COMBINING PRICE FORECASTING AND HEDGING OF CRUDE PALM OIL IN THE COMMEX MALAYSIA

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirement for
the Degree of
DOCTOR OF PHILOSOPHY
May 2001

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IN THE COMMEX MALAYSIA

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ACKNOWLEDGMENTS

I would like to express my sincere appreciations and thanks to my major advisor, Dr. Daniel S. Tilley, for his patience, understanding, advise, encouragement, support and guidance with this study. The contribution of my other committee members: Dr. Brian D. Adam, Dr. Rodney B. Holcomb and Dr. Ronald K. Miller are also greatly appreciated. Their constructive guidance and assistance were invaluable during the development and completion of this study.

I would also like to thank my friends that I had before I came to Stillwater, especially to the late Drs. Supriyadi R.S. MM, Drs. Adi Susilobudi, Drs. Darmanto Yatman SU, and Dr. Arief Budiman, who have literally changed my life. Also thanks to all my former bosses and colleagues at Moto Mobil Group, particularly Mr. Sindu Dharmali, Mr. Adi Suharno, Mr. Jio Eng Hoo and Mr. Thong Bun Tong, who gave me the opportunity to pursue my dreams. A special thanks goes to Indonesian European University Semarang branch, an institution that made my impossible dream come true.

I also wish to extend my appreciation to my fellow students and friends for giving their own time to help me with my research, especially Michael Huebschmann, Hubertus Puaha, Yulita Susanti, Yoesbar Sofyan, Haerani N. Agustini and others. The interaction I had with the faculty, staff, and students here at Oklahoma State University has been very pleasant and is gratefully acknowledged.

I would like to offer a sincere thanks to my late father and my mother, who have invested their life to raise and educate their seven children, for providing me with experience that inspired curiosity and wonder. I am grateful to my sisters, Liliana Adhitama MBA, Ir. Ingrid Yunita Adhitama, Amelia Sidney Jani MBA CPA, Natalie Mariana Adhitama SE MBA and Siska Anggraeni Adhitama SE MBA, my younger brother Drs. Prasetya Adhitama Akt MBA CPA, and my brother–in-law, Kurniawan Jani PE, who provide their unending support throughout my educational development and always believed I could do it.

I would like to offer my deepest appreciation and thanks to my wife, Drs. Endang Nina Sugiarti Psi., whose continued support, unending encouragement, assistance, understanding, and mostly her undying love, contributed greatly to the completion of this study. I would also like to offer my gratitude to her for being so patient during my lengthy time spent on this study and for always having faith in my ability to accomplish what I thought I could not achieve. She has played perhaps the biggest role in my success. She has been there to see me through the toughest times and the aftermath. Here is the future!

Lastly, I also would like to express deep gratitude to my kids: Mita Young, Gita Young and Jimy Young, whose curiosity, creativity, and loving support have nourished me in countless ways. Without their love and support throughout life, I would never have been able to succeed. They truly are a gift from God.

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Introduction

Crude Palm Oil

World production of the 17 major oils and fats in 1999 amounted to approximately 110 million metric tons. Palm oil forms an important part of it and accounted for as much as 29 percent and 40 percent of the production and exports respectively (COMMEX Malaysia, 2001). Palm oil is soybean oil's most important competitor. Soybean and palm oils consistently constitute more than half of world production and exports of vegetable oils. Soybean oil represented 28.3 percent of world production of vegetable oils in 1999 with palm oil ranks second with 23.5 percent.

The oil palm tree was originally cultivated as a source of oil in West and Central Africa, where it originated. Later it was planted in Malaysia and Indonesia. It has many tiny flowers crowded on short branches that develop into a large cluster of oval fruits one and one half inches long, black when ripe and red at the base. The outer fleshy portion of the fruit is steamed to destroy the lipolytic enzymes and then pressed to recover the palm oil, which is highly colored from the presence of carotene. The kernel of the fruit is also pressed in chemical screw presses to recover palm kernel oil, which is chemically quite different from the oil from the flesh of the fruit.

Although it is a perennial crop, producing oil-bearing fruits all year round, production of palm oil is seasonal. From January through March, oil palm trees enter a cycle in which the fruit will produce less oil. Its supply is relatively stable as producers often continue to harvest the fruit even during short periods of depressed prices. Oil palms are most productive between three and seven years of age, even though the trees remain commercially productive for 20-25 years. After 15 years they produce little oil, and are usually replaced (Fischer and Thompson, 1999).

For every 10 tons of palm oil, about 1 ton of palm kernel oil is also obtained. Several processing operations are used to produce the finished palm oil that meets the user's requirements, as shown in Figure 1. The first step in processing is at the mill, where the crude palm oil is extracted from the fruit to release fatty oil used in soaps, candy bars, snack food, fuel oil, cooking oil, shortening, vegetable ghee and a wide range of other products, as in Figure 2. Markets for inedible crude palm oil include soaps, tin plating, fatty acids and lubricants. The oil is also used in cosmetics, detergents, and as a diesel fuel substitute.

The oil palm was introduced into Malaysia in 1870 from West Africa, but was grown on a commercial scale beginning in 1917. Malaysia has been the world's largest producer and exporter of palm oil from the 1960s through 1990s. In 1994, Malaysia accounted for 51.7 percent of world production and 66.3 percent of world export. Indonesia is second with 26 percent of world production and 19 percent of export (Othman, Jani and Alias, 1998). In 1998 Malaysia produced 8.3 million tons (PORIM, October 25, 1999) and Indonesia produced an estimated 5.2 million (Financial Express, July 29, 1998). USDA expected Malaysia to produce 8.8 million and Indonesia produce roughly 5.5 millions metric tons of palm oil in 1998-99.

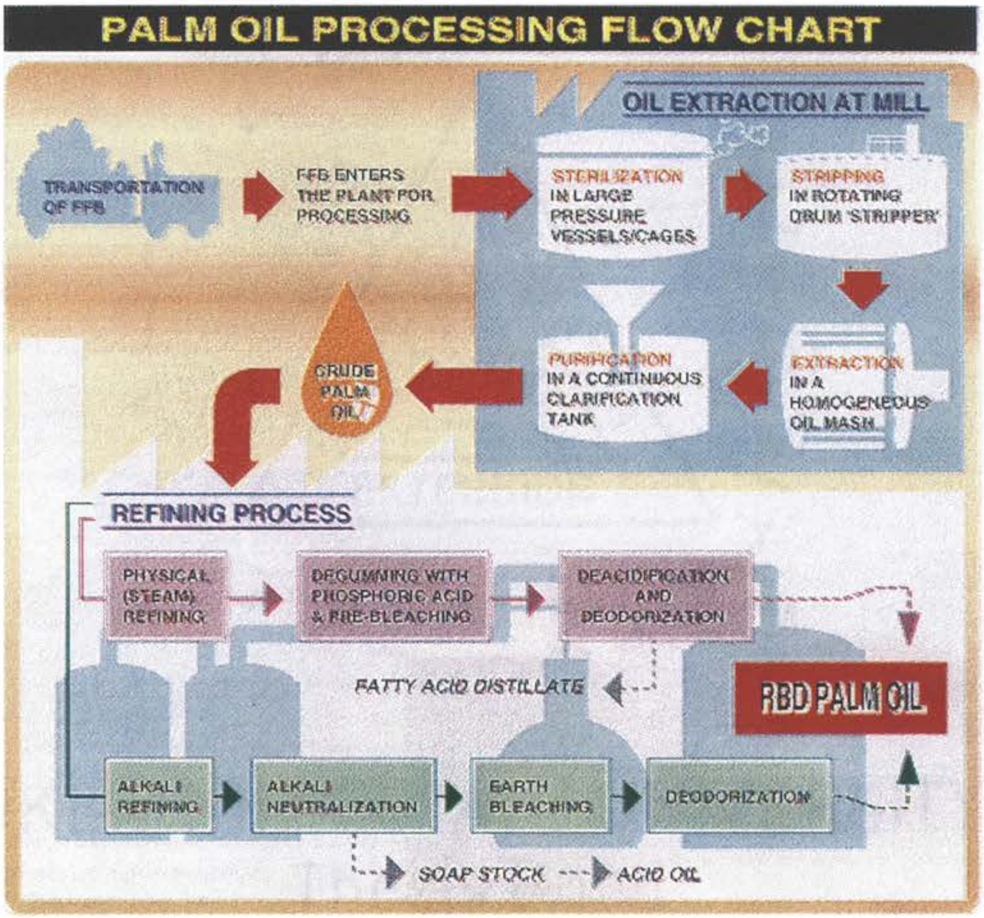

Figure 1: Palm Oil Proccessing Flow Chart

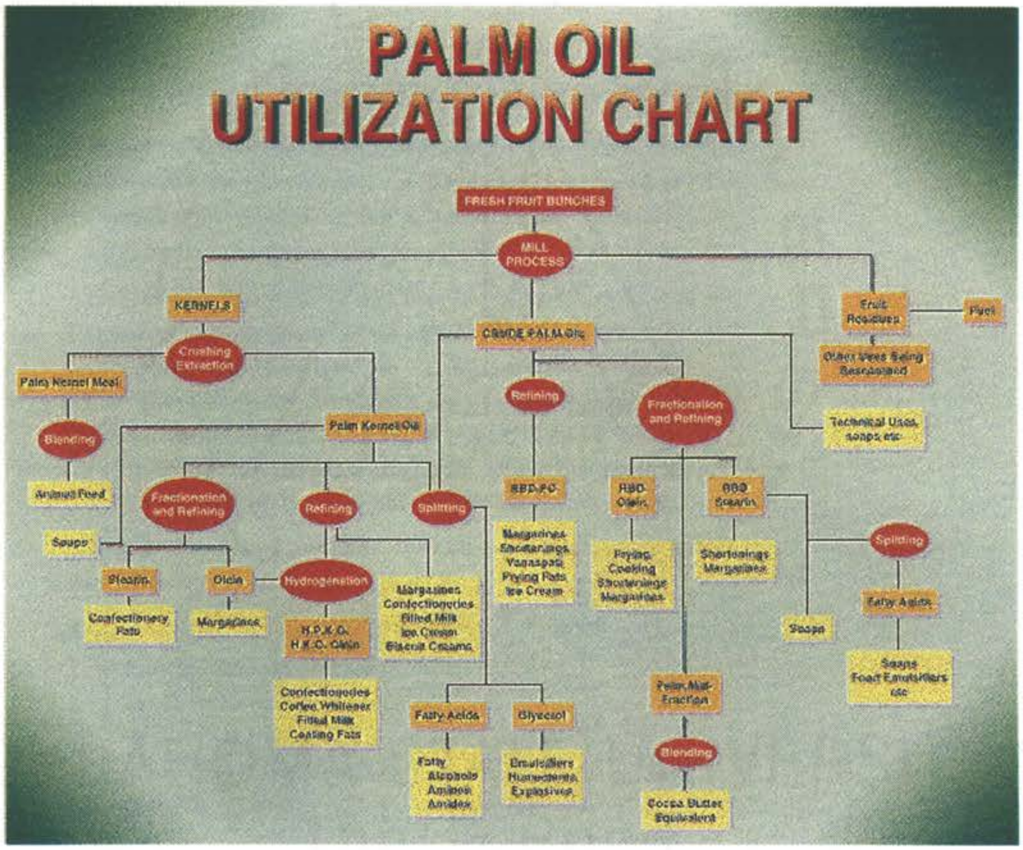

Figure 2: Palm Oil Utilization Chart

Palm oil is also an economically significant commodity for Indonesia. Crude palm oil (CPO) is processed into olein, which is used as cooking oil, an important source of vegetable oil for the Indonesian domestic market. Since early 1990, oil palm has been one of the fastest growing subsectors in Indonesia. In two decades, annual Indonesian output grew from less than 400,000 tons to more than 4 million (Larson, 1996). The share of palm oil in the total domestic market for cooking oils grew from 48 to 78 percent between 1984 and 1992. This increase has been largely at the expense of coconut oil since palm oil sells at a lower price than coconut oil.

Oil palm planting in Indonesia has expanded dramatically over the past 15 years. Between 1985 and 1994 planting grew by 12.5 percent per year, with the most significant development coming from both small holdings and private plantations. The area planted under oil palm has increased by a factor of seven from 261,000 ha in 1979 to 1.8 million ha in 1994 (P.T. Indeco Duta Utama , 1996). Availability of suitable land in Indonesia will not be a major problem for the oil palm industry for the next 20 years.

Indonesia ranks number two in terms of total tonnage after Malaysia, but due to recent Indonesian government policy, investment in Indonesian palm plantations has rapidly increased. Oil palm trade has gradually been liberalized starting in late 1987. The December 24, 1987 package (PAKDES) deregulated exports of Refined Bleached Deodorized Olein (RBDO). This made domestic price stabilization impractical as domestic RBDO prices were now directly linked to export prices. Quantitative restrictions on international trade in CPO, copra and Coconut Crude Oil (CCO) were eliminated in the June 3, 1991 policy package (PAKJUN). Private firms were free to export CPO. Further deregulation was contained in a May 23, 1995 deregulation package (PAKMEI).

After the International Monetary Fund made a recent financial package to Indonesia contingent on liberalization of the palm oil sector, and the establishment of the World Trade Organization, the government decided in 1995 to allow foreign investment in the palm oil sector. The move has been seen as beneficial to Malaysian companies, since they face expansion problems in their own nation due to scarcity of plantation workers and land. Indonesia, with her abundant supply of labor and land, enjoys a comparative advantage in the production of palm oil. Some 27 large Malaysian palm oil companies had agreed to joint ventures with Indonesian counterparts by March 1997 (Financial Times, August 11, 1997). The new joint ventures intend to develop about 1.5 million hectares, compared with a total existing area of oil palm groves in Indonesia of 2.2 million hectares.

Palm oil output in Indonesia is expected to grow from 4.7 million tons in 1995 to nearly 13 million tons in the year 2010 or at annual rate of 6.2 percent. Domestic consumption is expected to grow at 7 percent per year and hence the annual growth for exports for this period will only be at the rate of 5.8 percent per year. Even with this slower growth in exports, Indonesia will be able to export 8.7 million tons of palm oil (more than two-third of its output) in the year 2010 or nearly 3 times the quantity exported in 1995 (P.T. Indeco Duta Utama, 1996). USDA expects world palm oil production for the 1999-2000 marketing year to reach a record 20.6 million metric tons. Malaysia is set to become the world's largest producer at 10.2 million metric tons in 1999-2000, up from 9.7 million metric tons in 1998-99. Malaysian palm oil exports are set to rise by 550,000 metric tons, reaching 8.65 million metric tons in 1999-2000 (Papanikolaw, 1999).

Commodity and Monetary Exchange of Malaysia (COMMEX Malaysia)

The Commodity and Monetary Exchange of Malaysia (COMMEX Malaysia) was the only market in the world that trades CPO and Refined, Bleached Deodorized Olein (RBDO) futures until December 14, 2000, Jakarta Futures Exchange started trading CPO and it's derivative on December 15,2000, and Kuala Lumpur (KLIBOR) contracts. Trading is conducted in a pit on the trading floor using the open outcry system of trading. The KLCE was Malaysia's first futures exchange and commenced trading on July 14, 1980. On November 9, 1998 they changed the name to Commodity and Monetary Exchange of Malaysia (COMMEX Malaysia). The change of name reflects the imminent merger between the KLCE and its subsidiary, Malaysia Monetary Exchange (MME), which was finalized on December 7, 1998. COMMEX Malaysia operates under the supervision of the Securities Commission and is governed by the Futures Industry Act (FIA) 1993. The Exchange[1] also falls under the jurisdiction of the Ministry of Finance of Malaysia, thus offering investors the security of trading on a regulated Exchange with rules and regulations very similar to those in the more established markets worldwide.

The crude palm oil futures contract trades on a contract size of 25 metric tons of crude unbleached palm oil of good merchantable quality in bulk plus or minus not more than 2%, deliverable in Port Tank Installations in Malaysia at the option of the seller at

[1] COMMEX Malaysia located at 5th Floor, Citypoint, Kompleks Dayabumi, Jalan Sultan Hishamuddin, P.O. Box 1260, 50740 Kuala Lumpur.

