CHAPTER-05

EFFICIENCY OF COMMODITY FUTURES MARKET

Abstract:

The efficiency of futures markets is critical for the breadth and depth of the market. The recently set up commodity exchanges which offer trading in several commodities would go a long way in providing hedging for both producers and consumers if they are found to be efficient. This research is aimed at studying the spot and futures prices of several commodities (copper, gold, rubber and silver) in futures markets in India to test the joint hypothesis of market efficiency and unbiasedness of futures prices. The research concludes that the futures markets, in the Indian context, are inefficient and futures prices are not unbiased predictor of spot prices.

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5.1 DEFINITION OF AN EFFICIENT MARKET

One of the first definitions of market efficiency was provided by Working (1949): “If it is possible under any given combination of circumstances to predict future price changes and have the predictions fulfilled, it follows that the market expectations must have been defective; ideal market expectations would have taken full account of the information which permitted successful prediction of the price change.”

He revised this definition later. (Working, 1962) : “A perfect futures market is one in which the market price would constitute at all times the best estimate that could be made, from currently available information, of what the price would be at the delivery date of the futures contracts”.

This was followed by Fama's (Fama,1970) definition of an efficient market , which has become the standard:“A market in which prices always ‘fully reflect’ available information is called ‘efficient”.

According to this definition, a market can be considered as efficient if price at time t incorporates all available information at time t. If so, the price reflects the value of the asset and it is not possible to make abnormal profit by buying asset at that price. If price deviates from the efficient price, economic agents, assuming rationality, will arbitrage away any profit potential.

Thus, for a single price series, efficiency would imply,

$$E(P_t) = P_{t-1} + \mu_t$$ \hspace{1em} (5.1)

where

$$\mu_t = \text{Stochastic error term}$$, \hspace{0.5em} $$E(\mu_t) = 0$$, \hspace{0.5em} $$E(\mu_{t-i}, \mu_{t+j})=0$$

$$E(.)$$ is expectation operator
Equation (5.1) implies that the unbiased predictor of price at time t is the price at time \( t-1 \).

That is to say, the price at time \( t-1 \) reflects all the information available at time \( t-1 \) and there is no reason for price at time t to be different except in the case where new information flows between the periods \( t-1 \) and t, and which may have an effect on the value of the underlying asset and hence its price.

Since efficiency implies that the market price at time t incorporates all the information available at time t, risk neutral agents will not speculate on the future spot price and trade on the futures market since the abnormal profits would be zero owing to efficient markets.

Jensen (1978) revised the definition of Fama thus: “A market is efficient with respect to information set \( t_0 \) if it is impossible to make economic profits by trading on the basis of information set \( t_0 \).”

In sum, efficient market means a market in which asset prices follow an independent path because:

- Of the presence of a large number of investors in the market
- Of free flow of information to all investors
- Every investor is capable of interpreting the information
- Every kind of price sensitive information is discounted in the prices immediately
- No one is in a position to influence the market unduly.

**5.1.1 FORMS OF EFFICIENCY**

The definition of “available Information”, i.e., the information set, varies and hence results in three different possibilities of Efficient Market. Three different information sets of asset prices and returns are considered for defining efficiency. With a broader set of information, a stronger version of efficiency is associated.
The three forms of efficiency are weak form, semi-strong form, and strong form, each of which has different implications for how markets work.

5.1.1.1 Weak-form efficiency

Markets are said to be in weak-form of efficiency if all information contained in historical prices and firm characteristics (such as size of the firm, book value, etc) is incorporated in the current price. All historical information is reflected in the market price of the asset. Hence, the current asset price is the best, unbiased estimate of the value of the security.

(Nothing is said about the inclusion of any other information nor about the speed at which the information is incorporated in the price of the asset).

Characteristics of the weak form of efficiency:

- Weak form of efficiency implies that the past prices cannot be used to predict the future prices since all the information contained in the past prices is reflected in current prices.
- In a weakly efficient market, current asset price is the best unbiased estimate of the value of the asset. The current price imbibes all the information contained in the past prices.
- Therefore, past prices do not have any value for forecasting the future. No consistent excess returns can be earned by using investment strategies based on historical asset prices or other financial data.
- Technical analysis, which relies on the analysis of the past prices, cannot be used to predict the future and hence is irrelevant for making consistent excess returns.
- The fundamental analysis may be used to identify assets for their improper (undervalued and overvalued) valuation.
• The implication of Efficient Market Hypothesis (EMH) is that no one, trading on the basis of the information, should not be able to make (on an average) excess profits, i.e. he can (on an average) earn normal profits only.

**5.1.1.2 Semi-strong form efficiency**

A market is said to be semi-strong efficient if the asset prices include, in addition to information contained in past prices and about the firm characteristics, (required for weak form of efficiency), all Publicly available Information about the asset’s returns, such as financial statements, Annual Reports, Other disclosures, Announcements, which are normally available to market participants. These additional information is also incorporated in the current price of the asset.

Alternately, one can say that if the price adjusts within an arbitrarily small but finite amount of time and in an unbiased fashion to publicly available new information, so that no excess returns can be earned by trading on that information then the market is said to be semi-strong efficient.

Characteristics of Semi strong Efficient Markets:

• Since the market quickly adjusts to any new information (as Semi-strong form efficiency implies), any new information cannot be used to make consistent excess returns and the Fundamental analysis techniques will not be able to reliably produce consistent excess returns.

• The difference between weakly efficient and semi-strong efficient is that the weakly efficient market is only concerned with the present and the past and does not discuss the effect of any new information that might flow in the future. Semi-strong efficiency is one step further, and discussed how the market would react to any new information. Thus, semi strong efficiency implies weak efficiency and some more.
5.1.1.3 Strong-Form Efficiency

A market is said to strongly efficient if, in addition to all the requirements of semi-strong efficiency, the asset price also includes all privately available information. Examples of such private information is proprietary information, say private forecast of next period’s earnings.

Thus, if market is strongly efficient, the underlying asset price reflects all information and no one can earn consistent excess returns over a period of time. Strong Form efficiency is one step more to semi-strong form of efficiency, that it says that in an efficient market, no one can EVER make consistent excess profits.

Each information set is a subset of information set of the next level of efficiency. Hence, strong efficiency implies semi-strong efficiency and weak efficiency. Similarly, semi strong efficiency implies weak efficiency. But vice versa does not hold.

