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The undersigned certifies that the above student has satisfied the conditions of the project paper in partial fulfillment of the requirements for the degree of Master of Business Administration (Finance).

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ENHANCING PORTFOLIO RETURNS USING PETROLEUM FUTURES

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MBA Batch 3

Under the Supervision of
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MBA PROJECT PAPER

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CONTENTS

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ABSTRACT

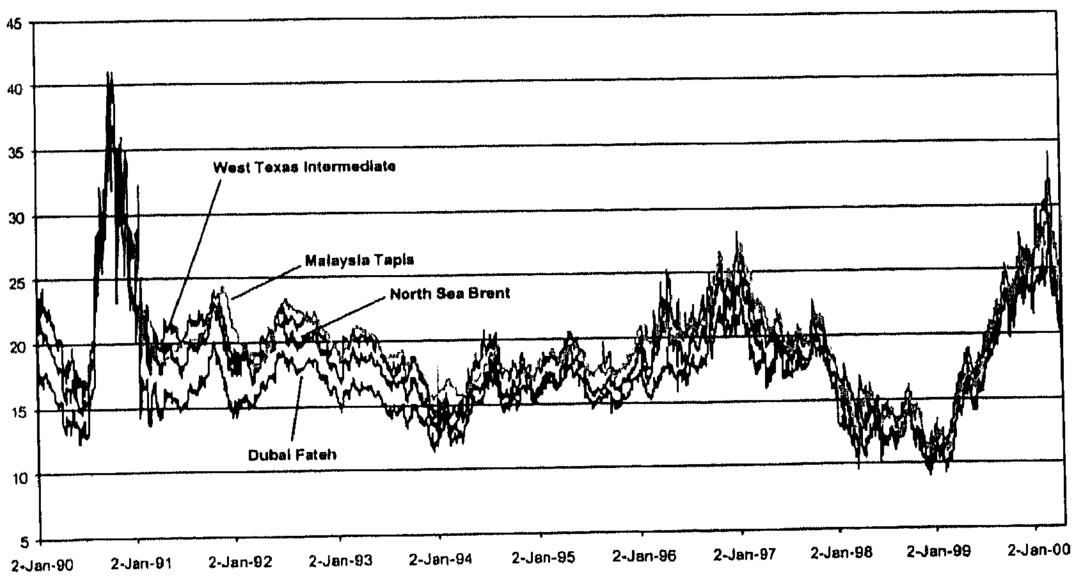
This study investigates the hypothesis that petroleum futures can be used to enhance portfolio returns. Using 10-year data from January 1990 to December 1999, the returns derived from petroleum futures contracts are compared against other asset class benchmarks. In particular, the Sharpe Ratios of individual asset classes and their correlations with petroleum futures are determined to help decide whether the inclusion of petroleum futures into a hypothetical portfolio of stocks and bonds can increase the risk-adjusted return of the portfolio. The study finds that petroleum futures do not merit to be stand-alone investment assets, but their inclusion in an optimized stock-bond portfolio ranging from 5% to 10% of total portfolio value can increase the Sharpe Ratio of the portfolio, thus enhancing its risk-adjusted return. The results are also consistent when evaluated using Treynor and Jensen measures, where improvements in T-values and alphas are observed for optimized portfolios that include petroleum futures within the range mentioned above.

CHAPTER 1

INTRODUCTION

Oil prices went through a roller-coaster ride during the course of 1990's. The beginning of the decade saw the American benchmark crude oil, West Texas Intermediate (WTI), climbed from $15 per barrel in June 1990 to $40 in October same year in response to Gulf War. Towards the end of the decade, WTI price dropped to $10 at end-1998 due to the sluggishness of Asian economic recovery and the buildup of excess inventory in petroleum supply system. However, by end of 1999 oil prices climbed up to $25 before reaching a peak at $35 in mid-March 2000. This prompts a question on whether there is money to be made from the petroleum market, given oil price volatility and the availability of various instruments that enable players to buy forward physical contracts and hedge the prices using paper oil futures or options.