Port Kelang, Butterworth/Prai and Pasir Gudang. Free Fatty Acid (FFA) of palm oil delivered into Port Tank Installations shall not exceed 4%, and from Port Tank Installations shall not exceed 5%. Moisture and impurities shall not exceed 0.25%.

Features and Limitations

The contract unit shall be 25 metric tons (25,000 kilogrammes). Bids and offers may be accepted in lots of 25 metric tons or multiples thereof. Price quotations are in Malaysian Ringgit (RM) per metric ton. The minimum price fluctuation is RM 1.00 per metric ton. The daily price limits are as follows: RM 100 per metric ton above or below the settlement prices of the preceding day for all months, except the current month. Each single floor transaction shall not exceed 20 lots. Limits are expanded when the settlement prices of all three months immediately following the current month, in any day, are limits as follows:

Table 1: Daily Price Limit.

Day	Limit (RM)
First	100
Second	150
Third	200

Daily price limits will remain at RM 200, when the preceding day's price of all the three quoted months immediately following the current delivery month settle at limits of RM 200.

Delivery months are the current and the next 5 succeeding months and thereafter alternate months up to 12 months forward. At any point in time, an individual may trade in any delivery month up to 12 months forward. Trading in each delivery month shall cease on the 15th day of each month. A contract month expires at noon on the 15th day of the month, or the preceding business day, if the 15th is a non-market day. The trading occurs on Monday through Friday except holidays while the trading hours are divided into Morning Session 10.30 – 12.30 and Afternoon Session 15.00 – 18.00 Malaysian Time. Malaysia is 8 hours ahead of Greenwich Mean Time and 14 hours ahead of United States Central Standard Time (13 hours ahead in Daylight Saving Time).

The initial margin for each contract ranges between RM 2,500 to RM 3,000 for spot months, between RM 1,250 to RM 1,600 for remote months and between RM 400 to RM 500 for spreads.

The reportable position and position limits are 100 contracts and 500 contracts respectively, long or short, in any one delivery month and all months combined.

All contracts executed on the Floor of the COMMEX Malaysia are guaranteed, initially by the respective Clearing Members and thereafter by the Clearing House once the contracts have been matched and accepted for clearing. The Clearing House only deals with its Clearing Members. Therefore, any COMMEX Malaysia member who wishes to trade directly on the floor of the COMMEX Malaysia, and who is not a Clearing Member himself, has to appoint a Clearing Member to clear their trades. This is to ensure that there is a financially strong party standing behind all contracts as soon as they are transacted.

Table 2: Minimum Cost of Trading (Roundturn in RM)

	Day Trade	Overnight Trade
Member	26.5	53
Trade Affiliate	26.5	53
Non Member	51.5	103
	(Negotiable to 29.50)	(Negotiable to 59)

Problem Statement

Malaysia will continue to be the main actor in world palm oil production in the next century. This is because Malaysia has highly efficient managerial skills, large amounts of accumulated capital and advanced technologies to refine crude palm oil, none of which is available in other major palm oil producing countries. In addition to being the largest producer, Malaysia should continue to dominate the global market by exporting roughly 84 percent of its output in 1998-99, compared to 45 percent for Indonesia (Papanikolaw, 1998), but many observers predict Indonesia will supplant Malaysia as the world's top producer in the first few years of the 21st century.

The palm oil industry in Indonesia is facing an evolution from government sponsorship and market interventions to private-sector-initiative responses to international price signals. As the (would-be) biggest producer who must market its commodity in the global market, Indonesian companies must cope with the risk of price changes. Price risk has always played a significant role in agricultural commodity trade. Risk management strategies and hedging tools must be developed to effectively stabilize prices and reduce risk. Ginn and Purcell (1987) showed an improvement in price risk management might contribute to the competitive nature of an industry.

Futures contracts are potential price risk-management tools for producers. The futures market, which provides price discovery and a mechanism for price risk management in a market economy, would enable them to hedge against the adverse fluctuations in cash prices. Hedging in the futures market offers a way of reducing this risk. Hedging, which is purported to reduce the risk of unfavorable cash price movement, producers can transfer cash price risk to another trader. Better management of commodity price risk, by forecasting futures prices and hedging in futures markets, could benefit producers, by reducing price risk. Brandt (1985), Holt and Brandt (1985), Park, Garcia and Leuthold (1989) have found encouraging results when combining hedging strategies with forecasting techniques. The core problem when deciding upon a hedging strategy is to see if futures prices are an unbiased forecast of the cash prices.

Objectives of the Study

The general objective is to determine if the COMMEX Malaysia palm oil futures contract can be used to reduce the Indonesian CPO producers' risk exposure due to cash price fluctuations.

Specific Objectives are to:

1. Evaluate the relationship between CPO's futures and cash prices, and
2. Measure the effectiveness of hedging in the CPO futures market.

Organization of the Dissertation

The remainder of this dissertation is organized as follows. Chapter II discusses futures markets, and how futures markets are linked to cash markets. In Chapter II, the ability of forecasting methods to generate information which, when incorporated with hedging strategies, can reduce producers' exposure to unfavorable price moves is evaluated. The concept of market efficiency is also introduced. Cointegration and the interrelationship of cointegration and econometrics are reviewed. A discussion follows on how cointegration reflects upon economic interrelationships in general (e.g., the Efficient Market Hypothesis). Chapter II presents the methodology used to determine which futures price is the unbiased prediction of the future cash price. This is accomplished by studying the time series relationship between daily data for CPO cash and futures prices. Implication of the results with respect to the above issues are discussed.

Chapter III evaluates how hedging in the futures markets against fluctuation in the actual cash commodity market may improve price risk management for risk-averse producers. Four models, with different utility functions, are applied to compare the hedging effectiveness of the naïve and port folio model-based hedges. Chapter IV summarizes the conclusions of the dissertation.

Chapter II

Cointegration Test for Market Efficiency

Purpose of this Chapter

This chapter discusses the futures market, and how futures market prices affect the market for the commodity or asset underlying the futures contract. Since forecasting futures prices is an integral component of profitable futures trading, it also determines whether forecasting methods, such as cointegration, can generate the information needed. The basics of cointegration-econometrics are reviewed. A discussion follows on how cointegration reflects upon economic interrelationships in general and, more specifically, how it reflects on issues of interest to futures market participant (e.g., market efficiency). The concept of market efficiency will be introduced. Efficiency implies futures prices are the best forecast of the future cash prices. This chapter utilizes cointegration testing to investigate market efficiency among Malaysian daily CPO cash and futures market prices and to examine whether a long-run relationship exists between CPO cash and futures prices.

Futures Market

One important role of a futures market[2] is to serve as a risk management vehicle for businesses facing price risk in the cash market. A benefit that futures markets provide is their ability to "discover" future equilibrium prices in cash markets – their price discovery role.[3] Price discovery in futures markets is commonly defined as the use of futures prices to determine expectations of (future) cash market prices (Peck 1985, Schroeder and Goodwin, 1991 and Working, 1948). Futures contracts are traded for the delivery of the underlying asset at various points in the future, and they reflect the current expectations of the market about the course of cash prices at those points in the future. The hypothesis that futures prices lead cash prices is that futures markets perform the function of price discovery as pointed out by Garbade and Silber (1983).

Futures markets enable price discovery and provide a mechanism for price risk management (hedging) in a market economy. The essence of this function is to establish a competitive reference (futures) price for a commodity from which the cash price can be (subsequently) derived. The price discovery benefit of futures trading is predicated on the assumption that futures prices reflect the combined views of a large number of buyers and sellers, all expressing their perceptions of the future value of some commodity. The primary benefits from commodity futures markets are informed production, storage, and processing decision (Black, 1976).

[2] Telser (1981) argued that organized futures market exist because they are superior to informal forward markets. An organized futures market has elaborate written rules, standing committees for adjudicating disputes, and a limited membership. In contrast to futures contracts, forward contracts rely on the good faith of individual parties.

[3] When the futures prices of commodities are known with certainty, there is no reason to establish a futures market. Economic agents can construct a futures position in any commodity by borrowing or lending, since the future value of both the loan and the commodity are known.

This does not imply that a futures price is necessarily a forecast of the price that will exist in the cash market at some future date. Futures markets do not set prices. Prices are determined by free market forces that can assimilate new information quickly and efficiently reflect current information about a commodity as market price. A futures price is a price at which individuals are willing to accept an immediate obligation to either make or take delivery of the traded commodity when the futures contract expires.[4]

For allocative effiency, the economy wants the supply of goods to equal the demand for goods, over time. In a market economy this is accomplished through cash and futures prices. Futures markets help to balance supply and demand over time, particularly by providing market guidance in the holding of inventories (Houthakker, 1992). The cash price is determined as the sum of the futures price, dependent primarily on expectations, plus a premium dependent on the shortage of currently available supply. If, for example, futures prices for distant deliveries are well above those for earlier deliveries, postponement of use becomes more attractive. Thus, changes in futures prices result in subsequent changes in cash prices arising from changes in the spot demand for the commodity.

The futures price can be viewed as an assimilation of opinion concerning future supply and demand conditions, which are based on the information available at the time the price is recorded. As the delivery period approaches, the information available to traders changes, and so do their perceptions of future supply and demand. Changes in supply and demand perceptions result in changes in the futures market prices. By continually recording changes in market agents' supply/demand perceptions, prices for future delivery periods are continually updated.

[4] In reality the delivery date is usually spread over some time interval.

Market Efficiency

If the changes in prices accurately reflect changes in actual supply/demand perceptions, then the benefits from allowing futures trading presumably accrue not only to the direct futures market participants, but also to anyone else with an interest in the future value of the traded commodity. If futures prices accurately reflect market participants' current supply/demand expectations for future delivery periods, the market is considered to be efficient. The efficiency of futures markets is critical to their price discovery role.

Market efficiency implies that futures prices do not consistently over- or underpredict cash prices. The market price should fully reflect all relevant and available information in determining price so that there exists no strategy from which a trader can profit consistently by speculating in the forward or futures market on the future level of cash prices. Under the hypothesis of market efficiency, an efficient market is one that accurately incorporates all known information and adjusts to new information when determining prices.[5]

Fama's (1970) original definition came to be known as the efficient market hypothesis (EMH). According to Fama, there are three levels of market efficiency. Weak-form effiency suggests that market prices reflect all market-related information, such as historical security price movement and volume of goods traded. Thus, investors will not be able to earn abnormal returns from trading strategies based solely on past price movements. Semistrong-form efficiency suggests that market prices fully reflect all public information. The difference between public information and market-related

[5] Fama (1970) referred to the definition used here as strong-form efficiency in his 1970 article and as tests for private information in his 1991 update article.

information is that public information also includes announcements by firms, economic or political news or events. Market-related information is a subset of public information. Thus, if semistrong-form efficiency holds, weak-form efficiency must hold as well. Investors could earn abnormal returns by using relevant information not immediately accounted for by the market. Strong-form efficiency suggests that market prices fully reflect all information, including private or insider information. If strong-form efficiency holds, semistrong-form efficiency must hold as well.

The success of a specific futures contract in providing price risk protection, however, is dependent on the ability of a potential hedger to accurately anticipate the future relationship between cash and futures prices. Garbade and Silber (1983), Herbst, McCormack, and West (1987), Kawaller, Koch, and Koch (1987), Schroeder and Goodwin (1991), and Pizzi, Economopoulos and O'Neill (1988) indicate that price discovery occurs more often in the futures market then in the cash market. Ollerman and Farris (1985), Brorsen, Ollerman and Farris (1989), Koontz, Garcia, and Hudson (1990), Bessler and Covey (1991) found that the cash price on a nonstorable commodity (live cattle) generally responded to futures prices.

If the futures market is efficient (ignoring transaction costs), futures prices should fully and instantaneously reflect all available relevant public information. If the market is efficient, current futures prices should be an unbiased predictor of future cash prices. If current futures prices are the unbiased predictor of future cash prices, this behavior implies a long-term relationship between current futures prices and future cash prices, and that these two series should be cointegrated.

Although cash and futures prices of most commodities are generated by stochastic processes that are nonstationary,[6] and may wander widely, the two series may share the same stochastic trend. A variable Y_t has a stochastic trend if its first difference, $Y_t - Y_{t-1}$, has a stationary invertible[7] auto regression moving average (ARMA) representation plus a deterministic component. For example, random walks have stochastic trends because their first difference is white noise.

Stochastic trends are prevalent in financial data (Brenner and Kroner, 1995; Phillips and Xiao, 1999). For example, stock prices, foreign exchange rates, forward prices, and futures prices are known to have stochastic trends. A crucial implication of this in empirical finance is that the set of statistical models and tests that can be used to test financial theory are restricted, because many popular models and tests are inappropriate in the presence of stochastic trends.

Cointegration

Cointegration is a statistical property that some non-stationary time series data possess, which may describe their long-run equilibrium relationship and short-run dynamics. The theory of cointegration is that even though individual variables behave wildly (are non-stationary) there may be relationships between them that are nicely

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[6] The practical implication of nonstationarity is that past prices cannot be used to predict future prices.

[7] Any stationary moving average process can be written as an auto regressive process. An MA process of order q, MA(q), has the form $y_t = e_t + \alpha_1 e_{t-1} + \ldots + \alpha_q e_{t-q} = (1 + \alpha_1 L + \ldots + \alpha_q L^q)et = \alpha_q(L)e_t$. Such a process can be written as an infinite AR process if all roots of the polynomial $\alpha_q(z) = 1 + \alpha_1 z + \alpha_2 z^2 + \ldots + \alpha_q z^q$ have modulus greater than 1, that is, the roots are outside the complex unit circle. An MA process that meets this condition is called invertible. If MA(q) is invertible, then MA(q) $\equiv$ AR(∞)

behaved (are stationary[8]). A cointegrated system is a set of time series data that individually follow difference-stationary linear processes, but one or more linear combinations of the series do not require differencing to appear stationary. In general terms, two variables are said to be cointegrated when they have a common trend, causing them to move together in the long run.

The theory of cointegration is used extensively in studies of the relationships between futures or forward prices and cash prices. The techniques of unit root testing[9] and cointegration may be used to test for common stochastic trends, and their implication for addressing the market efficiency hypothesis. Ackert and Racine (1998), Arize (1994), Brenner and Kroner (1995), and Hakkio and Rush (1989) used cointegration theory to test whether there is a long-run relation between two time series. Importantly, cointegration ties together several apparently disparate fields[10] (Erricson, 1991).

Two variables are said to be cointegrated when a linear combination of the two is stationary, even though each variable is non-stationary. The stationary linear combinations indicate long-run relationships. If the series are cointegrated, they are not expected to drift too far apart. Therefore, if the series are cointegrated, it can be concluded there exists a fundamental long-term equilibrium such that shocks can cause

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[8] A stationary series has a mean and there is a tendency for the series to return to that mean. It has a finite variance, shocks are transitory, and its autocorrelations ρ_k die out as k grows.

[9] Let $y_t = y_{t-1} + \varepsilon_t$, where ε is a stationary error term, i.e., ε is $I(0)$. Here y can be seen to be $I(1)$ because $\Delta y_t = \varepsilon_t$, which is $I(0)$. Now let this relationship be expressed in a slightly more general form as $y_t = \alpha y_{t-1} + \varepsilon_t$. If $|\alpha| < 1$, then y is $I(0)$, i.e., stationary, but if $\alpha = 1$ then y is $I(1)$, i.e., nonstationary. Thus normal tests of stationarity are tests for $\alpha = 1$, and because of this are referred to as tests for a unit root (Kennedy 1998).

[10] At a casual level, many observed time series seem to display characteristics. Some series grow in a secular way over long periods of time, others appear to wander around as if they have no fixed population mean.

the cash market and the futures market to diverge but they return rather quickly into equilibrium with each other.