5.1.2 Tests of Efficiency

5.1.2.1 Test for Weak Form of Efficiency

If the asset prices follow random walk model, then,

\[ \mathbb{E}(P_t) = P_{t-1} + \mu_t \] (Without drift)

Or

\[ \mathbb{E}(P_t) = a + P_{t-1} + \mu_t \] (With drift) \( (a = \text{constant} = \text{drift per period})\)

That is, expected next period price is the present price (plus a drift) plus a stochastic error term whose expected value is zero but has positive variance.

If asset prices follow random walk, it is implied that the present price is the unbiased predictor of next period price and that all past prices are irrelevant. Hence, if random walk model is followed, the market is said to be weakly efficient.
5.1.2.2 Test for Semi Strong Efficiency

For market to be semi strong efficient, the adjustments to previously unknown news must be of a reasonable size and must be instantaneous. Hence, to test for semi-strong form of efficiency, the prices are examined for consistent upward or downward adjustments after the initial change (say, within one day). If there are any such adjustments it would suggest that investors had interpreted the information in a biased fashion and hence in an inefficient manner. Then the market is said to be NOT semi strong efficient.

5.1.2.3 Test for Strongly Efficient Market

Profits from taking a position in the market are examined over a long period of time. If the profits are not consistently different from zero, then the market is said to be strongly efficient.

5.2 Nature of Study and Problem

Definition

The research study is to test whether the commodity futures market in India are efficient. This is examined through study of four commodities traded on commodities exchanges.

1. The hypothesis for testing the efficiency of the commodity market is as follows:

Null Hypothesis: \( H_0 \)

2. Future market prices are unbiased predictor of future spot prices in Indian commodity market.

Alternate Hypothesis: \( H_1 \)
3. Future market prices are not unbiased predictor of future spot prices in Indian commodity market.

5.3 LITERATURE REVIEW

5.3.1 EFFICIENCY STUDIES OF WORLD COMMODITY FUTURES MARKETS

Efficiency of financial markets in general and commodity markets in particular have been large, especially in the advanced countries. The study began with Fama analyzing the prices in the stock market and efficiency of the stock markets. Fama (1965, 1970) was the first to develop a test for efficiency.

After the path breaking study, several researchers have studied the dynamic behavior of prices of financial assets, products and commodities. The primary focus of the studies is whether it is possible to predict the future price and earn economic profits (after adjusting for risk). Thus, both principles of arbitrage and efficiency are involved. If it is possible to predict the price then the market is basically inefficient. If it is not possible to forecast to make economic profits, implication is that the current price incorporates all the available information such that the arbitrage profit is impossible. The market is then said to be efficient.

The efficiency studies test whether the price generating process follows random walk (i.e., it is a unit root generating process). If so, then the best forecast is the current price and hence there is no possibility of consistently making economic profits.

Alternately, researchers have examined whether the time series of prices are mean reverting—i.e., a stationary data generating process. If the series is mean reverting then the market is not efficient as it may be possible to make economic profits by anticipating the movement towards the mean. Such stationary time series may not
generate economic profits if the movement to the mean is sufficiently slow to preclude such profits (because of transaction cost).

Some of the prominent studies are discussed and summarized below.

Engel and Granger (1987) developed an econometric method for testing efficiency using co-integration method with auto correction method (VCM).

Elan and Doxom (1988) have shown that conventional F-test cannot be used for non-stationary time series. Johansen and Juselius (1990) have also used co-integration test with VCM.


Brenner and Kroner’s (1995) model of the commodity market suggests that efficiency or otherwise results are caused by the existence of arbitrage and do not reflect market efficiency issues.

**Efficiency of Metal Futures Markets:**

The efficiency of metal futures markets has been widely studied. The first major study for determining efficiency of metal futures markets was Goss (1981) who used daily data of several metal futures on LME for the period 1971 to 1978 to examine whether the futures price are unbiased predictor of spot price. He found that future prices were not unbiased predictor for some metals. Goss (1985) examined joint test of efficient market hypothesis for different metals on LME, for the period 1966-1984 and found the markets are efficient for lead and tin but not efficient for copper and zinc. Canarella and Pollard (1986) used three different estimation methods using overlapping and non-overlapping daily data of several metals for period 1975 to 1983 and concluded that the futures price is an unbiased predictor of the future spot price.
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 LME prices starting with the first trading day in 1983 till the last one in September 1984 for testing the efficiency. Based on the mean square error criterion, he provides evidence that the EMH is not rejected for the copper futures market. MacDonald and Taylor (1988a) have examined for stationarity before efficiency test for four metals in the LME covering the period 1976-1987. They conclude that the copper and lead futures markets can be considered as efficient, whilst the tin and zinc futures markets are inefficient. MacDonald and Taylor (1988b) study of some metals for the period 1976-1985 concluded that the markets are efficient for some metals. Shen and Wang (1990) has applied Engel-granger co-integration test and concluded that in the case of copper futures contract the evidence suggests efficient markets. 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. 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. However, 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) conclude that the copper futures markets are not efficient in the long run.

**Efficiency of Agricultural Commodities Futures Markets:**

Newbold et al (1999) have tested the efficiency of futures market for several commodities (heating oil, live hogs, live cattle, soybeans and orange juice). The authors surmised that seasonality of production could make the markets inefficient. Hence they augmented their model with dummy terms for seasonality. Then stationarity was tested using ADF test. Subsequently, quasi-Error Correction Model (ECM) framework is used to test for efficiency. The tests are carried out for two time
horizons a short (28 days) and a long (56 days). They conclude that the heating oil markets are affected by seasonality in the short run and that the market is inefficient. In a similar vein they found that the live cattle market is also inefficient.

Kaminsky and Kumar (1990) have examined seven commodity markets over the period 1976-1988 and find that the markets are inefficient. Dorfman (1993) has tested efficiency of corn and soybean by applying Bayesian non-parametric tests for stationarity of the time series. Efficiency is examined throughout the life of the contract. The series is generated from the hourly trade data on Chicago Mercantile Exchange for period starting July, 1990. The author found the time series for both the products to be stationary and hence markets to be inefficient.

Medoza et al (1995) have examined the efficiency of the corn futures market in Philippines. They find the market inefficient.

Kastens et al (1996) have examined the efficiency of wheat futures markets in Kansas. The period studied was 1947 to 1995. Authors formulate a parametric model which incorporates previous period price, expected production, expected exports, ratio of consumption to initial stocks, as independent variables. The authors found the wheat futures markets to be efficient.