Fig 1: Spot Benchmark Oil Prices Jan 1990 - Mar 2000
US$/barrel



While many studies have investigated the nature and behaviour of general commodity futures, this study will narrow its focus on petroleum futures. The uniqueness of petroleum market is that in addition to typical factors that affect commodity markets (eg. weather pattern, supply demand and inventory situation), it is also significantly affected by political situations. Changes in government energy policies, outbreak of war and diplomatic stand-off will affect oil prices.

There has been huge growth in commodity futures investments since 1980's. Investors are attracted to commodity futures markets as they provide alternative source of returns from traditional investments in stocks and bonds, and are now recognized as a distinct asset class. To earn a title 'asset class', an investment must have a unique characteristic of economic exposure. Petroleum futures, just like general commodity futures, are considered as Consumable/Transformable (C/T) assets. A C/T asset is an asset that derives its economic value from the need to consume or transform it into another functional use. It does not generate an ongoing stream of cash, and therefore cannot be valued using NPV analysis. This is different to capital assets like stocks and bonds, where the asset values are related to the ability to generate continuous stream of cashflow. Another asset class that will not be considered here is the Store of Value assets. This type of asset neither can be consumed nor generate income, but investors buy them on the expectation that they "worth something" in monetary terms. Examples of this asset class are fine arts and currency, whose valuations are depended upon other parameters like inflations and GDP indicators. Another distinction that separates a C/T asset from the other two is that the return on this asset is subject to global supply and demand factors. Allowing for transportation and handling costs, the value of similar grade of wheat or crude oil should be the same in all parts of the world.

The objective of this study is to test the hypothesis that petroleum futures can enhance the returns of traditional portfolio of stocks and bonds. In doing so, the study attempts to answer the following questions. First, what are the risk-return profiles of petroleum futures and how do they compare and correlate with other traditional asset classes? Second, should petroleum futures be a stand-alone investment or portfolio asset? Third, if there is any potential for petroleum futures to be a portfolio asset, what are the breakeven rates of return required from petroleum futures? Fourth, given all of the above questions, what is the optimal allocation for petroleum futures inclusion in a traditional portfolio consisting of stocks and bonds? Since these are empirical questions, more reliable answers can be obtained by maximizing the extent of time period. However, we decided to go only as far back as 1990 due to some contracts like Brent crudeoil and Natural Gas futures were only introduced in 1988 and 1990 respectively. A total of 30,000 daily data were used to enable a comprehensive analysis for this study.

A general conclusion of this study is that petroleum futures do not fit to become a stand-alone investment, but they can enhance a portfolio's risk-adjusted return through inclusion of between 5% to 10% of total portfolio value into an optimized stock-bond portfolio. By doing this, the Sharpe Ratio of an already optimized stock-bond portfolio can be further increased to achieve higher return per unit volatility.

This paper is organized as follows: Chapter 2 provides brief introduction to petroleum markets. Chapter 3 describes commodity futures market and the theoretical model governing futures prices. Chapter 4 reviews relevant literatures related to this study, while Chapter 5 describes the data and methodology used. Chapter 6 provides explanation on the outcome of the analysis and Chapter 7 concludes the paper.

CHAPTER 2:

THE PETROLEUM MARKET

Overview

The physical crude oil market is the foundation of petroleum market. There are more than one hundred grades of crude oil that are produced in fifty countries around the world. As every grade and location represent a different price and the relative values of crude oil are continually changing in response to changing pattern in supply and demand, the petroleum market is both remarkable and unpredictable.

Oil is now the biggest and most important commodity market in the world. The evolution and revolution of this market can be traced back to events in early and late 70's, where dramatic changes in oil prices led to the creation of oil markets to facilitate industry players to manage their price exposures.

Price of oil was relatively stable up until early 70's, when production of crude oil was largely controlled by the biggest oil companies, often referred to as 'seven-sisters'.[1] These large integrated companies would normally retain oil that they produced within their own refining and distribution systems, thus very little amount of oil would appear in the spot market. Even if there was any transaction of oil between companies, the contracts were often on long term with fixed prices. Consequently, price volatility was low and there was little need for risk management.