Consider two time series, say S_t for the future cash price and $F_{t\text{-}1}$ for the futures price of a commodity. Market efficiency implies that the current futures price, $F_{t\text{-}1}$, of a commodity futures contract expiring in period t-1 should equal the commodity cash price, S_t, expected to prevail in t during delivery at delivery point. Hence, efficiency implies $F_{t\text{-}1}$ is the b est forecast of S_t and that $F_{t\text{-}1}$ incorporates all relevant information including past cash and futures price.

A data series where the orders of observations are important is said to be integrated of order *b,* if *b* differences are required to transform the data to a stationary state. For example, a series of futures prices is integrated of order one if the series is stationary after first differencing. Assume that both S_t and $F_{t\text{-}1}$ are nonstationary and need to be differenced once to induce stationarity, it is said that the two series S_t and $F_{t\text{-}1}$ are cointegrated if individually they are integrated of order one.[11]

Similarly, a series of cash prices would be integrated of order *d* if *d* differences are required to transform the series to a stationary state. A series of data indexed by time (a set of data in which order of observation is important) is said to be integrated of order *d* if it requires *d* first differences to reduce the resulting series to stationarity e.g., $d = 2$ if $(X_t - X_{t-1}) - (X_{t-1} - X_{t-2}) = Z_t$ is stationary. Two series, for example cash S_t and futures prices, $F_{t\text{-}1}$ are said to be cointegrated if they are integrated of orders *b* and *d*, respectively, and their linear combination is integrated of order *b-d*, $d > 0$. In

[11] If an economic time series Y_t follows a random walk, its first differences form a stationary series. In this case Y_t is said to be integrated process of order 1 and denoted $I(1)$. On the other hand, if Y_t is stationary, then it is integrated of order zero, and denoted $I(0)$.

cointegration notation, two series are said to be cointegrated of order (d, b) if the individual series are integrated of order (d) and their linear combination is integrated of order ($d - b$) (Engle and Granger, 1987).

The most common case in the literature is where the two series are both integrated of order one and their linear combination is stationary without differencing. Gould and Nelson (1974) and Granger (1986) find that many economic time series do appear to require first differencing ($d = 1$) to achieve stationarity.

In general, most linear combinations of S_t and F_{t-1}, such as $S_t - \alpha F_{t-1} = V_t$, also are nonstationary. Of course, if first differencing causes S_t and F_{t-1} to be stationary, then V_t will be stationary after first differencing. However, there may exist a linear combination of S_t and F_{t-1} that is stationary. For example, there may be a number β such that $S_t - \beta F_{t-1} = V_t$ is stationary. In this special case, S_t and F_{t-1} are said to be cointegrated of order (1,1), with a cointegration factor of β. Thus, if S_t and F_{t-1} are cointegrated with a cointegration factor of 1.0, they cannot drift too far apart because their difference, $S_t - \alpha F_{t-1} = V_t$, must be stationary. However, if they are not cointegrated, they will, with probability one drift arbitrarily far apart since their difference, which is nonstationary, can and will take on arbitrarily large values.

If these two price series are not cointegrated, they will tend to deviate without bound, which is contrary to the market efficiency hypothesis. However, it can be shown under some plausible assumption that particular changes in information, such as a decline in interest rates, can cause changes in cash prices that move in the opposite direction of those for futures prices (Dewbree, 1981). To test the trend, econometric developments regarding the concept of cointegration (Engle and Granger, 1987) are particulary appropriate, and therefore the basis of the test for market efficiency.

The test for market efficiency consists of two related parts. The nonstationary series are first examined for cointegration. If they are found to be cointegrated, the restriction on the cointegration parameter that $\alpha = 0$ and $\beta = 1$ is then tested under the condition of cointegration using a likelihood ratio test.[12]

Although there are several tests for market efficiency as discussed in Hakio and Rush (1989), the following equation, the most commonly adopted model that denotes the relationship between the cash and futures prices, allows a simple discussion of the major concepts underlying the EMH:

(II-1) $$S_t = \alpha + \beta F_{t-1} + \varepsilon_t$$

where S_t is the cash price at time t, F_{t-1} is the price at time t-1 for the forward or futures contract maturing at time t, α and β are parameters, and ε_t is an error term with expected value of zero and constant variance σ^2. If the futures price F_{t-1}, contains all relevant information to forecast the next period's cash price, S_t, as this definition of market efficiency implies, then F_{t-1} should be an unbiased predictor of the future cash price. The futures (expected cash) price is replaced by the actual cash price plus an error term. This relationship assumes that new information will affect both cash and futures markets instantaneously and that new information will affect both markets in the same way.

[12] Market efficiency also requires the equilibrium error ε_t to be a white noise, whereas cointegration requires ε_t to be stationary only, i.e., a weaker condition than a white noise. Nonetheless, cointegration and the condition that $\alpha = 0$ and $\beta = 1$, at least, are necessary conditions for market efficiency.

To aid in understanding EMH, equation (II-1) is rearranged as follows:

(II-2) $$S_t - \beta F_{t-1} = \alpha + \varepsilon_t$$

pricing is considered efficient if $\alpha = 0$ and $\beta = 1$,[13] then

(II-3) $$S_t - F_{t-1} = \varepsilon_t$$

Last, taking the expectation of equation (II-3), assumed $E(\varepsilon_t) = 0$, yields:

(II-4) $$E(S_t - F_{t-1}) = 0$$

The price process described above is usually referred to as a random walk[14] (Campbell, Lo, and MacKinlay, 1977; Tomek and Querin, 1984). The expected average change in price is zero. Furthermore, if the ε_t's are uncorrelated, price changes are uncorrelated.

In testing the parameter restriction in equation (II-3), the issue arises regarding whether or not the price series is stationary. One of the basic assumptions made in econometric modeling is the concept of stationarity. A stochastic process $y_t = \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots\ldots + \alpha_{t-p} y_{t-p} + \varepsilon_t$ is said to be stationary if:

1) $E(y)$ is constant for all t.

2) $var(y)$ is constant for all t, and

3) $cov(y_t, y_{t+s})$ is constant for all t which are not equal to s.

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[13] The restrictions $\alpha = 0$ and $\beta = 1$ are based on a definition of market efficiency that argues that price changes from one period to the next should be unpredictable given the current information. If the futures prices, F_{t-1}, contains all relevant information to forecast the next period's spot price, S_t, as the definition of market efficiency implies, then F_{t-1} should be an unbiased predictor of the future spot price. This represents Fama's (1970) notion of weak form efficiency.

[14] A commonly used analogy of a random walk is the flipping of a fair coin. Random walk implies that, given the information set available at time t, the best guess of price at time $t+1$ is the price at time t and the expected change in price is zero. Random walk rules out a relationship between the expected mean price change, the information set available at time t and any other relationship involving higher conditional moments of price changes and the information set at time t.

These conditions amount to the simple statement that the mean and variance of y_t remain constant over time. The covariance property indicates that the correlation between any two values of y taken from different time periods depends only on the difference apart in time between the two values.

Stationarity means that the characteristics of the time series are describable in terms of the time separating observations and not the particular time of the observations. The stationarity property is important, since asymptotic distribution theory invoked to construct a test of the hypothesis relies critically upon it. Elam and Dixon (1988) observed that financial price series are generally found to be not stationary and they contain a unit root. As a result, the standard F-test of the hypothesis $\alpha = 0$ and $\beta = 1$ is no longer appropriate. Using Monte Carlo experiments, Elam and Dixon (1988) illustrated that the F-test tends to be biased toward incorrectly rejecting market efficiency.

In response to Elam and Dixon (1988), Shen and Wang (1990) suggest that the technique of cointegration developed by Engle and Granger (1987) may be used to test for market efficiency, since the cointegration approach is attractive in that it can properly account for the nonstationarity in price series. Hakkio and Rush (1989) used cointegration techniques to test whether the forward exchange rate is an unbiased predictor of the future spot rate in an efficient market. Chowdhury (1991), Lai and Lai (1991), Schroeder and Goodwin (1991), Fortenbery and Zapata (1993) and Pizzi, Economopoulus and O'Neill (1998) also used the cointegration to test for market efficiency.

The presence of cointegration between the cash prices and the future prices is necessary but not sufficient for market efficiency (Hakkio and Rush, 1989). For the market to be efficient, the cointegrating vector must be one and the residuals white noise.[15] Bessler and Covey (1991), Chowdury (1991), and Schroeder and Goodwin (1991) found that futures prices are cointegrated with cash prices, thus suggesting that futures prices can be predicted from historical prices in an efficient market. Engle (1996) provides the most recent review that the forward exchange rate is an unbiased predictor of futures cash enchange. Min and Najand (1999) and Silvapulle and Moosa (1999) found that the futures lead the cash prices.

Methods

Granger (1981) introduced the concept of cointegration, but Engle and Granger (1987) brought it to the attention of most economists. Engle and Granger (1987) demonstrated the correspondence between cointegrated time series and error-correction models: if two or more variables are cointegrated, then there must exist an error-correction model (ECM) linking these variables, and conversely, if two or more variables are integrated of the same order, and they have an error correction representation, then they are cointegrated.

In order to carry out a cointegration test, the nonstationarity of the series involved must be first established. The first step is to test the null hypothesis that each series is integrated of order one (denoted $I(1)$), i.e., they each have a unit root. If the series are not stationary, their means, variances and covariances are changing, and the standard t test in

[15] The white noise time series $\{\varepsilon_t\}$, $t = -\infty, +\infty$, where each element in the sequence has $E[\varepsilon_t] = 0$, $E[\varepsilon_t^2] = \sigma_\varepsilon^2$ and $cov[\varepsilon_t, \varepsilon_s] = 0$ for all s not equal t. Each element in the series is a random draw from a population with zero mean and constant variance. It is occasionally assumed that the draws are independent or normally distributed.

a regression is no longer valid. Fuller (1976) and Dickey and Fuller (1979) demonstrated that if under the null hypotheisis a series has a unit root (i.e., the series is nonstationary), then the *t* statistic for the estimated parameter in a regression is not distributed as a Student's *t*. [16]

Dickey and Fuller (1979) proposed a simple test for nonstationarity. They suggested regressing the first differences of the series on lagged values of the levels of the series. Under the hypothesis that the underlying process is a random walk, the regression coefficient will be negative and significantly different from zero for a stationary series. As the distribution theory underlying process is nonstandard, Monte Carlo-generated critical values must be used (Dickey and Fuller, 1979, pp. 134-136). Engle and Granger (1987) suggest an additional test for nonstationarity which adds lags of the dependent variable, sufficient to produce white noise residuals in the above-described univariate Dickey-Fuller regression. Termed the augmented Dickey-Fuller unit root test, it too relies on Monte Carlo-generated critical values.

The existence of long-term relationships among the cash and futures prices is tested using the Dickey-Fuller and augmented Dickey-Fuller[17] tests to determine the relationship. The Dickey-Fuller and augmented Dickey-Fuller tests are regression-type tests for determining whether the estimated time series of the residuals from the equilibrium regression has a unit root. The Engle-Granger (1987) two stage testing procedure employed. The first stage estimates appropriate cointegrating regressions by ordinary least square (OLS) for the variables in their nonstationary (level) forms and

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[16] A Student's *t* distribution is symmetrical like the normal distribution, but as the degree of freedom increase, the *t* distribution approximates the normal distribution, the mean is zero and its variance is *k / k-2*.

retrieving the resulting residuals. The second stage involves applying a similar augmented Dickey-Fuller test on the levels of the estimated residuals and checking for the presence of a unit root (nonstationarity). The variables are cointegrated if these residuals are stationary. If there is a unit root, the two series are not cointegrated.

Engel and Granger (1987) suggested that as a starting point for a unit root test, one can start by modeling the static relationship between the two series as in equation

(II-1): $$S_t = \alpha + \beta F_{t-1} + \varepsilon_t$$

When the cash price, S_t and the futures prices F_{t-1} are both $I(1)$, the linear combination

(II-5) $$V_t = S_t - \alpha - \beta F_{t-1}$$

is generally also $I(1)$.

Cointegration is tested by applying the Dickey Fuller test of unit root to the observed residual series V_t. When testing for unit root, the null hypothesis (H_0) is $\alpha = 0$ and $\beta = 1$, while the alternative hypothesis (H_a) is $\alpha < 0$ and $\beta < 1$. However, if there exist α and β such that V_t is stationary or $I(0)$, then S_t and F_{t-1} are said to be cointegrated, and the relationship:

(II-6) $$S_t - \alpha - \beta F_{t-1} = 0$$

is the cointegrating or equilibrium relationship with V_t in equation (II-5) representing the equilibrium error (Engel and Granger, 1987). Cointegration between S_t and F_{t-1} is a necessary condition for market efficiency.

[17] Engle and Granger (1987) explore the usefulness of a variety of unit-root test statistics for cointegration testing and concluded that the augmented Dickey-Fuller test is likely to perform best in practice.

One should reject the null hypothesis of cointegration if the regression coefficient is negative and significantly different from zero. Each series of S_t and F_{t-1} is then checked for stationarity, by testing the null hypothesis of a unit root with the augmented Dickey-Fuller test. If the null hypothesis of a unit root can not be rejected, then the cointegration test on the residual of equation (II-5) can be pursued.

Upon obtaining estimates of the first stage residuals, Engle and Granger (1987) propose seven tests for cointegration. A test for a unit root in the estimated residuals determines the absence of cointegration. Each test has as its null hypothesis the case of no cointegration. Rejection of the tests lend support for cointegration among markets. The test for cointegration recommended by Engle and Granger (1987) utilizes a Dickey-Fuller (1979, 1981) type regression to determine whether the autoregressive parameter for the estimated residuals from the cointegrating regression is significantly different from one. If there is a unit root, then the two series are not cointegrated. The augmented Dickey-Fuller regression for estimated residuals is:

(II-7.A) $$\Delta V_t = \psi + \theta_1 V_{t-1} + \sum_{j-1}^{p} \phi_j V_{t-j} + \varepsilon_t$$

(II-7.B) $$\Delta V_t = \psi + \theta_1 V_{t-1} + \theta_2 t + \sum_{j=1}^{p} \phi_j V_{t-j} + \varepsilon_t$$

where V_t is the first stage estimate of the residual from the cointegrating regression and Δ implies the first difference. Equation (II-7.A) is with constant, no trend and Equation (II-7.B) is with constant, with trend. The lagged differences are included to ensure that the second stage residuals of the augmented Dickey-Fuller regression, ε_t, are serially uncorrelated. A test statistic is contructed from the ratio of the estimated θ to its standard error (a "*t*-ratio"). The null hypothesis of no cointegration is rejected for values that are significantly different from zero. Engle and Yoo (1987) reported critical values for the augmented Dickey-Fuller cointegration test statistic for sample sizes of 50, 100, and 200 observation. In the ensuing analysis, the lag order (p) is selected by the minimum value of Akaike's information criterion (1973) final error.

If the null hypothesis of no cointegration is rejected then cointegration is implied by error correction representation and is expressed by the following equations:

(II-8.A) $$\Delta S_t = \varphi_1 + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$

(II-8.B) $$\Delta S_t = \varphi_1 + \varphi_2 t + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$

(II-9.A) $$\Delta F_{t-1} = \varphi_2 + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$

(II-9.B) $$\Delta F_{t-1} = \varphi_2 + \varphi_2 t + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$

where $| \gamma_1 |$ and $| \gamma_2 | \neq$ zero. Equation (II-8.A) and equation (II-9.A) are no trend and equation (II-8.B) and (II-9.B) are with trend. Equation (II-8) and (II-9) describe the short-run as well as the long run dynamics of the equilibrium relationship between the cash and futures prices. The error correction model is expected to provide better forecasts than a naive model provides. Parameters of equations (II-8) and (II-9) are estimated by OLS after running an OLS regression on equation (II-1) to collect the residuals which are then used in equations (II-8) and (II-9). A large number of lagged differences of cash and futures prices are used during the initial estimation stage. Following the approach of

Engle and Granger (1987), this procedure is repeated several times eliminating nonsignificant coefficients at each stage until the final model is derived.