McKenzie and Holt (1998) have analyzed efficiency of five futures markets- Live cattle, live hogs, Soybean meal, corn and Iced Broilers. They collected data on spot prices and futures prices for the period 1966 to 1995 (30 years). The series were first analyzed for stationarity using ADF and Philips-Perron Test and they found that the all series were not stationary but contained at most one unit root. The differenced series were tested for co-integration by using Engle-Granger co-integration test. The series were found to be co-integrated with coefficients to be about (0, 1). This proved that long run efficiency and un-biasedness. To test for short term efficiency Error Correction Model was used. It was found that short run efficiency existed in each of these markets.
Wang and Bingfan (2002) have studied the efficiency of the Chinese wheat and soybean futures markets. The authors studied two commodities: Wheat and Soybean. The spot and futures prices for the period of January 1998 to March 2002 were compiled from published data. Futures market efficiency was tested for six forecasting horizon ranging from one week to six months. The price series were examined for stationarity using ADF and Philip-Peron tests. The series were found to be non-stationary. The differenced series, after stationarity, were tested for Co-integration using Johansen’s co-integration test. Then the series are tested for unbiasedness. The authors found that for the wheat markets, the series were not integrated and hence were found to be inefficient. However, soybean markets were found to be weakly efficient.

5.3.2 EFFICIENCY STUDIES OF COMMODITY FUTURES MARKETS IN INDIAN CONTEXT

In Indian markets, there have been several studies to determine efficiency of stock markets, foreign exchange markets and commodities markets. However, studies for efficiency of futures markets in commodities are few. Some of the major studies of efficiency of commodities futures markets in India are summarized below.

Sahadevan (2002a and 2002b) are the first reported study of efficiency of futures markets. Raizada et al (2002) has studied the efficiency of commodity futures market (wheat) and its effect on social welfare and inflation in the country. The authors conclude that the wheat futures market is not weakly efficient.

Anand (2006) has examined market efficiency of Indian commodity futures market by studying data of 12 commodities traded on NCDEX futures markets for contracts ending in May 2006. The authors have applied Granger causality tests and Johansen Co-integration procedure. Authors find that different commodities have different lagged relationship, indicating that the information does not reach instantaneously and rate of information flow is different for different commodities.
They find the markets to be inefficient.

Sahi Gurpreet and Gaurav Raizada (2006) have examined the efficiency of wheat futures markets for the period 2004 to 2006 for various horizons. The authors find that the wheat futures market is not efficient either in short run or in the long run and hence the price discovery is poor. They also find that higher trading in the futures market has significant impact on the inflation and hence the welfare.

The authors have studied the commodity futures market efficiency in India and analyzing its effect on social welfare and inflation in the economy. The wheat futures market at National Commodity & Derivatives Exchange Ltd. (NCDEX) has been studied and its efficiency has been examined.

The data from NCDEX is collected for the period July 2004 to July 2006. The daily closing prices have been taken to be spot prices. Futures price efficiency is tested for five horizons—one week, two weeks, one month, two months and three months prior to expiry of each contract. Since for every horizon there is one couple of price series, there are a total of five couples of price series.

First, the authors have examined the stationarity of the price series using Augmented Dickey Fuller Test (ADF). The authors find that the series is not stationary and there exists a unit root. After first differencing, the series is found to be stationary, i.e., the authors find the series to follow $I(1)$ model.

In the second step, the authors examine whether the series are co-integrated by applying Johansen’s Co-integration test. They find the series are co-integrated for period up to one month but not co-integrated for a longer period (two and three months). Thus, markets are not efficient for period beyond one month.

Further the authors applied Test of Restrictions on Co-integration Vectors to establish efficiency for different futures forecasting horizons ranging from one week to one month.
The formal statistical tests on the efficiency of the commodity futures markets show that it is not even weakly efficient in the short term. The weak exogeneity of the spot price shows that spot price leads the futures price determination and that futures market are not performing their main role of allowing for price discovery.

Once the inefficient nature of the market is established, the authors test for the effect on inflation and hence on the loss of welfare.

Singh has examined the weak form of efficiency of Indian agricultural futures markets. Futures markets of Castor seed, Gur, Hessian, Pepper, Potato and Turmeric are studied. The study concludes, (using co integration techniques) that evidence for market efficiency is mixed and varies across the commodities. The author’s study shows evidence of efficiency and un-biasedness in relation to Gur and Potato. For other commodities, efficiency and unbiased-ness varies according to maturity and months left to maturity.

Roy (2007) has discussed futures market for crude futures in India.

Sahoo and Kumar (2009) have analyzed the efficiency of futures markets of five commodities. The commodities examined are gold, copper, petroleum crude, chana and soya oil. They find that the futures markets for all the five products are efficient.

5.4 METHODOLOGY

A futures market is said to be efficient if the futures price is an unbiased estimator of the future spot price.

Other conditions on the series are required to be met before the price series is tested for un-biasedness. These are stationarity test and co-integration test. If two series, spot price and corresponding futures price are stationary and co-integrated then parametric restriction test is applied to determine whether futures price is an unbiased estimator or not.
Econometric analysis, for testing efficiency of a time series, involves regressing price at time \( t \) with price at time \( t-i \) (\( i>0, i<t \)), and in the case of futures market regressing the spot price at maturity on the futures price at some time prior to maturity.

\[
E(P_{S,t}) = \alpha + \beta P_{S,t-i} + \epsilon_{t-i}
\]

OR

\[
E(P_{S,t}) = \alpha + \beta P_{F,t-i} + \epsilon_{t-i} \quad \ldots \quad (5.2)
\]

For market to be efficient, \( \alpha = 0 \) and \( \beta = 1 \). That is, estimated value of \( \alpha \) should not be statistically significant. And estimated value of \( \beta \) should not be statistically different from one. As \( i \) decreases, the probability of \( P_{F,t-i} \) (or, \( P_{S,t-i} \)) being unbiased predictor of \( P_{S,t} \) should increase and hence probability of market being efficient should increase. That is because probability of new news, affecting the valuation will decrease as time to maturity of futures contract decreases. If the regression results in rejection of null hypothesis (\( \alpha = 0 \) and \( \beta = 1 \)), implication is that \( P_{F,t-i} \) (or, \( P_{S,t-i} \)) is not an unbiased predictor of \( P_{S,t} \) and hence the market /futures market is not efficient. If \( \alpha \neq 0 \), it implies existence of non-zero risk premium, or, a constant trend.