Development of oil market

Two price shocks that happened in that decade, first in 1973 due to OPEC's action in response to Yom Kippur's war, and later in 1979 during Iran / Iraq war, triggered the need for a more open market for trading crude oil. Short term physical markets evolved rapidly,

[1] These companies are Exxon, Royal Dutch/Shell, British Petroleum (BP), Texaco, Mobil, Chevron and Total.

and naturally the players began to look for ways to manage the price volatility that has been a fundamental feature of the market. International Petroleum Exchange (IPE) in London launched Gasoil Futures in 1981, which was then followed by New York Mercantile Exchange (NYMEX) with its introduction of West Texas Intermediate (WTI) Futures in 1983. By this time, the world consumption of crude oil reached 65 million barrels/day, and traders began to look for a suitable hedging tools for managing crude oil price volatility.

In 1999, the world consumption of crude oil stood at 72 million barrels per day (bpd). The world's largest exporter, Saudi Arabia, produced around 9 million bpd while Malaysia produced about 675,000 bpd. OPEC as group produced 31 million bpd, constituting about 45% of world's production. The sheer size of OPEC's production renders it as an important organization that greatly influence the price of oil despite common analysts' remarks that refute their power to set oil prices. On the demand side, United States is the biggest consuming nation of oil, taking 25% of world's total demand. However, as a group, Asia Pacific and Europe are also major consumers, constituting 27% and 24% of world's total demand respectively.

Pricing of crude oils

A crude oil is characterized by two major properties: its lightness and sweetness. A light crude oil has more proportion of light hydrocarbons like liquefied petroleum gas (LPG), gasoline and kerosene, while a heavy crude oil has more proportion of heavier hydrocarbons like diesel, fuel oil and bitumen. Sweetness and sourness refer to the sulphur content in a crude oil. The more sulphur content it has, the more sour/acidic it is, and this increases the costs of processing it in the refineries as regulations stipulate strict sulphur limit in petroleum products. In normal market, the light and sweet curds command higher prices than the heavy and sour ones. This is demonstrated by the consistent positive historical price differential between light-and-sweet Tapis and heavy-and-sour Dubai since 1991.

Due to numerous variety of crude oils, traders tend to price them relative to a few benchmarks. These benchmark crude oils are chosen due to their popularity and familiarity of the traders to their qualities. The four benchmark crude oils are regional specific; America's West Texas Intermediate in North America, UK's Brent in Europe, UAE's Dubai in Middle East and Malaysia's Tapis in the Far East. All other crude oils in the respective regions will be priced relative to these crudes, eg. Gippsland crude of Australia is frequently quoted as Tapis ± x US$ per barrel, where x is the premium or discount relative to Tapis. Likewise, Sudanese crude in Africa is often quoted as Brent ± y US$ per barrel.

Crude oil is processed in a refinery for physical separation into various segments of hydrocarbons, mostly known as LPG, gasoline, kerosene, diesel, fuel oil and bitumen. Each of these products have their own regional market, namely United States Gulf Coast and New York, Europe's Rotterdam and Genoa, Persian Gulf for Middle East, Singapore and Japan for Asia Pacific. Each of the products have their individual prices that are directly linked to supply and demand of consumers. Thus theoretically, the supply and demand of these products should determine the crude oil prices and not the other way round. However, the mismatch between timing and inventory position may at times disconnect the link between petroleum products and crude oil.

The yield of crude oil will ultimately decide the attractiveness of processing it into products. The difference between weighted average value of products from refining a crude oil relative to the delivered price of that crude oil is referred to as refining margin. This margin provides the incentive for oil refiner to purchase the crude from oil producer. Likewise, the need for oil refiners to derive positive refining margin is a fundamental force that link the economics and prices of both crude oil and products.

There are three oil product futures contracts available for hedging tool. Unleaded gasoline, or petrol, is a fuel used for light transport eg. cars, vans and motorcycles. Gasoil is the petroleum industry's term for diesel, used for heavy transports like trucks and tractors. Heating oil is also known as fuel oil, used in factory burners and power generators. The details of these futures contracts are tabulated in the Appendix. Futures contracts for other products are not suitable due to limited number of participants (eg. kerosene where majority of users are only airline companies).