If V_t does not have a unit root, then V_t is not stationary and S_t and F_{t-1} are not cointegrated. This means if one is not able to reject the hypothesis of noncointegratedness, and an error correction model of the joint process may be specified (Engle and Granger, 1987). An ordinary least squares regression of changes in S_t on past changes in S_t and F_{t-1} and lags on residuals from the cointegrating regression in equation (II-1) is proposed. An analogous specification is defined as the regression of changes of F_{t-1} on past changes on F_{t-1} and S_t, and lags of the residuals from the cointegrating regression.

When there is a cointegration correlation between cash and a specific futures price, we still have to check for the cointegration vector and the residuals to check for market efficiency. If the market is efficient, one would expect a strong relationship between the futures price existing at contract expiration and the cash price for that same delivery period. The futures prices will be unbiased predictors of the future cash prices. Thus, the producer can use the futures prices as the expected cash price and will be able to utilize the information generated through the futures market to guide their cash market decisions.

The econometric model to test the hypothesis is also reported and discussed using the daily cash price Malaysia CPO data from 1987 to 1999 published by Palm Oil Registration and Licensing Authority (PORLA), Ministry of Primary Industries Malaysia and the daily settlement futures prices of one, two, three and four months to maturity for the same period from Commodity and Monetary Exchange Malaysia (COMMEX

Malaysia) to see if there is any relationship between the Malaysian CPO cash and futures prices in the COMMEX Malaysia. When there is a holiday, the data prices are calculated by averaging the price before the holiday and the price after the holiday. The cash prices will be paired with the futures prices of one, two, three and four months to maturity of the same date.

Table 3: The breakdown of data.

Year	Number of Data
1987	243
1988	243
1989	242
1990	243
1991	247
1992	244
1993	247
1994	248
1995	243
1996	248
1997	247
1998	245
1999	249
	3189

This is consistent with the traditional notion of attempting to approximate the long run by employing a relatively long time series. As suggested by Hakkio and Rush (1989), measuring the long run for economic time series may not be as trivial as collecting the longest time series available. In general, it is assumed that the longer the time span considered, the closer one comes to approximating long run dynamics.

When testing for the presence of a unit root in a time series of data against the hypothesis of stationary fluctuations around a deterministic trend function, the use of a long span of data has definite advantages. It allows tests with larger power compared to using a smaller span, in most cases even if the latter allows more observations. The drawback, however, is that a data set with a large span has more chance to include a major event which one would rather consider as an outlier or as exogenous given its relative importance (Perron, 1989).

Procedures

The first step in conducting a cointegration analysis is to analyze the cash price and futures price data series to determine whether a unit root exists, to make sure that nonstationarity is established. If the series under investigation is nonstationary, the usual distributional results and tests of significance are no longer valid. A unit root test provides an easy method of testing whether a series is stationary. Detection of a unit root indicates the series is following a nonstationary process.

In order to determine the order of integration of each series, the augmented Dickey-Fuller test (Dickey and Fuller, 1979 and 1981) was used. Unit roots in each series in levels and first differences was tested. The present approach gives a simple test for a unit root in univariate time series against stationary and trend alternatives. One need only to estimate a first-order autoregression with a constant and possibly a time trend and to calculate the appropriate transformed Z statistic.

These tests will be conducted twice for each pair. Once with the cash prices as the dependent variable and the one (two, three or four) month(s) futures prices before maturity as the independent variable and another with the designation reversed, within one, two, three and up to thirteen years period during the year 1987 to 1999 and the results will be examined to determine the stationarity.

Having established the stationarity of the series, we can proceed to a discussion of the cointegration results. The cash and one, two, three and four month futures prices before maturity are tested again for cointegration using the Engle-Granger two-step procedure. Using the Engle and Granger procedure, the cointegrating regression Durbin-Watson (CRDW) suggested by Sargan and Bhargave (1983) augmented Dickey-Fuller (ADF) suggested by Engle and Granger (1987) will be assessed to detect the market efficiency.

Result

In this chapter, the long-run relationships between the cash and one, two, three and four months to maturity futures prices of the CPO are investigated. To address the problem of nonstationary prices, the cointegration techniques are used to investigate the relationship.

The null hypothesis for both procedures is that a unit root exists. If the test statistics are smaller than the corresponding critical values, the null hypothesis may be rejected. Both test consider cases with trend and without trend.

The unit root tests, which is reported in Table 4, Table 5, Table 6, Table 7, Table 8 and Table 9 conclude that each price series is nonstationary in the levels but stationary after first differencing for all the pairs, except for the period of 1999, so they are integrated of order one. The period of 1999 (one year) is stationary for no trend is stationary in the level, but with trend it stationary after second differencing. The results indicated that the levels of the variables are integrated of order one, $I(1)$, except for the

Table 4: Result of the Unit-Root Test .

Augmented Dickey-Fuller unit root tests on the level for the daily cash prices against the futures 1 month, 2 months, 3 months and 4 months towards maturity prices.

Dependent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Independent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	-1.6703	-1.8976	-1.6703	-1.8976	-1.6703	-1.8976	-1.6703	-1.8976
1988-1999	-1.4555	-1.7388	-1.4555	-1.7388	-1.4555	-1.7388	-1.4555	-1.7388
1989-1999	-1.3884	-1.7384	-1.3884	-1.7384	-1.3884	-1.7384	-1.3884	-1.7384
1990-1999	-1.5595	-1.4008	-1.5595	-1.4008	-1.5595	-1.4008	-1.5595	-1.4008
1991-1999	-1.4888	-0.1307	-1.4888	-0.1307	-1.4888	-0.1307	-1.4888	-0.1307
1992-1999	-0.1446	-1.0719	-0.1446	-1.0719	-0.1446	-1.0719	-0.1446	-1.0719
1993-1999	-1.3714	-0.9887	-1.3714	-0.9887	-1.3714	-0.9887	-1.3714	-0.9887
1994-1999	-1.4893	-1.0237	-1.4893	-1.0237	-1.4893	-1.0237	-1.4893	-1.0237
1995-1999	-1.1336	-1.0595	-1.1336	-1.0595	-1.1336	-1.0595	-1.1336	-1.0595
1996-1999	-1.0354	-0.62943	-1.0354	-0.6294	-1.0354	-0.62943	-1.0354	-0.6294
1997-1999	-1.0643	-1.0445	-1.0643	-1.0445	-1.0643	-1.0445	-1.0643	-1.0445
1998-1999	-0.2980	-2.5564	-0.2980	-2.5564	-0.2980	-2.5564	-0.2980	-2.5564
1999-1999	-2.7656	-1.8112	-2.7656	-1.8112	-2.7656	-1.8112	-2.7656	-1.8112

H_0 : There is a unit root.

Two forms of the "augmented Dickey-Fuller"regression equation are:

$$\Delta V_t = \psi + \theta_1 V_{t-1} + \sum_{j=1}^{p} \phi_j V_{t-j} + \varepsilon_t \quad \text{with constant, no trend.}$$

$$\Delta V_t = \psi + \theta_1 V_{t-1} + \theta_2 t + \sum_{j=1}^{p} \phi_j V_{t-j} + \varepsilon_t \quad \text{with constant, with trend}$$

Critital Value 10%: Contant, No Trend: .- 2,57
Critital Value 10%: Contant, With Trend: - 3,13

Table 5: Result of the Unit-Root Test.

Augmented Dickey-Fuller unit root tests on the first difference for the daily cash prices against the futures 1 month, 2 months, 3 months and 4 months toward maturity prices.

Dependent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Independent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	-7.1715	-7.1887	-7.1715	-7.1887	-7.1715	-7.1887	-7.1715	-7.1887
1988-1999	-7.3116	-7.3171	-7.3116	-7.3171	-7.3116	-7.3171	-7.3116	-7.3171
1989-1999	-7.5068	-7.5159	-7.5068	-7.5159	-7.5068	-7.5159	-7.5068	-7.5159
1990-1999	-7.1275	-7.1786	-7.1275	-7.1786	-7.1275	-7.1786	-7.1275	-7.1786
1991-1999	-6.7538	-6.8017	-6.7538	-6.8017	-6.7538	-6.8017	-6.7538	-6.8017
1992-1999	-6.3883	-6.4449	-6.3883	-6.4449	-6.3883	-6.4449	-6.3883	-6.4449
1993-1999	-6.2391	-6.3099	-6.2391	-6.3099	-6.2391	-6.3099	-6.2391	-6.3099
1994-1999	-6.2263	-6.3606	-6.2263	-6.3606	-6.2263	-6.3606	-6.2263	-6.3606
1995-1999	-6.3104	-6.3297	-6.3104	-6.3297	-6.3104	-6.3297	-6.3104	-6.3297
1996-1999	-5.5604	-5.6868	-5.5604	-5.6868	-5.5604	-5.6868	-5.5604	-5.6868
1997-1999	-4.6796	-4.8898	-4.6796	-4.8898	-4.6796	-4.8898	-4.6796	-4.8898
1998-1999	-4.2103	-4.2725	-4.2103	-4.2725	-4.2103	-4.2725	-4.2103	-4.2725
1999-1999	-3.0525	-3.2285	-3.0525	-3.2285	-3.0525	-3.2285	-3.0525	-3.2285

Table 6: Result of the Unit-Root Test.

Augmented Dickey-Fuller unit root tests on the second difference for the daily cash prices against the futures 1 month, 2 months, 3 months and 4 months towards maturity prices.

Dependent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Independent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1999-1999	-6.4164	-6.4029	-6.4164	-6.4029	-6.4164	-6.4029	-6.4164	-6.4029

Table 7: Result of the Unit-Root Test.

Augmented Dickey-Fuller unit root tests on the level for the futures 1 month, 2 months, 3 months and 4 months towards maturity prices against the daily cash prices.

Dependent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Independent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	-1.5875	-1.7632	-1.5978	-1.8093	-1.6102	-1.8274	-1.6052	-1.8326
1988-1999	-1.4509	-1.7585	-1.4712	-1.8010	-1.4836	-1.8218	-1.4876	-1.8185
1989-1999	-1.5221	-1.9797	-1.4076	-1.8190	-1.4462	-1.9204	-1.4836	-2.0163
1990-1999	-1.6164	-1.4106	-1.5608	-1.4903	-1.5841	-1.5870	-1.6028	-1.6900
1991-1999	-1.4889	-1.3249	-0.1495	-1.3861	-1.5251	-1.4751	-1.5593	-1.5713
1992-1999	-1.5099	-1.2048	-1.5543	-1.2902	-1.5566	-1.3016	-1.6824	-1.6487
1993-1999	-1.4259	-1.1123	-1.4915	-1.1945	-1.5088	-1.2002	-1.518	-1.2065
1994-1999	-1.5579	-1.1384	-1.6245	-1.2087	-1.6371	-1.2061	-1.6486	-1.2082
1995-1999	-1.1203	-1.0414	-1.1727	-1.0919	-1.1908	-1.0917	-1.2081	-1.0875
1996-1999	-1.0364	-0.6338	-1.0731	-0.7114	-1.0915	-0.7322	-1.1104	0.0755
1997-1999	-0.9410	-0.9243	-1.1770	-1.1646	-1.1427	-1.1338	-1.0430	-1.0315
1998-1999	-0.5478	-1.7554	-0.4817	-1.5608	-0.5100	-1.5281	-0.4920	-1.5304
1999-1999	-3.0663	-2.2677	-3.2874	-2.4956	-3.1605	-2.6334	-3.2995	-2.7435

H_0 : There is a unit root.

Two forms of the "augmented Dickey-Fuller"regression equations are:

$$\Delta V_t = \psi + \theta_1 V_{t-1} + \sum_{j=1}^{p} \phi_j V_{t-j} + \varepsilon_t$$ with constant, no trend.

$$\Delta V_t = \psi + \theta_1 V_{t-1} + \theta_2 t + \sum_{j=1}^{p} \phi_j V_{t-j} + \varepsilon_t$$ with constant, with trend

Critital Value 10%: Contant, No Trend: .- 2,57
Critital Value 10%: Contant, With Trend: - 3,13

Table 8: Result of the Unit-Root Test.

Augmented Dickey-Fuller unit root tests on the first difference for the futures 1 month, 2 months, 3 months and 4 months towards maturity prices against the daily cash Prices.

Dependent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Independent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff	1st diff
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	-7.4881	-7.5035	-7.4263	-7.4407	-7.9020	-7.9178	-7.9270	-7.9425
1988-1999	-7.4253	-7.4297	-7.3391	-7.3451	-7.4241	-7.4275	-7.4483	-7.4521
1989-1999	-6.9687	-6.9770	-6.7953	-6.8020	-6.7407	-6.7467	-6.5947	-6.6002
1990-1999	-6.4960	-6.5419	-6.4302	-6.4728	-6.3718	-6.4116	-6.2215	-6.2592
1991-1999	-6.7609	-6.8044	-6.4998	-6.5396	-6.4953	-6.5330	-6.2809	-6.3163
1992-1999	-7.1616	-7.2120	-6.3049	-6.3540	-6.1583	-6.2074	-5.9718	-6.0204
1993-1999	-6.6544	-6.7155	-6.8586	-6.9204	-6.5698	-6.6333	-5.9799	-6.0493
1994-1999	-6.1909	-6.3175	-6.3632	-6.4859	-6.0904	-6.2113	-5.9122	-6.0345
1995-1999	-5.7263	-5.7321	-5.9229	-5.9381	-5.4810	-5.4924	-6.3104	-6.3297
1996-1999	-5.4572	-5.5678	-5.5311	-5.6428	-4.9587	-5.0542	-5.1160	-5.2320
1997-1999	-4.2680	-4.4752	-5.0623	-5.2520	-4.0676	-4.2800	-5.2281	-5.4388
1998-1999	-5.9465	-5.9629	-5.6169	-5.6188	-5.3365	-5.3267	-5.1393	-5.1297
1999-1999	-2.8579	-2.8725	-2.8726	-2.9061	-3.0254	-3.0149	-3.0727	-3.0541

Table 9: Result of the Unit-Root Test.

Augmented Dickey-Fuller unit root tests on the second difference for the futures 1 month, 2 months, 3 months and 4 months towards maturity prices against the daily cash prices.

Dependent	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Independent	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff	2nd diff
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1999-1999	-7.4263	-7.4450	-7.6827	-7.7039	-7.0544	-7.0480	-7.4196	-7.4097

Table 10: Result of the R-square Test

Augmented Dickey-Fuller cointegration tests on the level for the daily cash prices against the futures 1 month, 2 months, 3 months and 4 months towards maturity prices.

Regressand	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Regressor	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	0.9988	0.9989	0.9962	0.9962	0.9909	0.9909	0.9854	0.9854
1988-1999	0.9987	0.9988	0.9960	0.9960	0.9904	0.9904	0.9845	0.9845
1989-1999	0.9988	0.9989	0.9961	0.9961	0.9906	0.9906	0.9850	0.9850
1990-1999	0.9987	0.9988	0.9959	0.9959	0.9902	0.9902	0.9842	0.9843
1991-1999	0.9986	0.9986	0.9954	0.9954	0.9891	0.9893	0.9825	0.9829
1992-1999	0.9984	0.9985	0.9949	0.9950	0.9879	0.9885	0.9805	0.9817
1993-1999	0.9982	0.9983	0.9942	0.9944	0.9862	0.9871	0.9778	0.9796
1994-1999	0.9979	0.9979	0.9932	0.9937	0.9836	0.9858	0.9737	0.9780
1995-1999	0.9980	0.9981	0.9945	0.9946	0.9878	0.9883	0.9811	0.9821
1996-1999	0.9984	0.9984	0.9959	0.9960	0.9920	0.9921	0.9984	0.9886
1997-1999	0.9981	0.9981	0.9951	0.9951	0.9902	0.9902	0.9859	0.9859
1998-1999	0.9978	0.9989	0.9948	0.9950	0.9901	0.9913	0.9858	0.9888
1999-1999	0.9940	0.9951	0.9878	0.9908	0.9784	0.9844	0.9702	0.9785

A high R square value, and a low Durbin-Watson value is evidence of cointegration.