The above procedure for testing of efficiency (outlined in section 5.4.1 below) is applicable if the series for the asset under investigation is stationary. If the series is/are non-stationary, the above procedure, as represented by equation-4 cannot be used, except when the said non-stationary series are made stationary by some mechanism.

**Integrated Series:**

If a non stationary time series, \( (x_1,x_2,x_3,\ldots,x_n) \), becomes stationary after first differencing, \( (y_1,y_2,y_3,\ldots,y_{n-1}; \text{ where } y_i=x_{i+1}-x_i) \), then that series is said to be co-
integrated of order 1, I(1). If a series is found to be non stationary, then it can be made stationary by differencing, once or more than once. Thus, a non-stationary time series is said to be integrated in order “n”, generally denoted by I(n), if the series is stationary after the n-order differencing.

The standard tests for efficiency can then be applied to the differenced series.

5.4.1 EFFICIENCY TEST FOR STATIONARY SINGLE SERIES

For a single asset price series, inferring efficiency is relatively straightforward exercise. The testing for a single asset requires, first, testing the series for stationarity, making the non-stationary series stationary, specifying a pricing model and ascertaining that price of an asset follows the model and the independent variable is an unbiased estimator of the price at a future time.

For example, price may follow random walk and one can infer weak efficiency.

OLS test for Efficiency - Random Walk Model:

For a single price series, efficiency would imply,

\[ E(P_t) = P_{t-1} + \varepsilon_t \]  \hspace{2cm} (5.3)

Where,

\[ \varepsilon_t = \text{Stochastic error term}, \ E(\varepsilon_t) = 0 \ E(\varepsilon_{t-i}, \varepsilon_{t-j}) = 0 \]

\( E(.) \) is expectation operator

Equation (5.3) implies that unbiased predictor of price of an asset at time \( t \) is its price at time \( t-1 \). That is to say, the price at time \( t-1 \) reflects all the information available at time \( t-1 \) and there is no reason for price at time \( t \) to be different except in the case where new information flows in between the period \( t-1 \) and \( t \), and which may have an effect on the value of the underlying asset and hence
its price. If equation (5.3) is satisfied, one can conclude that the market is weakly efficient.

The generic Random Walk Model may be specified as:

\[ P_t = \alpha + \beta P_{t-j} + \mu_t \]

Where \( \alpha \) and \( \beta \) are constants. \( P_t \) is regressed against \( P_{t-j} \) \((j>0)\) and constants \( \alpha \) and \( \beta \) are determined. This model specifies a constant drift, \( \alpha / (t-j) \) over a single time period.

If prices do follow random walk, then, \( \alpha \) should be statistically insignificantly different from zero and \( \beta \) should be statistically not different from 1.

The efficiency for a single price series can also be tested through other methods too, for example, Run test Sign test, Filter test.

### 5.4.2 Efficiency Test for Non Stationary Single Series

The time series of asset are generally not stationary. If a series is found to be non stationary, then it can be made stationary by differencing, once or more than once.

### 5.4.3 Efficiency Test for More Than One Series Which Are Interrelated

If there are two time series (for example, in the case of futures markets, spot price series and futures price series) which are inter-related then for applying simple OLS for testing of efficiency, one must first test for stationarity of both the series (For example, the futures price series and underlying asset spot price series.)

**Co Integration - a Definition:**
An \((n \times 1)\) vector time series \(X_t\) is said to be co-integrated if each of the series taken individually is \(I(1)\) while some linear combination of the series’ \(A Y\) is stationary for some nonzero vector \(A\) (Hamilton, 1994).

when one series \(A\) is dependent on the other series, \(B\), then joint testing for efficiency of the two series requires that the two series are co-integrated. Co-integration of two series is a necessary condition for market efficiency.

The stationary series are thus required to be tested for co-integration, The above can be elaborated for the series of spot prices and futures prices as follows:

Let \(S_t\) be the cash price of the commodity at time \(t\) and \(F_{t-i}\) be futures price taken at \(i\) periods before the contract matures at time \(t\), where \(i\) is the number of periods interested. If the futures price can provide a predictive signal for the cash price \(i\) periods ahead, then some linear combination of \(S_t\) and \(F_{t-i}\) is expected to be stationary: that is there exist \(a\) and \(b\) such that \(z_t\) is stationary with mean 0, where,

\[
z_t = S_t - a - bF_{t-i}
\]

If both \(S_t\) and \(F_{t-i}\) are \(I(1)\), a condition that usually holds for prices, the vector process \((S_t, F_{t-i})\) is said to be co-integrated.

In case of futures markets, co-integration between \(P_{S,t}\) and \(P_{F,t-i,t}\) is a necessary condition for market efficiency. Co-integration ensures that there exists a long-run equilibrium relationship between the two series. If \(P_{S,t}\) and \(P_{F,t-i,t}\) are not co-integrated, they will drift apart without bound, so that the futures price provides little information about the movement of the cash price.

Hakkio and Rush (1989) have proved that though co-integration is a necessary condition for markets to be efficient, it is not sufficient condition. Restrictions on values of \(a\) and \(b\) \((a=0, b=1,\text{ both jointly and individually})\) and the serial independence of \(\bar{e}_t\) is the second necessary condition for market efficiency.

In conclusion, these conditions (Stationarity, Co-integration and parametric restriction), together, are sufficient for markets to be efficient.
5.4.4 TESTING FOR EFFICIENCY OF FUTURES MARKET

Futures market has no independent existence in absence of the underlying asset market. Though F is a function of S, simply testing for efficiency of S is not sufficient to conclude that F is efficient. To prove that F is efficient, one needs to prove that F is the best unbiased predictor of S. i.e., If we assume that the economic agents are risk neutral, then if the markets are efficient, then,

\[ F_{t-i} = E(S_t) + \epsilon_t \]  \hspace{1cm} (5.4)

Where, \( F(.) \) and \( S(.) \) are natural logarithms of futures price and spot price respectively.

