.000]	0.44896 [.503]	3529.8 [.000]

P – values are in parentheses.

VI. INTERPRETATION AND IMPLICATIONS OF RESULTS

The results presented here suggest that the futures price is not an unbiased predictor of the future spot price for the case of fifteen months futures contract, since cointegration has been rejected and the two price series tend to drift apart over time. Moreover, while the cointegrating relationship between the spot prices and the three months futures prices confirms the first necessary condition for long-term efficiency, the three months futures market is not efficient in both the long-term and short-term, according to further tests examined the long-run and short- run dynamics of their relationship. Hence, this evidence suggests that copper futures market in London Metal Exchange is inefficient and the three and fifteen months of futures prices do not provide unbiased estimates of the future spot prices in both the long-run and short-run.

However, this rejection of the joint hypothesis of market efficiency and unbiasedness in futures prices does not allow the identification of the reason for the rejection. Given that the unbiasedness of futures prices is the most commonly accepted model to test efficiency and the risk premium is assumed to be linear and constant over time here, this rejection could be due to a positive time varying risk premium.

On the other hand, unlike previous studies which either ignored the problems caused by non-stationary variables, or they have only considered the long-run efficiency, if cointegration has been used, this finding demonstrates the importance of examining all the necessary conditions to conclude for market efficiency. If only cointegration has been examined without any further investigation of the long-run and short-run dynamics in the relationship between spot price and futures price, then the conclusion would have been incorrectly drawn that the three months futures market was efficient during 1990s.

Finally, our findings have two important implications for market participants in the London copper futures market. First, it suggests that there are opportunities for consistent speculative profits to be made. Second, in relation to the price discovery role of the copper futures market, it appears that the market does not fulfill this function and hence the information incorporated in futures prices is not considered as important in order to forecast future spot prices.

VII. SUMMARY AND CONCLUSIONS

This paper has investigated the efficiency of copper futures market in the London Metal Exchange, testing the joint hypothesis of market efficiency and unbiasedness of futures prices.

The unit root tests conclude that each series is non-stationary in levels, but stationary after first differencing. The copper spot and futures price series are then tested for cointegration. The results indicate that the spot prices and the fifteen months futures prices are not cointegrated. This could be due to the turbulence and increased volatility characterized the copper futures market during 1990s, resulting to the presence of factors determined the future copper spot prices that are not reflected in the futures prices of contracts with extensive expiration date (fifteen months). Given that market efficiency implies that the futures price is an unbiased predictor of the future spot price and so at least cointegration between them must exist, the fifteen months copper futures market is not efficient.

On the contrary, the cointegration hypothesis between the three months copper futures prices and the relative spot prices is accepted and so the first necessary condition for market efficiency holds. However, as far as long-run and short- run efficiency is concerned, the second and the third necessary condition do not hold. This is because the restrictions on the parameters in the cointegrating relationship and the error correction model are rejected, even though a method for correcting the autocorrelation due to overlapping observations is applied satisfactorily.

Overall, the empirical results suggest that copper futures market on the London Metal Exchange is inefficient and the three and fifteen months of futures prices do not provide unbiased estimates of the future spot prices in both the long-run and short-run. This evidence is consistent with the findings provided by earlier studies on LME copper futures market using cointegration techniques (e.g., MacDonald and Taylor, 1988a and 1988b; Chowdhury, 1991; Beck, 1994; Moore and Callen, 1995). These studies also support the rejection of the Efficient Market Hypothesis during 1970s and 1980s, even though either they fail to test relevant parameter restrictions or do not examine efficiency in both the long-run and the short-run.

Finally, this study has opened up three interesting research questions regarding the efficiency of copper futures markets. First, a further study could explore the role of a time varying risk premium into the model of the unbiasedness of futures prices. Second, the relationship between price discovery and volume of futures trading in each month of different contracts constitutes an interesting topic for future research. Third, attention has to be given to price volatility in examining futures market efficiency. Given the increased use of volatility to examine stock market efficiency, this investigation will offer additional means by which to examine the joint hypothesis of market efficiency and unbiasedness in futures markets.

ENDNOTES

1. This can be seen if reform equation (2) as following: $S_t - F_{t-n,t} = \alpha + (b-1)F_{t-n,t} + e_t$. The new equation is similar to (2) if b=1.

2. It should be noted that it has been assumed that the risk premium as it is represented from the intercept α is of a linear form and constant over time.

3. Analysis of the data indicated that there was a problem of normality. This appears to be due to the copper market crisis of June 1996 from the reported loss by Sumitomo Corporation of Japan. The problem of non-normality in the data is overcome by including a dummy variable relating to this one observation. The results in Table II and III relate to tests including a stationary dummy variable. Exclusion of the dummy does not alter the pattern of results.

4. In the interests of brevity, tests results are not presented here. Results are available from the authors on request.

5. For example, a futures contract that signed at time t (period 1) and matures 3 periods afterwards (that is $F_{t,t+3}$ or $F_{1,4}$) is a function of S_1, S_2, S_3, S_4. All the futures contracts till the $F_{4,7}$ have (as functions of the relevant spot prices) in common at least the spot price S_4. The only futures that would have no S_t in common are $F_{1,4}$ and $F_{5,8}$. So, to avoid overlapping observations (t+3+1) differences (where t+3 is the time to maturity) must be taken if an error correction model is to be constructed.

6. The full outcome of the ARCH model is available from the authors on request.

7. With t-ratio = 6.71› 1.96 (critical value), the null hypothesis of non-significance is rejected.

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