Four Forms of the "augmented Dickey-Fuller" cointegration equations are:

$$\Delta S_t = \varphi_1 + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$ with constant, no trend

$$\Delta S_t = \varphi_1 + \varphi_2 t + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$ with constant, with trend

$$\Delta F_{t-1} = \varphi_2 + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$ with constant, no trend

$$\Delta F_{t-1} = \varphi_2 + \varphi_2 t + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$ with constant, with trend

Table 11: Result of the R-Square Test

Augmented Dickey-Fuller cointegration tests on the first difference for the futures 1 month, 2 months, 3 months and 4 months towards maturity against the daily cash prices.

Regressand	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Regressor	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	0.9988	0.9988	0.9962	0.9962	0.9909	0.9909	0.9854	0.9854
1988-1999	0.9987	0.9988	0.9960	0.9960	0.9904	0.9904	0.9845	0.9846
1989-1999	0.9988	0.9988	0.9961	0.9961	0.9906	0.9907	0.9850	0.9853
1990-1999	0.9987	0.9988	0.9959	0.9959	0.9902	0.9904	0.9842	0.9848
1991-1999	0.9986	0.9986	0.9954	0.9955	0.9891	0.9897	0.9825	0.9839
1992-1999	0.9984	0.9985	0.9949	0.9952	0.9879	0.9890	0.9805	0.9830
1993-1999	0.9982	0.9983	0.9942	0.9945	0.9862	0.9877	0.9778	0.9810
1994-1999	0.9979	0.9979	0.9932	0.9939	0.9836	0.9864	0.9737	0.9795
1995-1999	0.9980	0.9980	0.9945	0.9946	0.9878	0.9885	0.9811	0.9826
1996-1999	0.9984	0.9984	0.9959	0.9960	0.9920	0.9921	0.9884	0.9985
1997-1999	0.9981	0.9981	0.9951	0.9951	0.9902	0.9902	0.9859	0.9859
1998-1999	0.9978	0.9978	0.9948	0.9948	0.9901	0.9904	0.9858	0.9867
1999-1999	0.9940	0.9947	0.9878	0.9895	0.9784	0.9812	0.9702	0.9736

Table 12: Result of the Durbin-Watson Test

Augmented Dickey-Fuller cointegration tests on the level for the daily cash prices against the futures 1 month, 2 months, 3 months and 4 months towards maturity prices.

Regressand	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Regressor	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	1.0670	1.1140	0.3487	0.3497	0.1473	0.1468	0.0897	0.0892
1988-1999	1.0570	1.1020	0.3424	0.3427	0.1440	0.1435	0.0876	0.0872
1989-1999	1.0280	1.0760	0.3325	0.3318	0.1388	0.1386	0.0849	0.0849
1990-1999	1.0300	1.0900	0.3316	0.3315	0.1378	0.1388	0.0842	0.0852
1991-1999	1.0480	1.0980	0.3401	0.3447	0.1411	0.1464	0.0858	0.0901
1992-1999	1.0700	1.1040	0.3439	0.3564	0.1413	0.1527	0.0858	0.0946
1993-1999	1.0760	1.1180	0.3433	0.3570	0.1408	0.1541	0.0855	0.0963
1994-1999	1.1610	1.1780	0.3692	0.4045	0.1499	0.1775	0.0911	0.1132
1995-1999	1.1450	1.1520	0.4279	0.4369	0.1900	0.1997	0.1187	0.1275
1996-1999	1.1830	1.1830	0.5307	0.5109	0.2509	0.2551	0.1717	0.1739
1997-1999	1.1810	1.1840	0.4819	0.4819	0.2337	0.2338	0.1583	0.1583
1998-1999	1.2380	1.2350	0.5538	0.5598	0.2893	0.3072	0.1959	0.2252
1999-1999	1.1290	1.3000	0.6822	0.8111	0.4083	0.4824	0.2856	0.3303

A high R square value. and a low Durbin-Watson value is evidence of cointegration.

Four Forms of the "augmented Dickey-Fuller" cointegration equations are:

$$\Delta S_t = \varphi_1 + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$ with constant, no trend

$$\Delta S_t = \varphi_1 + \varphi_2 t + \gamma_1 v_{t-1} + \sum_{j=1}^{p} \delta_j \Delta S_t + \sum_{j=1}^{p} \delta_j \Delta F_{t-1} + \varepsilon_{1t}$$ with constant, with trend

$$\Delta F_{t-1} = \varphi_2 + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$ with constant, no trend

$$\Delta F_{t-1} = \varphi_2 + \varphi_2 t + \gamma_2 v_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta S_t + \sum_{j=1}^{p} \lambda_j \Delta F_{t-1} + \varepsilon_{2t}$$ with constant, with trend

Table 13: Result of the Durbin-Watson Test

Augmented Dickey-Fuller cointegration tests on the first difference for the futures 1 month, 2 months, 3 months and 4 months towards maturity against the daily cash prices.

Regressand	Futures 1 month		Futures 2 months		Futures 3 months		Futures 4 months	
Regressor	Cash	Cash	Cash	Cash	Cash	Cash	Cash	Cash
Year	No Trend	Trend	No Trend	Trend	No Trend	Trend	No Trend	Trend
1987-1999	1.0680	1.1150	0.3490	0.3504	0.1476	0.1475	0.0900	0.0898
1988-1999	1.0580	1.1030	0.3427	0.3434	0.1444	0.1442	0.0879	0.0878
1989-1999	1.0290	1.0770	0.3328	0.3326	0.1391	0.1393	0.0852	0.0856
1990-1999	1.0300	1.0910	0.3319	0.3322	0.1381	0.1396	0.0844	0.0859
1991-1999	1.0490	1.0990	0.3404	0.3454	0.1413	0.1472	0.0860	0.0981
1992-1999	1.0700	1.1050	0.3442	0.3571	0.1461	0.1534	0.0860	0.0953
1993-1999	1.0770	1.1190	0.3437	0.3577	0.1411	0.1549	0.0858	0.0970
1994-1999	1.1162	1.1790	0.3696	0.4052	0.1503	0.1781	0.0914	0.1138
1995-1999	1.1460	1.1530	0.4283	0.4373	0.1904	0.2002	0.1190	0.1280
1996-1999	1.1830	1.1840	0.5039	0.5111	0.2512	0.2554	0.1720	0.1742
1997-1999	1.1810	1.1850	0.4821	0.4821	0.2340	0.2341	0.1585	0.1585
1998-1999	1.2390	1.2390	0.5540	0.5602	0.2897	0.3067	0.1962	0.2229
1999-1999	1.1320	1.3060	0.6868	0.8213	0.4139	0.4936	0.2910	0.3403

Table 14: OLS regression result: Coefficient b from $S_t = bF_{t-1} + \varepsilon_t$

Dependent	Cash	Cash	Cash	Cash
Independent	Futures 1 month	Futures 2 months	Futures 3 months	Futures 4 months
1987-1999	1.0094	1.0304	1.0466	1.0607
	(6.2040E-04)	(1.1330E-03)	(1.7790E-03)	(2.2910E-03)
1988-1999	1.0089	1.0296	1.0455	1.0596
	(6.5860E-04)	(1.2090E-03)	(1.9010E-03)	(2.4520E-03)
1989-1999	1.0087	1.0291	1.0450	1.0595
	(6.7570E-04)	(1.2430E-03)	(1.9540E-03)	(2.5150E-03)
1990-1999	1.0084	1.0273	1.0418	1.0551
	(7.2460E-04)	(1.3330E-03)	(2.0940E-03)	(2.6920E-03)
1991-1999	1.0067	1.0222	1.0333	1.0444
	(8.1050E-04)	(1.4760E-03)	(2.3090E-03)	(2.9650E-03)
1992-1999	1.0047	1.0193	1.0288	1.0393
	(8.9910E-04)	(1.6410E-03)	(2.5700E-03)	(3.2990E-03)
1993-1999	1.0043	1.0199	1.0291	1.0380
	(1.2021E-03)	(1.8680E-03)	(2.9320E-03)	(3.7650E-03)
1994-1999	0.9985	1.0113	1.0171	1.0225
	(1.1910E-03)	(2.1730E-03)	(3.4140E-03)	(4.3710E-03)
1995-1999	0.9977	1.0196	1.0352	1.0489
	(1.2620E-03)	(2.1620E-03)	(3.2800E-03)	(4.1560E-03)
1996-1999	0.9977	1.0225	1.0426	1.0603
	(1.2820E-03)	(2.0810E-03)	(2.9910E-03)	(3.6570E-03)
1997-1999	0.9964	1.0167	1.0334	1.0483
	(1.5890E-03)	(2.6260E-03)	(3.7810E-03)	(4.6120E-03)
1998-1999	0.9989	1.0194	1.0359	1.0512
	(2.1150E-03)	(3.3280E-03)	(4.6690E-03)	(5.6970E-03)
1999-1999	1.0289	1.1012	1.1672	1.2060
	(5.0960E-03)	(7.7970E-03)	(1.1070E-02)	(1.3470E-02)

** The numbers in parentheses are standard deviation.*

Table 15: OLS regression result: Coefficient b from $F_{t-1} = bS_t + \varepsilon_t$

Dependent	Futures 1 month	Futures 2 months	Futures 3 months	Futures 4 months
Independent	Cash	Cash	Cash	Cash
1987-1999	0.9895	0.9668	0.9468	1.0607
	(6.0820E-04)	(1.0630E-03)	(1.6090E-03)	(2.2910E-03)
1988-1999	0.9900	0.9674	0.9473	0.9291
	(6.4630E-04)	(1.1360E-03)	(1.7230E-03)	(2.1500E-03)
1989-1999	0.9902	0.9679	0.9480	0.9297
	(6.6330E-04)	(1.1690E-03)	(1.7730E-03)	(2.2070E-03)
1990-1999	0.9904	0.9694	0.9505	0.9328
	(7.1170E-04)	(1.2580E-03)	(1.9100E-03)	(2.3800E-03)
1991-1999	0.9919	0.9738	0.9572	0.9407
	(7.9850E-04)	(1.4060E-03)	(2.1390E-03)	(2.6700E-03)
1992-1999	0.9973	0.9761	0.9602	0.9443
	(8.8930E-04)	(1.5710E-03)	(2.3990E-03)	(3.0010E-03)
1993-1999	0.9939	0.9748	0.9583	0.9420
	(1.0100E-03)	(1.7860E-03)	(2.7300E-03)	(3.4160E-03)
1994-1999	0.9994	0.9822	0.9671	0.9522
	(1.1920E-03)	(2.1110E-03)	(3.2460E-03)	(4.0710E-03)
1995-1999	1.0003	0.9754	0.9542	0.9354
	(1.2650E-03)	(2.0680E-03)	(3.0230E-03)	(3.7060E-03)
1996-1999	1.0007	0.9740	0.9514	0.9322
	(1.2860E-03)	(1.9830E-03)	(2.7290E-03)	(3.2150E-03)
1997-1999	1.0018	0.9788	0.9582	0.9405
	(1.5970E-03)	(2.5180E-03)	(3.5060E-03)	(4.1380E-03)
1998-1999	0.9989	0.9758	0.9558	0.9378
	(2.1150E-03)	(3.1860E-03)	(4.3080E-03)	(5.0820E-03)
1999-1999	0.9661	0.8971	0.8383	0.8045
	(4.7850E-03)	(6.3520E-03)	(7.9480E-03)	(8.9850E-03)

** The numbers in parentheses are standard deviation.*

period of 1999 , which are integrated of order zero *I*(0) for no trend, and are integrated of order two, *I*(2) with trend. Having identified that cash and futures prices are *I*(0), *I*(1) and *I*(2) stationary variables, cointegration techniques are used next to examine the existence of a longrun relationship between the series. If both the cash price and the futures price are integrated of order one and two, then the two series must be cointegrated for a stationary linear combination to exist.

The result of the test statistic from the cointegrating regression between cash price and futures prices and futures prices and cash prices are reported in Table 10, Table 11, Table 12 and Table 13.The output report of the R^2 are reported on Table 10 and Table 11 and the Durbin Watson test statistics are reported in Table 12 and Table 13. A high R^2 value and a low Durbin Watson value is evidence of cointegration.[18]

The results as shown indicated that cointegration relations are consistent across crop year in the market studied. Using cointegration analysis, cointegration is found between all cash and futures market prices pairs considered. The results showed that a cointegrating vector consistently existed between the pairings of all the series investigated. All the tests results reject the null hypothesis of noncointegration.[19] The cash and futures price have unit roots and cointegrated over the 1987-1999 period. The tests have shown that there are evidence of cointegration among them, therefore, there are a long-run equilibrium relationship among the cash price and futures price that would help to explain why other futures price seemed to be able to help predict own futures cash price.

[18] For more discussion se Engle and Granger, 1987.

This study also investigated efficiency within series by testing for a long-run relation between the cash and futures prices. Such a long-run relation should exist, as futures prices should be an unbiased predictor of the future cash prices. The augmented Dickey-Fuller test result indicates that the cash and futures prices are cointegrated, a necessary condition for market efficiency. For market to be efficient, the cointegrating vector must be (1,-1). To test market efficiency, a regression was estimated in this study and run with OLS command. Table 14 and Table 15 showed that CPO market is efficient in one direction but not if it reversed. These results substantially improve the understanding of price discovery in commodity futures markets. The result found that one, two, three and four months CPO futures prices are unbiased predictor for the future cash price, since their cointegrating vector is (1, -1),[20] but the cointegrating vector for cash price against one, two, three and four months CPO futures prices are not. It confirmed that futures markets, rather than cash markets, are the primary point for price discovery (Garbade and Silber, 1983, Peck 1985, Schroeder and Goodwin, 1991 and Working, 1948). It verified the prediction hypothesis, that futures prices are a useful predictor for future cash price.

The futures price appears to be an unbiased predictor of the subsequent cash price in the CPO markets. These results on market efficiency are important for the usefulness of futures markets to the hedgers. Market efficiency was established to exist for the one, two, three and four-month futures prices before maturity and cash prices.

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[19] The residuals from a cointegrating relationships are required to be of lower order of integration than the variables involved in the relationship. The acceptance of cointegration property is equivalent to the acceptance of stability in the long-run behavior.

[20] Brenner and Kronner (1995) found that cash and forward prices and cash and futures prices should be cointegrating with cointegrating vector (1, -1).

The implications of these findings are the following. It is commonly believed that many economic time series are tied together even though they are all trending. The unbiased expectation hypothesis suggests that price of a futures contract before maturity should be an unbiased predictor of the cash price on the maturity date of the contract. Market participants receive accurate signals from futures prices and can use the information generated by these prices in order to guide their physical market decisions; therefore the producers can use the futures prices as indicators of the future cash prices. Futures prices are unbiased predictor for future cash prices, but not vice versa.

The conclusion of this research is that the CPO market exhibits a cointegrating relation among the cash and futures markets. This long-term equilibrium indicates that there is a flow of information between the two markets. This research finding is important because this process reflects the basis for nearby contracts and as such suggests that market participants can use the futures price discovery mechanism as an effective price risk management tool. The knowledge of the cointegration relationship and market efficiency will improve the forecasting models for the palm oil market.

CHAPTER III

Hedging Effectiveness

Purpose of this Chapter

The objective of this chapter is to understand how price forecasts can be effectively used to formulate a futures hedging strategy, which will reduce cash price risk, if the futures price can be used as the expected cash price. Can forecasting and hedging contribute to price risk management improvement for risk-averse producers[21]?

Hedging

One of the primary economic functions of the futures market is to provide a mechanism by which producers can manage the risks.[22] Producers face risk in the underlying cash markets due to unknown future changes in commodity prices, and attempts to transfer the risks to others. Such risks, which may be associated with established or anticipated cash positions, can be reduced or eliminated by hedging in the futures market. Futures markets are market organizations specially developed for

[21] Producers are assumed risk-averse.