This can be re-written as,

\[ E(S_t) = F_{t-i} + \epsilon_t \]  \hspace{1cm} (5.5)

Where, \( S_t \) = Spot price of the asset at time \( t \)

\( F_{t-i} \) = Futures price of the asset at time \( t-i \), maturing at time \( t \)

\( \epsilon_t \) = Stochastic Error Term, \( E(\epsilon_t) = 0 \), \( E(\epsilon_{t-i}, \epsilon_{t-j}) = 0 \)

\( E(.) \) is expectation operator. i.e., expected value of the error is zero and the error terms in any two periods are not correlated.

Equation (5.5) implies that Futures price at time \( t-i \), is an unbiased predictor of future spot price at time \( t \). Thus, given all the information at time \( t-i \), one can conclude that the price of the underlying asset at some future time \( t \) will be \( F_{t-i} \). Unless there is new information flowing between time \( t-i \) and time \( t \), the future spot price will not deviate from the present futures price for the date.

If economic agents form rational expectations and are risk neutral, then futures price being unbiased predictor of future spot price is sufficient condition for market
to be efficient. It is shown that if one can prove that the futures prices are unbiased estimator of the future spot price, then one can conclude that the futures market is efficient. Hansen and Hodrick (1980) have proved that (5.5) can be used to test for unbiasedness as well as efficiency. That is, if (5.5) holds, the futures price is an unbiased predictor of future spot price as well as the market is efficient.

This has now become a standard method of testing efficiency of futures market.

5.4.5 SUMMARY

Thus, to summarize,

1. Markets are efficient if \( F_{t-1,t} = E_{t-1} (S_t) \) \----------(5.6)
   This is same as saying, the spot price at a future date would equal the current future price for that future date plus some random noise/stochastic error term.

   This is equivalent to:

   \[
   E(S_t) = F_{t-1,t} + \tilde{\varepsilon}(t) = \tilde{\varepsilon} + \tilde{\varepsilon}F_{t-1,t} + \tilde{\varepsilon}_{t-1} \quad \text{----------}(5.7)
   \]

   \[ E(\tilde{\varepsilon}(t))=0 \quad \text{and} \quad E(\tilde{\varepsilon}_{t},\tilde{\varepsilon}_{t+k})=0 \]

2. Two Series have to be stationary.
3. Two Series have to be co-integrated.
4. Test for \( \tilde{\varepsilon}=0 \) and \( \tilde{\varepsilon}=1 \)
   If the futures market is efficient, then this would be true since futures price incorporates all the available information at time \( t-1 \).
5. The error terms have to be serially independent.
5.4.6 TESTING PROCEDURES FOR EFFICIENCY OF FUTURES MARKET

If there are more than one series, the procedure for testing of efficiency are as follows.

There are four major steps in determining efficiency of futures markets.

First Step: test of Stationarity and Co-integration

- Collect data on time series of Spot Price and Futures Price
- Test if both the series are stationary or not
- If the series are found to be non-stationary, each series needs to be tested whether it is integrated of some order d. Common methods used for testing for I(d) are Augmented Dickey-Fuller (ADF) Test and the Phillips-Perron unit root test. (Chowdhury, 1991; Lai and Lai, 1991; Mackenzie and Holt, 1998).
- If both series are co-integrated of order d and e respectively, examine whether co-integration exists between the two series.
- If the series (St and Ft-i) are found to be co-integrated, then the next step is testing the equation (5.3) with restriction on parameters, \( \alpha = 0 \) and \( \beta = 1 \).

Second Step: test for parametric restriction

- The second step may consist of multiple tests: \( a = 0 \) and \( b = 1 \) jointly or each individually.
- The constraint \( \beta = 1 \) is a more important indicator for market efficiency, because \( \beta \) is non-zero under the existence of risk premium and/or transportation costs even when the market is efficient.
- That is why we also test them separately though \( \alpha = 0 \) and \( \beta = 1 \) are often tested jointly.

Third Step: test for serial independence
If the first two steps are satisfied, third step requires testing for serial independence of the error terms.

Fourth step: testing for Short term efficiency

If the series is found to be stationary as per above procedure, (The co-integration relationship and the parameter restrictions also can be tested using Johansen’s approach and the likelihood ratio test, respectively) it still needs to be tested for short term efficiency.

5.4.6.1 Stationarity

Stationarity is tested by applying Augmented Dicky Fuller Test (ADF).

If the two series are stationary, then the series are automatically (said to be) co-integrated (of order 0). Then they need to be tested for parametric restriction only.

If the series are found to be non stationary, as is expected, efficiency can still be tested if the series can be made stationary. If new series are formed by differencing the original series, it is possible that the new differenced series are stationary. This is because the common factors present in the error terms of two consecutive periods are removed by differencing. Hence, Normally, 1st difference of both series are sufficient to make the series stationary. If the series, even after one differencing, are found to be non stationary, then the revised series can be differenced again and again till the resulting series are stationary (as per some test, e.g., ADF Test).

5.4.6.2 Tests For Co-integration

There are two method which are widely used for testing for co-integration.

If an OLS regression is estimated with non-stationary data and residuals, then the regression is spurious. To overcome this problem the data has to be tested for a unit root (i.e. whether it is stationary). If both sets of data are I(1) (non-stationary), then if the regression produces an I(0) error term, the equation is said to be co-integrated. The most basic non-stationary time series is the random walk, the Dickey-Fuller test essentially involves testing for the presence of a random walk.

If two price series are both integrated of some order \(d\), a linear combination of the two series can be formed which is integrated of order less than \(d\). Thus, if two series are integrated of order 2, each, some linear combination can be formed which is integrated of order 1 or zero.

Thus, if two price series, one that of spot price and one that of futures price, are non-stationary but contain a unit root, e.g., I(1) (that is to say that first difference series is stationary), then a linear combination of the two series can be generated that is stationary, I(0). The two series are then said to be co-integrated.

Suppose \(S_t(.)\) and \(F_t(.)\) are the two series, spot price and futures price respectively. They both have unit root and are integrated of order 1. Then are said to be co-integrated if there is a non-zero vector \(A\) of constants such that \(AY\) is stationary. That is, it is possible to generate a series, from \(S(.)\) and \(F(.)\), by multiplying non-zero vector \(A\), such that the series is stationary. This can be represented as a Co-integration Equation: \(S_t=\alpha-\beta F_{t-i}+\mu_t\)

For markets to be efficient, Co-integration of the two series is a necessary condition. This is so because the efficient market hypothesis implies that the two price series move together in a pre-determined fashion, and not drift apart, so that futures price is an unbiased predictor of spot price. The co-integration of two series, as shown in equation (4) implies precisely that. Thus, if (4) holds, futures price is an unbiased predictor of future spot price.