Apart from supply, demand, inventory level and political situations, petroleum market is also affected by shipping and chemical markets. Shipping market dictates the flexibility of moving crude oil cargoes from one place to another, whereas chemical market affects oil prices due to many oil products and natural gas are feedstocks for production of chemicals.

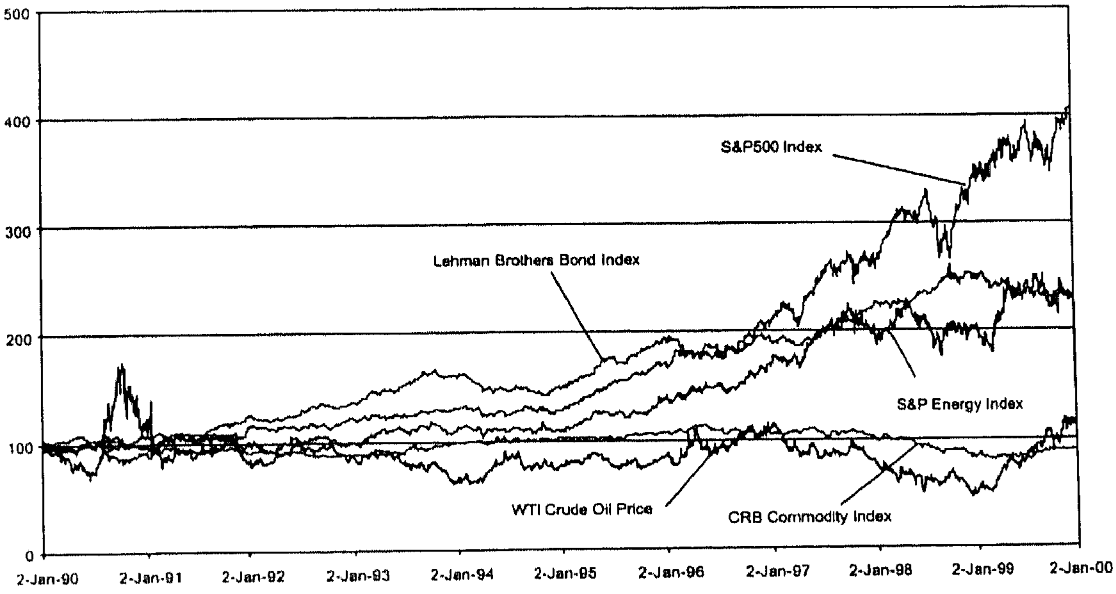
Natural Gas

Natural gas has a separate market, which has little correlation with the oil market. It has its own economics and supply demand profile. This market is relatively young, with Henry Hub Natural Gas contract only introduced in 1990. In the early days, natural gas was priced using fuel oil (heating oil) plus some adjustment factor that takes into account of heat content of natural gas. However, as natural gas increases its share in the global energy source, there is sufficient scale for it to be priced on its own. Furthermore, switching from oil to gas is a one-way action where you cannot turn back to oil just because oil is cheap. Due to the inflexibility of turning back to oil and the encouragement by many governments for their industries to switch to gas, there is continual growing demand of gas. The price of natural gas has been in the range of 2.00 to 3.50 US$ per MMBTU (million British Thermal Unit) for the past two years both in the United States and Asia.

Recent trends in petroleum markets

Over the years, there has been greater tendency for traders to shift their attention from United States WTI to UK's Brent. This is due to the fact that the latter offers several features that make it more attractive than WTI. First, there is no restriction on bringing Brent crude out of the UK. In contrast, United States does not allow the export of their native crude oils (except certain crudes from Alaska). Secondly, delivery of WTI must be less than 5,000 barrels via pipeline at Cushing, Oklahoma. This is quite cumbersome as traders prefer to transact based on bigger parcel size that can be delivered by ships as offered by Brent IPE contract. Furthermore, North Sea contains many oil fields that produce crudes of similar qualities to Brent, and the total production of North Sea (both in the UK and Norwegian shores) constitute 9% of world's production. This implies that Brent is highly liquid. Another factor that makes Brent more attractive to WTI is due to the geographical location of North Sea which is at the mid-point between the largest producer (Middle-East) and the largest consumer (United States). This makes Brent as a natural price benchmark and a source of information for arbitrage opportunities.