[22] Risks due to nature such that they cannot be covered by means of ordinary insurance. A commercial insurance company can undertake to cover risks due to unknown future evens if the possible unfavorable events against which insurance is sought, are independent of each other; and if the number of separate insurances against such independent is very large.

facilitating the shifting of risks due to unknown future changes in commodity prices[23] and are visualized as a convenient mechanism through which price risk can be transferred from one group to another. They facilitate hedging for investors who are long (short) in the cash market by allowing them to sell (buy) related futures contracts.

Since Working's (1953) classic study, many have considered hedging as the primary use of futures contracts. Hedging by the agricultural producer generally involves selling the commodity at the commodity exchange market because producers want to lock in a price floor (a minimum price they will receive).[24] Hedgers are typically viewed as involved in the storage or production process or are committed to produce. Producers use futures market transactions to reduce price risk associated with holdings of the underlying commodity. Hedgers take a position in a futures market opposite to a position held in the cash market to minimize the risk of financial loss from an adverse price change. The simultaneous sale or acquisition of an equal amount of the same or similar commodity is used as a temporary substitute for a cash transaction that will occur later. By hedging, market participants seek to control or reduce the risk of adverse price

[23] If expectation concerning future value changes were certain, forward prices would always exceed spot prices by the amount of net carrying cost (i.e. total carrying cost minus the yield) and forward prices could only fall short of spot prices if net carrying costs were negative (i.e. the yield is larger than total carrying cost). The sum of expectations in the market being reflected in the spot price and risk due to uncertainty of expectations being absent, no one would be prepared to sell forward at less than spot price plus net carrying cost; for in the absence of risk this would always be considered less profitable than to carry the stocks and sell spot at the forward date. Similarly no one would be prepared to buy forward at a price higher than the spot price plus net carrying cost; for this would be less profitable than to buy spot and carry the stocks to the forward date. Spot prices could only exceed forward prices by more than net carrying cost if there were such a scarcity of spot supplies that it were impossible for all who want to do so, to buy spot and carry stocks to the forward date. In the real world, however, expectations are uncertain and, therefore, forward transaction entail risks.

[24] Working (1962) distinguished among several different categories of hedging: carrying charge hedging, operational hedging, selective hedging, anticipatory hedging, and pure risk avoidance hedging.

changes, usually in the expectation of a favorable change in the relation between cash and futures prices.

According to the traditional concept, hedging consists in matching one risk with an opposing risk, and hedging in futures is effective because changes in cash prices of a commodity tend to be accompanied by similar changes in the futures price. The hedge is constructed by choosing a futures position so that losses (gains) in the cash market are offset by gains (losses) in the futures market.[25] Here hedging is related to the risk reduction or insurance aspect and when cash and futures prices move in parallel, hedging undertaken for this purpose will be perfectly effective. When prices move in this manner, that is, when basis[26] is constant, ignoring operating cost and the cost of storage, losses (gains) that would have been sustained without hedging are completely eliminated by hedging. To the extent that parallelism of price movement does not occur, the hedge is imperfect. In this matter, the effectiveness of hedging (i.e. the effectiveness of neutralizing price risks in the cash market by assuming opposite risk in the futures market) must be impaired to the extent to which the movements of cash and futures prices diverge. The present concept, the purpose of hedging is the combined goal of risk avoidance, avoidance of loss, and expected profit maximization. The commodities are hedged when a price decline is expected.

Hedging is more about reducing volatility than maximizing profit. By hedging, one gives up the opportunity to realize gains from positive price movements, but at the same time protect oneself against negative price movements. In doing this, hedgers can

[25] Pure risk avoidance hedging is virtually nonexistent in modern business practice.

[26] The difference between cash and the futures prices of the same asset due to quality or transportation cost.

add stability to their earnings and cash flow, which is a key factor underlying market evaluations. The core problem when deciding upon a hedging policy is to strike a balance between uncertainty and the risk of opportunity loss. The decision maker either hedges or does not hedge, depending on the signal provided by the price forecast, hedging transaction fees and others. Williams (1986, 1987) showed risk-neutral firms will hedge if transaction costs are lower in the futures market than in the cash market. Brorsen (1995) found that if the value of capital is uncorrelated with output price, firms are shown to hedge more as cash price variability increases.

Hedging has been used extensively by individual investors and financial institutions as a tool in risk management. The theoretical and empirical evidence on hedging agricultural commodities has been discussed in numerous studies, i.e., Wisner (1991), Leuthold et. al. (1989) and Working (1953) suggest that hedging using futures markets is beneficial. Ginn and Purcell (1987) indicate that an improvement in price risk management may contribute to the competitive nature of the industry.

Hedging can be defined as taking positions in one asset so as to reduce or eliminate exposure to adverse price movements in other assets. Hedging in commodity futures involves the purchase or sale of futures in conjunction with another commitment involving the simultaneous sale or acquisition of an equal amount of the same or similar commodity. A seller will hedge if the current futures market prices (adjusted for basis and hedging costs) for delivery in the subsequent quarter is higher than the forecast cash price for that quarter.[27] They do so to protect themselves against further potential losses. Similarly, a seller will not hedge if the adjusted futures market price for a delivery option

[27] Because the commodities are hedged when a price decline is expected, the purpose of hedging is not risk avoidance in the strict sense, but avoidance of loss.

in the next quarter is lower than the forecast cash price. The behavior would be opposite in the case of the buyer.

While it is theoretically possible for the cash price to increase as the futures price falls, it is much more common for both prices to move in the same direction, given the typical high correlation between the cash and futures prices. However, the only reason a risk neutral agents would hold both cash and futures positions is if they expect the prices to move in opposite directions. As long as both prices move in the same direction, they will lose money on one of the transactions. If the futures price falls more than the cash price, they lose money on the inventory, but make more than the inventory loss on the short position in the futures market. If the cash price rises more than the futures price, they make more on the cash position than is lost in the futures market. Traders have a good reason to think that one of these situations will occurs, but don't know with certainty.

The advantage of hedging may often (perhaps usually) be measured approximately by the amount of loss avoided by hedging. A perfect hedge occurs where the losses on the cash position are exactly offset by gains in the futures market. Such perfect hedges are only possible when one can predict the change in basis with certainty. In practice such perfect hedges are rarely possible because the relationship between futures and cash prices is not deterministic, except to the extent they will converge at the settlement date of futures contract if the asset being hedged corresponds exactly to that in the underlying the futures contract. Futures prices may not track cash prices perfectly because they represent investments at different points in time or delivery at different locations.

The extent to which hedgers are able to reduce cash price risk (i.e., hedging performance) can be measured using the concept of hedging effectiveness. The purpose of measuring hedging effectiveness is to express the usefulness of trading futures contracts, based on comparing the results of a combined cash-futures portfolio and the cash position alone. Ederington (1979) applied the concept of portfolio theory to hedging in determining a risk-minimizing hedge ratio and derived a measure of hedging effectiveness. Tashjian and McConnell (1989) showed that hedging effectiveness is a very important determinant of the success of futures contracts.

The hedging effectiveness measure indicates the proportion of the unhedged return variance that can be purged through hedging when only price variability is considered. The authors who have proposed measures of hedging effectiveness include Chang and Fang (1990), Chang, Chang and Fang (1996), Chang and Shanker (1987), Ederington (1979), Gjerde (1987), Hsin, Kuo and Lee (1994), Howard and D'Antonio (1984, 1987), Lasser (1987), Nelson and Collins (1985) and Pennings and Meulenberg (1997). Chang, Chang and Fang (1990) showed that the covariances between interest rate and cash and futures prices explain the differential, the larger the covariances are, the larger the differential will be. Chang and Shanker (1987) compared the hedging effectiveness of two instruments, currency futures contracts and option synthetic futures, using a modified measure of Howard and D'Antonio's (1984). Gjerde (1987) found optimal hedging strategies with futures contracts, while Hsin, Kuo and Lee (1994) showed a new measure to compare the hedging effectiveness of foreign currency futures versus options.

The most popular measure of hedging effectiveness is that of Ederington (1979), in which a representative hedger minimizes risk upon hedging the position in a single cash commodity through transactions in a single futures contract. Common to all these measures is an attempt to indicate the extent to which hedgers are able to reduce cash price risk by using futures contracts.

According to the traditional hedging theory, the objective is to minimize the portfolio risk. Following Working's (1953, 1962) seminal work, Johnson (1960) and Stein (1961) introduced the concept of portfolio theory through hedging the cash position with futures. The portfolio theory or utility maximization approach views hedging as a trade-off between risk and return. Such a trade-off can exist only if the futures price is believed to be unbiased, and the hedger is risk averse. Ederington (1979) derives the optimal hedge ratio by minimizing the variance of the portfolio and a measure of hedging effectiveness.

Ederington (1979) considered only risk reduction in the hedging strategies. These have been followed by numerous studies, including Hill and Schneeweis (1981, 1982), Grammatikos and Saunders (1983), Figlewski (1984, 1985), Witt, Schroeder, and Hayenga (1987), Meyer and Thompson (1989), Castelino (1990, 1992), Myers (1991), Viswanath and Chatterjee (1992). Hill and Schneeweis (1981, 1982) found portfolio approach to hedging and the associated minimum of hedge ratio the benefit of being able to trade futures. Grammatikos and Saunders (1983) noted that the empirical estimates of these variables have been nonstationary across time for debt and foreign exchange market respectively. Figlewski (1984, 1985) assumed that hedger have perfect foresight Myers (1991) suggested that optimal hedge ratio estimation may require that the conditional variance and covariance of futures and cash prices be time variant, resulting in time-varying hedge ratios. Viswanath and Chatterjee (1992) showed that the simple regression model using price changes provided estimates very close to those obtained with their generalized approach.

Recognizing this hedging strategy is not general, several studies deal with futures investment in a risk-return framework proposed measurement of hedging effectiveness that takes into account both return and risk characteristics of the contracts. In the portfolio-based modeling approach, Anderson and Danthine (1980, 1981), Chang and Shanker (1987), Chang and Fang (1990), Hsin, Kuo and Lee (1994), Howard and D'Antonio (1984, 1987), and Nelson and Collins (1985), advocate a single-parameter measure of hedging performance that takes into account both expected returns and risk. All these single-parameter measures try to indicate to what extent hedgers are able to reduce cash price risk by using futures contracts. Howard and D'Antonio (1984, 1987) and Chang and Shanker (1987) risk return measures all suffer from the drawback that they focus on hedged return versus cash return rather than hedged return versus equilibrium return. The model is built on the risk-return separation, making it useful to individual with different degrees of risk aversion.

Howard and D'Antonio (hereafter HD, 1984) proposed optimal hedge ratios and effectiveness measure, HE_{HD}, based on the Sharpe index. Chang and Shanker (hereafter CS, 1987) compared ex post the hedging effectiveness between currency option futures and currency futures contracts using a modified measure, HE_{CS}, and found an error in the HD's paper that would lead to ambiguous results in practical applications. CS (1987) proposed a new measure of hedging effectiveness that eliminates the ambiguity in the original measure. In reply, HD (1987) pointed out that, although the proposed measure eliminates a potential problem, it is not an adequate measure either. An alternative measure, labeled *HBS*, is described as having a number of desirable ex ante and ex post statistical properties, was proposed by HD (1987).

Ederington Hedging Effectiveness

The traditional approach, which is the basis for the portfolio model, assumes that the major motivation for hedging is to reduce price risk and that the hedger should assume that cash and futures prices generally move together. The traditional's objective of a hedge is to minimize the risk of a given position, represented by the variance of the returns.

If X_s are the cash and X_f are the futures market holdings, in order to completely offset risk price hedger has to have the futures position of $X_f = -X_s$ units. The expected gain or loss on an unhedged of X_s units of a cash commodity held from time 1 to 2 is $E(U) = X_s E(P_s^2 - P_s^1)$ and for futures market position is $E(V) = X_f E(P_f^2 - P_f^1)$. The variance of return for the cash market is $Var(U) = X_s^2 \sigma_s^2$ and for the futures market is $Var(V) = X_f^2 \sigma_f^2$. When the change in futures prices exactly parallels the change in cash prices from time 1 to 2, the hedger's net position will be unchanged, since the change in value of the future position will offset the change in the value of the cash position. In this situation the hedger would have a perfect hedge.

Since cash and futures prices do not always move together, Ederington (1979) introduced the minimum variance model. In Ederington's (1979) portfolio model cash and futures market holding are not viewed as substitutes. Next will be shown how

Ederington derived his hedging effectiveness. There is no presumption, as in traditional theory, that $X_f = -X_s$. The cash market holdings are viewed as fixed and the decision is how much of this stock to hedge.

Ederington's hedging effectiveness (HE_{Ed}) was measured by the square of the correlation coefficient between price changes of the cash and that of the futures. He derives a closed-form solution for the optimal hedge ratio, which is the ratio of the size of the futures position relative to the size of the cash position. HE_{Ed} measures the proportion of risk that has been hedged away and ignores the impacts on portfolio returns due to hedging. Such an assumption may be particularly unsuitable when applied to individual options hedges, where the exercise feature permits consideration of numerous risk-return outcomes. Pure risk-avoidance hedging ignores potential tradeoffs between risk and return and is apparently inconsistent with empirical practices.

Let X_s and X_f be the cash and futures market holdings respectively, P_s^1, P_s^2, P_f^1 and P_f^2 are cash and futures prices at time 1 and 2, ($P_s^2 - P_s^1$) and ($P_f^2 - P_f^1$) are the gain or loss on a cash or futures position, $E(U)$ and $E(V)$ represent the expected of return on an unhedged cash and futures position respectively, $Var(U)$ and $Var(V)$ are the variance of return, σ_s^2 and σ_f^2 represent the variance of the possible cash and futures price change, σ_{sf} the covariance of the possible cash and futures price changes from time 1 to time 2 and R represent the return on a portfolio, which is a combination of position in cash market holdings, X_s, and futures market holdings, X_f. The portfolio may be a portfolio which is either completely or partially hedged and has a total expected return $E(R)$ and a total variance of variance $Var(R)$.

(III-1) $$E(R) = X_s E(P_s^2 - P_s^1) + X_f E(P_f^2 - P_f^1) - K(X_f)$$

(III-2) $$Var(R) = X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2 X_s X_f \sigma_{sf}$$

where $K(X_f)$ are brokerage and other costs of engaging in futures transactions including the cost of providing margin. σ_s^2, σ_f^2 and σ_{sf} represent the subjective variances and the covariance of the possible cash and futures price changes from time 1 to time 2.

The hedge ratio b, is defined

(III-3) $$b = -\frac{X_f}{X_s}$$

which is the ratio of units of hedged stocks to units of total stocks. If the hedger has a long cash position then X_f will be negative because the hedger will be short futures. If the hedger short in the cash market, then X_s will be negative and X_f positive. Since in a hedge X_s and X_f always have opposite sign, b is usually positive.

Substitute (III-3) into (III-1) and (III-2):

(III-4) $$Var(R) = X_s^2 (\sigma_s^2 + b^2 \sigma_f^2 - 2 b \sigma_{sf})$$

and

(III-5) $$E(R) = X_s \{ E(P_s^2 - P_s^1) - b E(P_f^2 - P_f^1) \} - K(X_s, b)$$

$$= X_s \{ (1 - b) E(P_s^2 - P_s^1) + b E(P_s^2 - P_s^1) - b E(P_f^2 - P_f^1) \} - K(X_s, b)$$

Let $E(\Delta b) = E\{ P_f^2 - P_s^2 - (P_s^1 - P_f^1) \}$ is the expected change in the basis, and $E(S) = E(P_s^2 - P_s^1)$ is the expected price change on one unit of the cash commodity, so

(III-6) $$E(R) = X_s \{ (1 - b) E(S) - b E(\Delta B) \} - K(X_s, b)$$

A hedging effectiveness measure for futures should focus on the difference between actual hedged return and expected hedged return in equilibrium. This difference approaches zero as if the expected change in the basis is zero, then clearly the expected gain or loss is reduced as $b \rightarrow 1$. The expected changes in the basis may add to or subtract from the gain or loss which would have been expected on an unhedged portfolio $E(U) = X_s E(S)$.