**5.4.6.3 Test for Parametric Restriction**

In the third step, the series are modeled and tested for Parametric Restriction.
Once it is found that the two series are co-integrated, then they have been tested for Parametric Restrictions.

This test can be performed appropriately either when the series are stationary or the two series of data are co-integrated.

\[ S_t = a + b F_t + u_t \]

Where,

\( t = \text{time} \)

\[ \Delta S_t = S_{t+1} - S_t \]

\[ F_t = F_t - S_t \]

\( S_t \) and \( S_{t+1} \) are the logarithm of the spot rate at time \( t \) and \( t+1 \) respectively and \( F_t \) is the logarithm of the futures price and \( u_t \) is the error term.

In this form the unbiasedness hypothesis implies that \( \alpha = 0, \beta = 1 \) and \( u_t \) should have zero mean and be serially uncorrelated.

### 5.4.6.4 Testing for Efficiency in Short Term

If all necessary conditions for market efficiency are met, the efficiency of the series is proved for the long run. It does not necessarily imply efficiency in the short run. Short run market efficiency still needs to be tested (Hakkio and Rush, 1989).

This is so because even though long term equilibrium exists (as proven by satisfaction of the abovementioned conditions), in the short run there could be considerable departure from long run equilibrium relationship.

The short term market efficiency can be tested by Error Correction Model (ECM).

ECM can be written as:

\[ E_t = \sum_{i=1}^{\infty} \beta^i e_t \]
\[ i=m \quad i=n \]
\[ \Delta S_t = \alpha \cdot \rho U_{t-1} + \beta \Delta F_{t-1} + \sum \beta_t \Delta S_{t-1} + \sum \gamma_i \Delta F_{t-1,i} + \mu_t \]
\[ i=1 \quad i=1 \]

Where, \( \alpha \) is the intercept, \( \Delta S_t \) is the change in spot price of the commodity from period \( t-1 \) to \( t \), \( \Delta F_{t-1} \) is the change in futures price of the commodity, and \( U_{t-1} = S_t - c_1 F_{t-1} + c_0 \) is the error correction term (ECT).

In equation above, co-integration implies only that \( \rho > 0 \), because the spot price changes respond to deviations from the long run equilibrium as described by equation-3.

Short term efficiency can now be tested by testing the following restriction: \( \beta \neq 0 \) (i.e., all new information concerning future spot price is immediately reflected in a change in the current spot price), \( \beta_i = \gamma_i = 0 \), (i.e., past information is already completely incorporated in the current futures price) and \( \rho = 1 \) and \( \rho c_1 = \beta \).

If restrictions \( \rho = 1 \) and \( \rho c_1 = \beta \) 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) contribute useful information for the formation/prediction of the spot price of the present period.

Since \( c_1 \) is the coefficient of \( F_{t-1} \) in the co-integration relationship, and that for the market to be efficient, \( c_1 \) should be 1, we can finally conclude that the restrictions imposed for testing market efficiency are as follows: \( \beta_i = \gamma_i = 0 \), \( \rho = 1 \), \( \beta = 1 \) and \( \alpha = 0 \) (if we do not allow for the presence of a risk premium according to the unbiasedness hypothesis).

If the above relationship holds, these restrictions, thus, constitute the third condition for market efficiency.
Hence, if these three conditions are met, then one can conclude that the futures market for that commodity is efficient and that the futures price provide unbiased estimates, both, in the short run and in the long run.

To reiterate, the three conditions for market efficiency are:

A. For long Run

1. Co-integration is a necessary condition for market efficiency (assuming non-stationarity).
2. 1st Condition: The restrictions on values of $\beta$ and $\gamma_i (\beta=0, \gamma_i=1$, both jointly and individually), and,
3. 2nd Condition: The serial independence of $u_i$ is the second necessary condition for market efficiency.

B. For Short Run

1. Co-integration is a necessary condition for market efficiency (assuming non-stationarity).
2. Additional 3rd condition: The restrictions imposed for testing market efficiency are: $\beta_i=\gamma_i=0$, $\rho=1$, $\beta=1$ and $\alpha=0$

5.5 RESULTS AND ANALYSIS

5.5.1 DATA AND SAMPLING PLAN

The following four commodities’ futures markets are analyzed:

- Precious metals: 2 commodities, gold and silver
- Base metals: 1 commodity: Copper
- Agro commodities: 1 commodity: Rubber

The data collected are for the June and December contracts in 2007. Delivery dates are daily for 1 month forward.
The data consists of two time series for each commodity:

1. Daily commodity spot prices data for the period relevant period.
2. Daily commodity futures price with maturity of 1 month for the relevant period.

The required data is obtained from secondary sources. The data have been collected from major commodity exchanges in India, viz., MCX and NCDEX.

5.5.2 ANALYTICAL STEPS

Efficiency of four futures markets, viz., copper, gold, rubber and silver are examined in this research.

Efficiency is examined in four steps:

1. Check for Stationarity: Augmented Dicky Fuller (ADF) Unit Root Test for Stationarity
2. Check for Co Integration: Engle-Granger Co-Integration Test
3. Check for parametric Restriction: Wald test for Parametric Restriction
4. Check for uncorrelated error terms

However, since all the markets are found to be inefficient in the long term in 3rd step itself, 4th step was not carried out. Further, possible 5th step of examining short term efficiency was not executed since long term inefficiency exists.

5.5.3 COPPER

Copper (June, 2007 and December, 2007) futures contracts are analyzed for efficiency tests. Daily spot and futures prices are examined for one month period prior to the expiration date.

Visual indication from the price graph is that both price series are not stationary.
Hence, both the price series are tested for unit root. ADF test is applied and it is found that The coefficient of regression is not significantly different from zero at 95% confidence level. Hence, there is a unit root for both spot and futures series and hence the two series are non stationary. The series are then differenced and ADF test is applied again. The series are found to be stationary. These stationary series are tested for co integration by Engle-granger co integration test.

Spot price of copper is regressed against its futures price and the value of error term is obtained.