T consider the effect of a change in b, the proportion hedged, on the expected return and variance of the portfolio R, X_s was held constant.

(III-7)
$$\frac{\partial Var(R)}{\partial b} = X_s^2 (2b\sigma_f^2 - b\sigma_{sf})$$

and setting the derivative equal to 0, the risk minimizing the variance of return b, b^*, is

(III-8)
$$b^* = \frac{\sigma_{sf}}{\sigma_f^2}$$

It is assumed that σ_{SF} and σ_F^2 are time invariant. The model-based hedge ratio minimizes the variance of the value of a portfolio, which includes a long (short) position in the cash currency and a short (long) position in the futures contract.

The formula for b^* is the slope coefficient for a simple regression of cash on futures price. The interpretation of b^* is that it is the ratio of the number of the units of futures to the number of units of the cash position which must be assumed in order to offset the variance of the cash market position.

Substituting (III-8) in (III-4) yields

$$Var(R^*) = X_s^2 (\sigma_s^2 + b^2\sigma_f^2 - 2b^2\sigma_f^2$$

(III-9)
$$Var(R^*) = X_s^2 (\sigma_s^2 - b^2\sigma_f^2)$$

The measure of hedging effectiveness is defined as the percentage reduction in the variance of the return on the portfolio achieved by hedging optimally in the futures market rather than not hedging at all, (III-10) $$HE_{ED} = \frac{Var(U) - Var(R^*)}{Var(U)}$$

The equation (III-11) usually is expressed as:

(III-11) $$HE_{ED} = 1 - \frac{Var(R^*)}{Var(U)}$$

Substituting (III-9) into (III-11)

(III-12) $$HE_{ED} = 1 - \frac{X_s^2 \sigma_s^2 + X_s^2 b^2 \sigma_f^2}{X_s^2 \sigma_s^2}$$

Consequently, by substituting (III-8) into (III-12):

(III-13) $$HE_{ED} = \frac{\sigma_{sf}^2}{\sigma_s \sigma_f}$$

where HE_{Ed} = the minimum-variance measure for the model-based hedged position, σ_{SF}^2 = the covariance of the possible price change from cash to futures, σ_s^2 = the variance of the cash price and σ_f^2 = the variance of the futures price

Ederington's hedging effectiveness was measured by the square of the correlation coefficient between price changes of the cash and that of the futures. It will range from 0 to 1 depending on the degree of correlation between the cash and the futures price changes. Maximum effectiveness will be achieved when there is a perfect correlation between the two, but since cash and futures prices do not typically move exactly in tandem, it may be of the hedger's advantage to have a hedge ratio less than unity. HE_{Ed} performance measure is included in this study because its tractability has made it widely accepted and reported among hedging practitioners and in numerous futures hedging studies.

Howard and D'Antonio Hedging Effectiveness (1984)

The Howard and D'Antonio (HD) (1984, 1987) using the Sharpe-ratio to construct a risk-return measure for hedging effectiveness,[28] derived a measure of hedging effectiveness for a futures contract that incorporates both minimization of risk and maximization of excess return. HD also incorporate correlation between cash and hedge price changes which the futures and option literature emphasizes as a principle determinant of effectiveness and more general risk-return assumptions are examined. With this contribution the utility function of a hedger is extended from minimizing risk to optimizing risk and return.

HD defined hedging effectiveness as the ratio of the excess return per unit of risk of the optimal portfolio of the cash commodity and the futures instrument to the excess return per unit of risk of the portfolio containing the cash position alone. It examines improvement in excess return (above a risk-free interest rate *i*) per unit of risk for a hedged futures or options position relative to an unhedged (cash) position. With an existing position in a cash asset, an investor's one-period optimization problem is then to maximize the Sharpe index of the hedged portfolio θ_H, i.e.:

(III-16)
$$\text{Max}\,\theta = \frac{(R_p - i)}{\sigma_p}$$

where R_p is the expected return (percent) for the cash, futures portfolio, i is the domestic risk-free rate of return (percent), and σ_p = the standard deviation of return (percent) for the cash, futures portfolio.

[28] The reward to variability ratio derived by Sharpe (1966) is simply the ratio of the excess return (expected return of the portfolio minus the risk-free interest rate) and the standard deviation of the portfolio.

HD assumed that only mean and variance are relevant in choosing a portfolio and that there are no margin requirements[29] for futures contracts. It follows that the hedged portfolio has an expected return and a standard deviation as below:

$$\text{(III-15)} \qquad Rp = \frac{C_sP_s(r_s) + C_fP_f(r_f)}{(w_sP_s)}$$

$$\text{(III-16)} \qquad \sigma_p = \frac{\sqrt{(C_s^2P_s^2\sigma_s^2 + C_f^2P_f^2\sigma_f^2 + 2C_sC_fP_sP_f\sigma_s\sigma_f\rho)}}{C_sP_s}$$

where the subscript s denotes the cash currency, f the currency futures, C_i = the holdings in currency cash or futures, P_i = the currency rate per dollar on the cash or the futures, r_i = the expected one-period rate of return, σ_i = the standard deviation of return, and ρ is the correlation between the returns of the cash and the futures. HD assumed that only mean and variance are relevant in choosing a portfolio and that there are no margin requirement for futures contracts. This is why the futures position does not appear in the denominators in equation (III-15) and (III-16).

[29] The assumption of zero margin requirement is fairly common in the future literatures (Johnson, 1960 and Stein, 1961). If the initial margin requirement is not assumed zero, then the hedging problem would have to be solved by using an optimization technique.

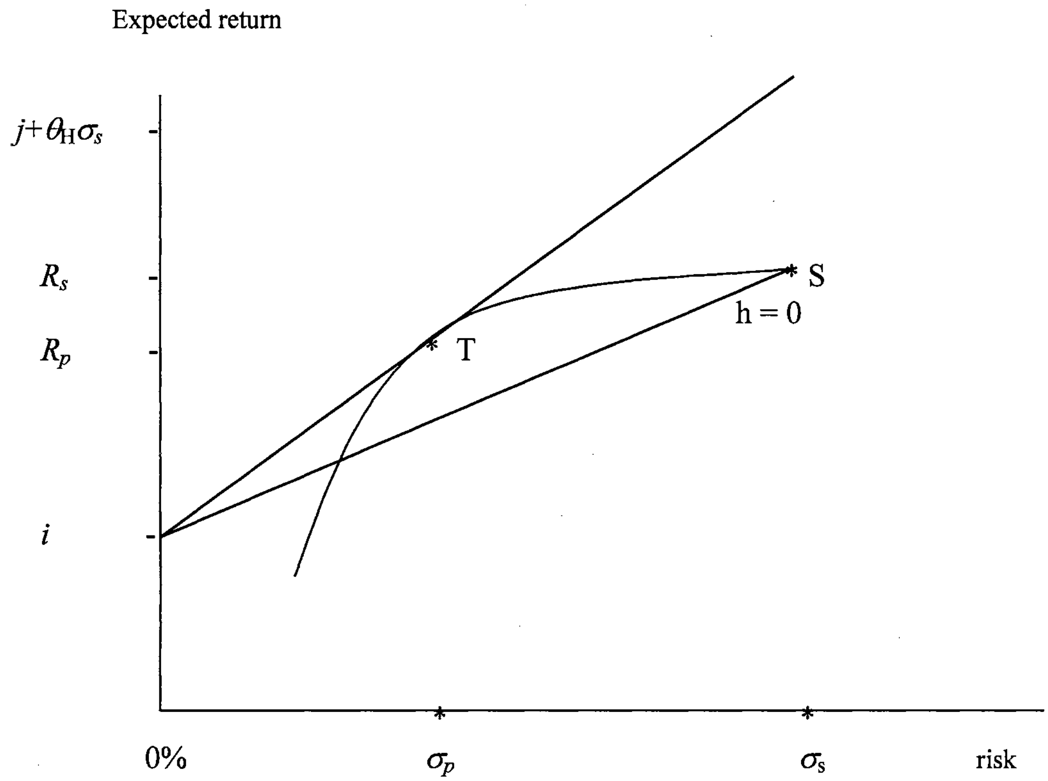

Figure 3: The HD model to maximize expected excess return per degree of risk.

The HD model can be graphed in risk-return space as illustrated in Figure 3, which assumes that the expected return on the unhedged portfolio (R_s) is greater than the risk free rate (i). The cash portfolio is represented by point *S* and corresponds with a hedge ratio (h) of 0 and is the unhedged market return. The straight line between point *S* and *i* represent the possible outcomes from the hedged portfolio as the hedge ratio increases from 0 to 1, assuming that futures are always priced at their equilibrium value. R_p =is the return on the hedged cash-futures portfolio. When cash and futures prices are not in perfect alignment, basis risk exists, a hedge ratio less than 1 results in the minimum variance position. The curve is a possible risk-return profile as the hedge ratio increases from 0 to the point of minimum variance. Point *T* is the point of tangency between the hedge portfolio possiblility curve and a line from the risk-free asset between the hedged portfolio possibility curve and a line from the risk-free asset (i); it is the point where the θ_H, the expected excess return per degree of risk, is maximized.

According to HD, an investor would hold the appropriate number of futures contracts to obtain tangent portfolio T and then combine T with the risk-free asset to move to the preferred point on the tangent line. The hedging effectiveness measure based on this model and the investors' optimization problem is to maximize θ with respect to C_f where:

(III-18) $$\max_{C_f} \frac{\overline{R_p - i}}{\sigma_p}$$

solving for the optimal level C_f, by substituting R_p with equation (III-15) and σ_p with equation (III-16), taking derivative of equation (III-18) with respect to C_f, then setting the derivative equal to zero will obtain:

(III-19) $$C_f^* = C_s b^*$$

(III-20) $$b^* = \frac{(\lambda - \rho)}{\gamma\pi\ (1 - \lambda\rho\ )}$$

(III-21) $$\lambda = \frac{\alpha}{\pi} = \frac{r_f}{\sigma_f} \bigg/ \frac{r_s - i}{\sigma_s}$$

(III-22) $$\pi = \frac{\sigma_f}{\sigma_s}$$

(III-23) $$\alpha = \frac{r_f}{r_s - i}$$

(III-24) $$\gamma = \frac{P_f}{P_s}$$

The measure of Howard and D'Antonio's hedging effectiveness (HE_{HD}) can be derived from equation (III-20)

(III-25) $$HE_{ED} = \frac{\theta_H}{\theta_S}$$

where θ_H is the excess return per unit of risk possible and results when $C_f = C_f^*$, the optimal value of the number units of the futures position.

(III-26) $$\theta_S = \frac{R_S - i}{\sigma_S}$$

is the Sharpe index for the cash position and σ_S is the standard deviation of the portfolio returns. By substituting equation (III-18) to equation (III-24) and equation (III-26) into equation (III-25), the hedging effectiveness measure base on this model and proposed in HD (1984) is:

(III-27) $$HE_{ED} = \sqrt{\frac{1 - 2\lambda\rho + \lambda^2}{1 - \rho^2}}$$

Chang and Shanker hedging effectiveness.

Chang and Shanker (CS) (1986) later noted that the measure HE_{HD} is ambiguous when θ_S, the excess return on the cash portfolio $(r_s - i)$, is negative. According to them, the second order condition in footnote 7 of HD (1984) is too narrowly defined. CS

(1986)[30] showed that the HD effectiveness measure actually decreases in size, although hedging performance is improving, whenever the percentage excess return is negative. Since a negative excess return on the cash $[E(r_s - i)]$, which implies a negative θ_S, often occur in practice, CS developed an alternative measure based also on the Sharpe index. CS constructed an improved measure similar to the HD measure by decomposing the position into separate long and short hedging categories. CS addressed problems of negative excess returns inherent in the hedging performance measure and suggested the following measure as an alternative:

(III-28)
$$HE_{CS} = \frac{\theta_H - \theta_S}{|\theta_S|}$$

Their measure is positive when θ_H is greater than θ_s, and negative when θ_H is less than θ_s. The advantage of this measure of hedging effectiveness HE_I over HE_{HD} is that the ambiguity inherent in the definition of HE_{HD} is resolved. Whatever the sign of $(r_s-i)/\sigma_s$, the greater the value of θ^*, the greater the hedging effectiveness. The measure is neater, in that if $\theta^*>(r_s-i)/\sigma_s$, $HE_I>0$, if $\theta^*<(r_s-i)/\sigma_s$, $HE_I<0$. Mathematically, their measure is:

(III-29)
$$HE_{CS} = \frac{\theta^* - (r_s - i)\sigma_s}{|(r_s - i)\sigma_s|}$$

[30] Chang and Shanker (1986) and Lien (1993) compared the hedging effectiveness between currency futures and option synthetic futures using a modified measure.

Howard and D'Antonio Hedging Effectiveness (1987)

In their response to CS, HD (1987) agree that their first HE measure is ambiguous, but they criticize HE_{CS} because it (like HE_{HD}) still has the undesirable property, that if the difference between the mean cash return and risk-free rate $(r_s\text{-}i)$ is very small or zero, the measure become very large, approaches plus or minus infinity. CS' risk-return measures all suffer from the drawback that they focus on hedged return versus cash return than hedged return versus equilibrium return.

HD (1987) derive the following measure, called HBS for hedging benefit per unit of risk, to solve this problem:

(III-30) $$HBS = \frac{(i + \theta_H \sigma_s - r_s)}{\sigma_s}$$

which they claimed to correct the inconsistency of HE_{HD}. *HBS* gives the extra return that can be realized using futures in a position with the risk of the cash position without this futures. This risk-equivalent extra return on the combined hedged-risk-free asset portfolio (compared to the return of the cash portfolio) is expressed per unit risk. Note that $i + \theta_H \sigma_s$ is indicated on Figure 3, and represents the amount of return on the line of tangency that corresponds with the level of risk.

Since all the Sharpe ratio model adaptation offered a different findings, this study will evaluate all of those mentioned above. In this study, Ederington's (1979) minimum variance model, three Sharpe-ratio models by Howard and D'Antonio, 1984, Chang and Shanker 1986 and Howar and D'Antonio are used to evaluate the hedging effectiveness of CPO in the futures market using the same data.

To determine an optimal hedging from the producers' point of view, it is assumed that a hedger first used some time period to calculate the model-based hedge ratio. After this period the amount of futures contract, the amount of futures contracts, as calculated by the model-based hedge ratio, is used to hedge a cash position. The return of this model-based hedged position will be compared with a naively hedged position in the same period. In this study model based hedge ratios are calculated for each of the three previously discussed measures of hedging effectiveness.

Methods and Procedures

The hedging effectiveness for the futures prices that cointegrated with the cash prices will be tested in this chapter. Hedging effectiveness are calculated based on cash and futures prices data that cointegrated and showed market efficiency.

The Ederington hedging effectiveness measure (HE_{ED}), the Howard and D'Antonio hedging effectiveness measure (HE_{HD}, 1984), Chang and Shanker hedging effectiveness measure (HE_{CS}, 1986) and), and the revised Howard and D'Antonio hedging effectiveness measure (*HBS*), are calculated with the usage of the data using the same as in the previous chapter to see if hedging can be used to reduce cash price risk.

All the hedging effectiveness measures will be calculated using the SAS program. The calculation will be on the same data span as the cointegration and market efficiency calculation, that is, from year 1987 to 1999, 1988 to 1999, 1989 to 1999, 1990 to 1999, 1991 to 1999, 1992 to 1999, 1993 to 1999, 1994 to 1999, 1995 to 1999, 1996 to 1999, 1997 to 1999, 1998 to 1999 and 1999 alone, between the cash and one, two, three and four month futures prices before maturity to see the effectiveness of the hedging.