Then the difference between error terms of two time period is regressed with the error term of the previous time period. The results for june, 2007 contracts are as follows:

<table>
<thead>
<tr>
<th>TABLE-5.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-Integration Test for Copper Futures and Spot Price-June 2007 Contract</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Observations = 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>1 u(-1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>R-Squared</th>
<th>0.372796</th>
<th>3</th>
<th>Standard error of regression 0.023526</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Adjusted R-squared</td>
<td>0.372796</td>
<td>4</td>
<td>Durbin-Watson Statistic 2.017755</td>
</tr>
</tbody>
</table>
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for Copper June 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below:

------------------------------------------

Regression Statistics

Multiple R                   0.48
R Square                    0.23
Adjusted R Square    0.20
Standard Error           0.23
Observations                30

------------------------------------------

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>-0.55</td>
<td>0.19</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the futures market for copper is not efficient.
This market is again analyzed using December, 2007 contracts. The spot and futures price series are found to be non-stationary by ADF test, are made stationary by first differencing, and then tested for co-integration. The results are:

Co-integration Test for Copper Futures and Spot Price-December 2007 Contract

| TABLE-5.2 |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Number of Observations = 30 |
| Variable | Coefficient | Std. Error | t-Statistic | 2-tail Sig. |
| 1 | u(-1) | -0.6877564 | 0.1478484 | -4.6514530 | 0.000 |

The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for Copper December 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below

Regression Statistics

Multiple R 0.36
R Square 0.13
Adjusted R Square    0.11  
Standard Error           0.03  
Observations                42  


<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>-0.36</td>
<td>0.15</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the futures market for copper is not efficient.

Thus, for both June, 2007 and December 2007 copper futures contracts, the market is found to be inefficient.

5.5.4 GOLD

Gold (June, 2007 and December, 2007) futures contracts are analyzed for efficiency tests. Daily spot and futures prices are examined for one month period prior to the expiration date.

Visual indication from the price graph is that both price series are not stationary.

Hence, both the price series are tested for unit root. ADF test is applied and it is found that The coefficient of regression is not significantly different from zero at 95% confidence level. Hence, there is a unit root for both spot and futures series and hence the two series are non-stationary. The series are then differenced and ADF test is applied again. The series are found to be stationary. These stationary series are tested for cointegration by Engle-Granger cointegration test.
Spot price of copper is regressed against its futures price and the value of error term is obtained.

Then the difference between error terms of two time period is regressed with the error term of the previous time period. The results for June 2007 contracts are as follows:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>2-tail Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ( u(-1) )</td>
<td>-0.2227624</td>
<td>0.0751533</td>
<td>-2.9641056</td>
<td>0.004</td>
</tr>
</tbody>
</table>

The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for Copper June 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below

Regression Statistics

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple R</td>
<td>0.038671</td>
</tr>
<tr>
<td>R Square</td>
<td>0.001495</td>
</tr>
</tbody>
</table>
The null Hypothesis is Rejected. It implies that the futures market for gold is not efficient.

This market is again analyzed using December,2007 contracts. The spot and futures price series are found to be non stationary by ADF test, are made stationary by first differencing, and then tested for co-integration. The results are:

**TABLE-5.4**

Co-Integration Test for Gold Futures and Spot Price-December 2007 Contract

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>2-tail Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 u(-1)</td>
<td>-0.4871013</td>
<td>0.0973987</td>
<td>-5.0011045</td>
<td>0.000</td>
</tr>
<tr>
<td>1 R-Squared</td>
<td>0.252835</td>
<td>3</td>
<td>Standard error of regression</td>
<td>0.008050</td>
</tr>
<tr>
<td>2 Adjusted R-squared</td>
<td>0.252835</td>
<td>4</td>
<td>Durbin-Watson Statistic</td>
<td>2.435127</td>
</tr>
</tbody>
</table>
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for Gold December 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below

------------------------------------------------
Regression Statistics

Multiple R         0.1492
R Square           0.0223
Adjusted R Square  0.0087
Standard Error     0.0107
Observations       74
------------------------------------------------

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0015</td>
<td>0.0013</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>-0.1692</td>
<td>0.1321</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the futures market for gold is not efficient.
Thus, for both June, 2007 and December 2007 gold futures contracts, the market is found to be inefficient.

5.5.4 Rubber

Rubber (June, 2007 and December, 2007) futures contracts are analyzed for efficiency tests. Daily spot and futures prices are examined for one month period prior to the expiration date.

Visual indication from the price graph is that both price series are not stationary.

Hence, both the price series are tested for unit root. ADF test is applied and it is found that the coefficient of regression is not significantly different from zero at 95% confidence level. Hence, there is a unit root for both spot and futures series and hence the two series are non stationary. The series are then differenced and ADF test is applied again. The series are found to be stationary. These stationary series are tested for cointegration by Engle-Granger cointegration test.

Spot price of rubber is regressed against its futures price and the value of error term is obtained.

Then the difference between error terms of two time period is regressed with the error term of the previous time period. The results for June, 2007 contracts are as follows:

| TABLE-5.5  
<table>
<thead>
<tr>
<th>Co-Integration Test for Rubber Futures and Spot Price-June 2007 Contract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Observations = 101</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for Rubber June 2007 contract.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.000</td>
<td>-1.84</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>0.020</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the futures market for rubber is not efficient.

This market is again analyzed using December, 2007 contracts. The spot and futures price series are found to be non stationary by ADF test, are made stationary by first differencing, and then tested for co-integration. The results are:

<table>
<thead>
<tr>
<th>Number of Observations = 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>1 u(-1)</td>
</tr>
</tbody>
</table>
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for rubber December 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below.

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.00</td>
<td>0.00</td>
<td>0.96</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>-0.04</td>
<td>0.04</td>
<td>-1.25</td>
</tr>
</tbody>
</table>
The null Hypothesis is Rejected. It implies that the futures market for rubber is not efficient.

Thus, for both June,2007 and December 2007 rubber futures contracts, the market is found to be inefficient.

**5.5.7 SILVER**

Silver (June,2007 and December,2007) futures contracts are analyzed for efficiency tests. Daily spot and futures prices are examined for one month period prior to the expiration date.

Visual indication from the price graph is not conclusive.

Hence, both the price series are tested for unit root. ADF test is applied and it is found that the coefficient of regression is significantly different from zero at 95% confidence level. Hence, there is no unit root for both spot and futures series and hence the two series are stationary. These stationary series are tested for cointegration by Engle-granger co integration test.

Spot price of silver is regressed against its futures price and the value of error term is obtained.