HE_{HD}, HE_{CS}, and *HB*'s calculation will be done in two steps. First, the standard deviation of one-period returns (percent) for the cash and futures, σ_s and σ_f, and the correlation factor between the returns of the cash and the futures, ρ, will be calculated using the SAS program. The HE_{HD}, HE_{CS}, and *HBS* will also be calculated using SAS program. The HE_{HD}, HE_{CS}, and *HBS* monthly, bimonthly, 3-month and 4-month cash and futures prices were constructed from the daily prices to examine the impact of the hedging effectiveness. The expected return for cash position and futures position are assumed at 10%. The risk free interest *i* is 2.75% quoted from the Central Bank of Malaysia inter bank interest rate.

Result

Table 16 tabulates the value of the hedging performance measured by the Ederington measure, HE_{ED}, for each time interval. HE_{ED} is a risk-reduction (theoretically risk-minimization) measure, which is measured by the square of the correlation coefficient between price changes of the cash and that of the futures. A perfect hedge will result the value of one, but to have a hedging effectiveness less than unity, will be in the hedger's advantage. Table 16 showed that overall, the result of HE_{ED} are less than, but very close to unity, which means that hedging is very effective within the framework of the model that Ederington has applied to hedging with financial future. The degree of hedging effectiveness seems to decrease as the period of hedges increase. The result showed that futures price of one month to maturity showed the highest hedging effectiveness compared with the more distant futures. These results are consistent for different span of time, from 13 years to 1 year only.

The effectiveness of hedging need to be checked using another measure of hedging, that is HE_{ED}, HE_{CS}, and *HBS* which indicates relative improvement in excess return (above risk-free interest rate) per unit of risk. HE_{ED} only measured the percentage reduction in the variance returns. HE_{HD}, HE_{CS}, and *HBS* are calculated for monthly, bimonthly, 3-month and 4-month cash and futures prices and the result are shown on Table 17, Table 18 and Table 19. HE_{HD}, HE_{CS}, and *HBS* provides the hedger with a tool to construct a portfolio consist of unit of cash and futures position, in other word to find the total unit of futures contract needed to hedge a unit of cash position. The computation of the portfolio as suggested did offer give satisfactory result.

Table 17 showed the result of Howard and D'Antonio 1984 hedging effectiveness based on the Sharpe ratio index. Result of this hedging effectiveness measure also showed that hedging are effective, since all the result, which showed the return plus the excess of return, if hedging was done, showed a positive number.

Table 18 showed the result of Chang and Shanker hedging effectiveness based on the Sharpe ratio index, showed a mix result. This hedging effectiveness measure only showed the excess of return. Some of the returns are negative, but those number are actually consistent with the result of Howard and D'Antonio 1984 hedging effectiveness which are very small for those period (see Table 17)

Table 19 showed the result of the revised Howard and D'Antonio 1987 hedging effectiveness based on the Sharpe ratio index. The result showed a similar trend with the result from their measurement of 1984 and Chang and Shanker hedging effectiveness.

Table 16: Ederington Hedging Effectiveness.

$$HE_{Ed} = \frac{\sigma_{sf}^2}{\sigma_s \sigma_f}$$

Year	Futures 1 month	Futures 2 months	Futures 3 months	Futures 4 months
1987-1999	0.99880	0.99616	0.99088	0.98536
1988-1999	0.99875	0.99596	0.99036	0.98448
1989-1999	0.99879	0.99608	0.99064	0.98501
1990-1999	0.99873	0.99588	0.99017	0.98424
1991-1999	0.99857	0.99540	0.98905	0.98246
1992-1999	0.99843	0.99492	0.98786	0.98501
1993-1999	0.99822	0.99424	0.98619	0.97782
1994-1999	0.99790	0.99322	0.98362	0.97370
1995-1999	0.99804	0.99450	0.98781	0.98106
1996-1999	0.99837	0.99593	0.99195	0.98841
1997-1999	0.99813	0.99514	0.99022	0.98591
1998-1999	0.99780	0.99479	0.99013	0.98578
1999-1999	0.99400	0.98782	0.97836	0.97023

**Maximum effectiveness if* $HE_{ED} = 1$. *Best if close to unity.*

Table 17: Howard and D'Antonio 1984 Hedging Effectiveness

$$HE = \frac{\theta_H}{\theta_S}$$

Year	Futures 1 month	Futures 2 months	Futures 3 months	Futures 4 months
1987-1999	1.07198	1.16589	1.17457	1.19353
1988-1999	1.06425	1.15350	1.16302	1.18284
1989-1999	1.06426	1.15321	1.16339	1.18589
1990-1999	1.05961	1.13436	1.14219	1.16240
1991-1999	1.04095	1.09138	1.09761	1.11520
1992-1999	1.02574	1.07092	1.07964	1.09240
1993-1999	1.02193	1.06851	1.07411	1.08789
1994-1999	1.00268	1.03168	1.04006	1.05080
1995-1999	1.00148	1.06885	1.09990	1.12648
1996-1999	1.00132	1.10135	1.16569	1.21992
1997-1999	1.00025	1.05945	1.10395	1.14300
1998-1999	1.00335	1.07018	1.11453	1.15473
1999-1999	1.11303	1.45805	1.65568	1.72606

**The result showed the initial investment plus percentage excess of return.*

Table 18: Chang and Shanker Hedging Effectiveness

$$HE_{CS} = \frac{\theta^* - (r_s - i)\sigma_s}{|(r_s - i)\sigma_s|}$$

Year	Futures 1 month	Futures 2 month	Futures 3 month	Futures 4 month
1987-1999	0.00999	0.03236	0.05137	0.06855
1988-1999	0.00951	0.03166	0.05057	0.06797
1989-1999	0.00933	0.03114	0.04993	0.06750
1990-1999	0.00902	0.02946	0.04692	0.06355
1991-1999	0.00747	0.02451	0.03899	0.05367
1992-1999	0.00551	0.02194	0.03511	0.04859
1993-1999	0.00522	0.02285	0.03629	0.04975
1994-1999	-0.00045	0.01471	0.02553	0.03625
1995-1999	-0.00132	0.02240	0.04160	0.05895
1996-1999	-0.00149	0.02460	0.04681	0.06646
1997-1999	-0.00271	0.01914	0.03847	0.05573
1998-1999	-0.00002	0.02209	0.04108	0.05878
1999-1999	0.03198	0.10795	0.17999	0.22439

**The result showed the percentage excess of return only.*

Table 19: Howard and D'Antonio 1987 Hedging Effectiveness

$$HBS = \frac{(i + \theta_H \sigma_s - r_s)}{\sigma_s}$$

Year	Futures 1 month	Futures 2 month	Futures 3 month	Futures 4 month
1987-1999	0.000005476	0.000017736	0.000028154	0.000037575
1988-1999	0.000005173	0.000017218	0.000027500	0.000036963
1989-1999	0.000004898	0.000016353	0.000026219	0.000035444
1990-1999	0.000004696	0.000015332	0.000024421	0.000033076
1991-1999	0.000003991	0.000013092	0.000020831	0.000028668
1992-1999	0.000002976	0.000011844	0.000018953	0.000026232
1993-1999	0.000002839	0.000012426	0.000019735	0.000027053
1994-1999	-0.000000260	0.000008500	0.000014757	0.000020953
1995-1999	-0.000000738	0.000012500	0.000023214	0.000032894
1996-1999	-0.000000754	0.000012433	0.000023660	0.000033593
1997-1999	-0.000001353	0.000009544	0.000019188	0.000027792
1998-1999	-0.000000009	0.000010593	0.000019699	0.000028184
1999-1999	0.000025368	0.000085631	0.000142773	0.000177990

**The result showed the percentage excess of return only.*

Table 20: Comparison Hedging Effectiveness Futures 1 Month to Maturity

Year	Ederington	HD 1984	CS	HD 1987
1987-1999	0.99880	1.07198	0.00999	0.000005476
1988-1999	0.99875	1.06425	0.00951	0.000005173
1989-1999	0.99879	1.06426	0.00933	0.000004898
1990-1999	0.99873	1.05961	0.00902	0.000004696
1991-1999	0.99857	1.04095	0.00747	0.000003991
1992-1999	0.99843	1.02574	0.00551	0.000002976
1993-1999	0.99822	1.02193	0.00522	0.000002839
1994-1999	0.99790	1.00268	-0.00045	-0.000000260
1995-1999	0.99804	1.00148	-0.00132	-0.000000738
1996-1999	0.99837	1.00132	-0.00149	-0.000000754
1997-1999	0.99813	1.00025	-0.00271	-0.000001353
1998-1999	0.99780	1.00335	-0.00002	-0.000000009
1999-1999	0.99400	1.11303	0.03198	0.000025368

Table 21: Comparison Hedging Effectiveness Futures 2 Months to Maturity

Year	Ederington	HD 1984	CS	HD 1987
1987-1999	0.99616	1.16589	0.03236	0.000017736
1988-1999	0.99596	1.15350	0.03166	0.000017218
1989-1999	0.99608	1.15321	0.03114	0.000016353
1990-1999	0.99588	1.13436	0.02946	0.000015332
1991-1999	0.99540	1.09138	0.02451	0.000013092
1992-1999	0.99492	1.07092	0.02194	0.000011844
1993-1999	0.99424	1.06851	0.02285	0.000012426
1994-1999	0.99322	1.03168	0.01471	0.000008500
1995-1999	0.99450	1.06885	0.02240	0.000012500
1996-1999	0.99593	1.10135	0.02460	0.000012433
1997-1999	0.99514	1.05945	0.01914	0.000009544
1998-1999	0.99479	1.07018	0.02209	0.000010593
1999-1999	0.98782	1.45805	0.10795	0.000085631

Table 22: Comparison Hedging Effectiveness Futures 3 Months to Maturity

Year	Ederington	HD 1984	CS	HD 1987
1987-1999	0.99088	1.17457	0.05137	0.000028154
1988-1999	0.99036	1.16302	0.05057	0.000027500
1989-1999	0.99064	1.16339	0.04993	0.000026219
1990-1999	0.99017	1.14219	0.04692	0.000024421
1991-1999	0.98905	1.09761	0.03899	0.000020831
1992-1999	0.98786	1.07694	0.03511	0.000018953
1993-1999	0.98619	1.07411	0.03629	0.000019735
1994-1999	0.98362	1.04006	0.02553	0.000014757
1995-1999	0.98781	1.09990	0.04160	0.000023214
1996-1999	0.99195	1.16569	0.04681	0.000023660
1997-1999	0.99022	1.10395	0.03847	0.000019188
1998-1999	0.99013	1.11453	0.04108	0.000019699
1999-1999	0.97836	1.65568	0.17999	0.000142773

Table 23: Comparison Hedging Effectiveness Futures 4 Months to Maturity

Year	Ederington	HD 1984	CS	HD 1987
1987-1999	0.98536	1.19353	0.06855	0.000037575
1988-1999	0.98448	1.18284	0.06797	0.000036963
1989-1999	0.98501	1.18559	0.06750	0.000035444
1990-1999	0.98424	1.16240	0.06355	0.000033076
1991-1999	0.98246	1.11520	0.05367	0.000028668
1992-1999	0.98501	1.09204	0.04859	0.000026232
1993-1999	0.97782	1.08789	0.04975	0.000027053
1994-1999	0.97370	1.05080	0.03625	0.000020953
1995-1999	0.98106	1.12648	0.05895	0.000032894
1996-1999	0.98841	1.21992	0.06646	0.000033593
1997-1999	0.98591	1.14300	0.05573	0.000027792
1998-1999	0.98578	1.15473	0.05878	0.000028184
1999-1999	0.97023	1.72606	0.22439	0.000177990

Table 20, Table 21, Table 22 and Table 23 compared the result of the hedging effectiveness. Besides the Ederington hedging effectiveness measure, which statistically different, the other three hedging effectiveness based on Sharpe ratio showed a similar result, with the exception of some short periods on the futures 1 month to maturity.

Chapter IV

Findings

The main goal of the study is to show the usefulness of the time series forecasting technique combined with hedging to reduce from the cash price risk faced by CPO producer. Result of these study showed that in CPO market, forecasting and hedging could be done and could reduce cash price risks.

The system of futures trading is based on the fact that cash and futures prices move together. The parallel movement of cash and futures prices is assured by the fact that buyers (or sellers) of futures are entitled to demand (or to enforce acceptance of) delivery of the commodity. The movement has to have some degree of dependency that will enable to predict how the cash prices will move following the futures prices. The statistical question in most works center on whether there is cointegration between the cash and futures prices, which is necessary if futures prices are unbiased predictor of cash markets (Brenner and Kroner, 1995).

Prices on cash and futures markets of many commodities are observed to change frequently and in an apparently erratic manner. Taking cash and futures prices data on a daily basis is desirable, because prices in many cases do change from time to time, one day to the next. Cointegration test and market efficiency test involving daily cash price data and matching it to futures price data with one, two, three and four months to maturity are investigated.

Covey and Bessler (1995) and Fortenbery and Zapata (1993) have argued that cointegration may depend on asset storability. They have argued that researcher should expect cointegration between cash and futures prices for storable commodities. The results of the cointegration test showed that cointegration exist between the cash and futures prices with one, two, three and four month to maturity.

According to unbiasedness hypothesis (Brenner and Kroner, 1995), futures prices are an unbiased estimate of future prices. Black (1976) and Peck (1985) argued that the forward pricing role of futures markets maybe sufficient to justify future prices as unbiased predictor for cash prices. If futures markets provide a forward pricing function, they are efficient.

Market efficiency was established to exist for CPO futures prices with one, two, three and four month to maturity and cash prices. Efficiency implies that the current futures price is indeed the best forecaster of the expected cash price, and that the current futures price therefore should incorporate all available information. The implication of market efficient is that in general, over time (or in the long run), the current futures market prices are likely to predict accurately future cash prices of the same commodity.

Consistent with Black (1976) and Peck (1985)'s finding, in this study futures market provide certain long-run price information to cash markets for CPO for all period studied. Because futures market prices can be used to predict cash market up to four months in advance, producer can use the futures prices to assess when they market their harvest, but not for longer term production planning decision.

As CPO futures prices with one, two, three and four month to maturity are good predictor of CPO cash prices. The availability of hedging instrument in futures market, the problem facing the agricultural firm is one of selecting the optimal selection that will minimize the risk.

One main function of a futures market is the opportunity it provides to producers to the ability to control the risk of adverse price changes in the cash market through hedging. Hedging involves taking a position in the futures market, which is opposite to the position that one already has in the cash market.

Hedger sells as the commodity prices fall. He does so to protect himself against further potential losses. Hedger enters into risk commitments in the futures market because he wants to diminish his total risk. It is assumed that his objective is to minimize risk, not to maximize expected utility, which also depends on the expected return, so he will do hedging selectively. When hedging is done selectively, the advantage of the hedging to the individual firm may often be measured approximately by the amount of loss avoided directly by hedging.

Four hedging effectiveness measures, Ederington's (HE_{ED}), Howard and D'Antonio's (HE_{HD}, 1984), Chang and Shanker (HE_{CS}, 1986), and the revised Howard and D'Antonio (*HBS*, 1987) hedging effectiveness measure are introduced and analyzed in this study. The result of first hedging effectiveness measure, HE_{ED} which is only a risk reduction measure, showed that hedging CPO in futures market is efficient. The result would encourage CPO producer to hedge in the futures market.

The Sharpe ratio based hedging effectiveness measure, HE_{HD}, HE_{CS}, and *HBS*, which will show the excess of return of a commodity portfolio, all showed that hedging are effective. When hedging effectiveness are examined, the result showed that hedging in futures market would benefit producer since they give except for some short periods in this study.

This study's finding regarding prevalent cointegration and market efficiency between cash and futures prices on commodity markets suggest that cointegration and market efficiency should be incorporated into commodity hedging decisions. Many recent empirical studies on financial markets (Ghosh, 1995, Ghosh and Clayton, 1996 and Kroner and Sultan, 1993) have shown that hedge ratios and hedging performance may change considerably if cointegration between cash and futures prices is mistakenly omitted from the statistical model.

Based on this study, it seems likely the Indonesian CPO producers would be better of if they are hedging in COMMEX Malaysia.

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