Then the difference between error terms of two time period is regressed with the error term of the previous time period. The results for June,2007 contracts are as follows:

| TABLE-5.7 |
| Co-Integration Test for silver Futures and Spot Price-June 2007 Contract |
| Number of Observations = 101 | |

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>2-tail Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>u(-1)</td>
<td>-</td>
<td>0.0366397</td>
<td>-2.5322791</td>
</tr>
</tbody>
</table>

0.013
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for silver June 2007 contract.

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.000</td>
<td>-1.84</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>0.020</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the silver market for rubber is not efficient.

This market is again analyzed using December, 2007 contracts. The spot and futures price series are found to be non stationary by ADF test, are made stationary by first differencing, and then tested for co-integration. The results are:

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.000</td>
<td>-1.84</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>0.020</td>
<td>1.10</td>
</tr>
</tbody>
</table>

The null Hypothesis is Rejected. It implies that the silver market for rubber is not efficient.
The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for silver December 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>0.090</td>
<td>0.174</td>
</tr>
</tbody>
</table>

The results clearly show that the two series are co-integrated. So the primary condition for market efficiency holds true for silver December 2007 contract.

Next, the regression equation is tested for parametric restriction. The null hypothesis is that the parametric coefficient is not significantly different from 1. The result of the test is shown below

---

Regression Statistics

Multiple R 0.071
R Square 0.005
Adjusted R Square -0.014
Standard Error 0.013
Observations 54

---

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.003</td>
<td>0.002</td>
</tr>
<tr>
<td>X Variable 1</td>
<td>0.090</td>
<td>0.174</td>
</tr>
</tbody>
</table>
The null Hypothesis is Rejected. It implies that the futures market for silver is not efficient.

Thus, for both June, 2007 and December 2007 silver futures contracts, the market is found to be inefficient.

5.6 Results of Empirical Analysis and Conclusions

This study has used:

4. Augmented Dicky Fuller (ADF) Unit Root Test for Stationarity
5. Engle-Granger Co-Integration Test
6. Wald test for Parametric Restriction

The results are summarized below.

Copper spot price series and futures prices series for June 2007 contract are stationary hence co-integrated. When the series are tested for parametric restrictions, the constant term is found to be not statistically different from zero. However, the coefficient of the independent variable is statistically different from zero. Hence, it is concluded that the copper futures market is inefficient. This result is confirmed again for December 2007 contract.

Gold spot price series and futures prices series for June 2007 contract have unit root and are both non stationary. The first difference series are stationary and are co-integrated. When the series are tested for parametric restrictions, the constant term is found to be not statistically different from zero. However, the coefficient of the independent variable is statistically different from zero. Hence, it is concluded that the gold futures market is inefficient. This result is confirmed for December 2007 contract.

Rubber spot price series and futures prices series for June 2007 contract are stationary hence co-integrated. When the series are tested for parametric restrictions, the constant term is found to be not statistically different from zero.
However, the coefficient of the independent variable is statistically different from zero. Hence, it is concluded that the gold futures market is inefficient. This result is confirmed for December 2007 contract.

Silver spot price series and futures prices series for June 2007 contract are stationary hence co-integrated. When the series are tested for parametric restrictions, the constant term is found to be not statistically different from zero. However, the coefficient of the independent variable is statistically different from zero. Hence, it is concluded that the gold futures market is inefficient. This result is confirmed for December 2007 contract.

<table>
<thead>
<tr>
<th>Table-5.9</th>
<th>Results of Futures Markets’ Efficiency Tests</th>
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<tbody>
<tr>
<td>Commodity</td>
<td>Future Contract</td>
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<td>Copper</td>
<td>June 2007</td>
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<tr>
<td>Copper</td>
<td>December 2007</td>
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<td>Gold</td>
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The finding of this research suggests that the Indian Commodity futures markets are inefficient across all the four commodities tested. Though the period of the study is 2007, the results are probably true even today. The results are in line with the experience across the world. The futures markets, without adequate depth, and broad spectrum of participation, are likely to be inefficient.

Market inefficiency implies that the price discovery is inefficient and hence the markets do not really provide hedge or that the basis risks that replace price risks are quite large. This is not surprising since a very large number of producers are not educated, do not participate in the market. To this add that since weather is a major input and influence on the output and whose stochastic path itself is difficult to predict price prediction is not easy. For other assets, e.g. financial assets, short term price movement has been well researched and it is well established that they follow log normal weiner process. For price of commodities the path, though known to be stochastic, is not necessarily log normal.

Second, the spot markets themselves are inefficient as can be seen from wide fluctuations of prices over a short period. Even in the spot markets, trading in small hemlets is controlled by an oligopolist trading community which may have a cartel against the primary producers. The spot markets are fragmented and hence not coordinated. Information flow and flow of physical products is slow. Thus, for example, there could be large disruption in local spot markets even when the national markets may digest this information only slowly or not at all. In such cases, obviously, the futures markets have different outcomes for different producers of the same product. Besides, operational inefficiencies in Physical market, like,
Troubles in handling, transportation, warehousing and delivery of products to contract specification, directly affect the efficiency of the spot market.

Third, since the participation is small, the markets have remained small as compared to the world commodities markets and equity markets.

It is likely that existence of multiple regulatory authorities result in inefficiency of the markets. For example, the spot or physical markets in agriculture are controlled by APMC act and are a state subject. But the derivative commodity markets come under FMC and hence central government jurisdiction.

In India, and for that matter most developing countries, the government intervention in the market could be unpredictable, sudden and frequent. For example, recent case of onions price rise. Large policy flip flop and delay in intervention when required affected welfare of a large populace. Banning of few commodities to be traded in derivative segment (in most cases without scientific reasons) could act as deterrent for players to enter the commodity derivative market.

One reason that focus of this research is less on agricultural products is precisely because metals markets are more competitive, have more predictable production path and hence are more likely to deliver efficient futures markets. When even those markets are not efficient, one can reasonably say that the entire futures markets for commodities are likely to be inefficient.

This is not to say that the futures markets fail to play constructive role. The futures markets do provide hedging for players who participate and are knowledgeable. Also, futures markets provides taking a position and liquidating them as soon as new information comes in, hence it allows risk taking. The benefits are too few, though.
5.7 LIMITATIONS OF THE STUDY

This study was conducted in 2008. It is likely that the efficiency of the markets have improved since then.