Fig 2: Indexed Performance of Various Investments (2/1/90 = 100)



CHAPTER 3:

PETROLEUM AND COMMODITY FUTURES MARKETS

Background

Petroleum futures are typically considered as a subset to commodity futures. All commodity futures indexes include petroleum futures in their baskets. Commodity futures indexes attempt to replicate return available by holding long positions in commodity investment. Theoretically, this kind of investment has three sources of return: price, roll and collateral returns. Price return is derived from changes in commodity futures prices. Roll return arises from rolling over futures positions forward through time, where positive return is derived if futures price on the rolling date is lower than the spot price on delivery date. Collateral return assumes that the full value of the underlying asset is invested at risk-free rate. Goldman Sachs (GSCI) and JP Morgan (JPMCI) commodity indexes include all three components in their index calculation but others like CRB and Dow Jones Futures indexes are based on price return alone.

Each of the major indexes is composed of different group of commodities, different ways of calculating index value and different scheme of adjusting its components. JPMCI is composed of industrial commodities (energy and metals only) but CRB and GSCI include agriculture and live-stock commodities in addition to energy and metals. In principle, different basket composition indicates different exposure objectives but it may also be due to liquidity considerations. An index that includes illiquid assets is difficult to replicate and will not generate return as intended.

While there is a perception that futures trading is a zero-sum game, there is also increasing acceptance among portfolio managers that managed futures do not restrict them from gaining superior risk-return tradeoffs relative to other assets. This study will look at the enhancement that petroleum futures can do to an optimized portfolio of stocks and bonds, illustrating how a traditional portfolio performance can be stretched by including an unrelated asset that derives its return from other sources.

Theoretical Model of Futures Market

The futures prices of storable commodities like crude oil and agriculture products are determined by the spot prices and the costs incurred while the commodities are stored awaiting delivery sometime in the future. The cost of holding a commodity until delivery date is known as the cost-of-carry. In the case of crude oil, the cost-of-carry consists of the cost of hiring storage tanks to store the oil (typically in the range of 20 to 50 US cents per barrel per month), insurance cost (between 0.03% to 1% of the total crude oil value) and the opportunity costs of holding the oil. Assuming the oil market is perfectly efficient and there is no significant price changes, the futures price will be a function of spot price and cost-of-carry as given by

$$F_{t,T} = S_t \times C_{t,T} \qquad (1)$$

where $F_{t,T}$ = futures price at time t for delivery in period T

S_t = spot price at time t

$C_{t,T}$ = cost-of-carry incurred during holding period from time t to T

Furthermore, cost of carry is defined as

$$C_{t,T} = (1 + R_f + C)^{t,T} \qquad (2)$$

where R_f = risk free rate

C = cost of storage and other expenses related to storing the product

If the futures price is greater than the product of spot price and cost-of-carry, it will then be profitable to buy spot, store the oil (thus incurring cost-of-carry) and sell futures. Net profit, N, will be given by

$$N_{t,T} = F_t - (S_t \times C_{t,T}) \qquad (3)$$

The attempt of market participants to capture this profit will drive upward pressure on spot price and downward pressure to futures price until profit is eliminated.

There are several sources of volatility in futures prices. The year-effect refers to year-to-year changes due to random shocks, such as weather pattern (eg. El-Nino phenomenon) and political events (eg. Gulf War) that affect supply and demand of the commodity. The calendar-month effect refers to the seasonal changes within a year of the demand and supply of that commodity. For example, agriculture futures price volatility increases during summer months when traders await latest data on the quantity of crops harvested which will then affect supply availability for the rest of the year. Likewise, petroleum markets show similar behaviour with gasoline and heating oil prices exhibit greatest volatilities during summer and winter respectively. The third source of volatility is the maturity effect, where competitive forces in the market ensure futures prices converge to spot price at maturity. Here, the prices of futures contracts close to expiration date react more strongly to new information about the commodity than those of more distant contracts, where little is known about what is going to happen at maturity date which is far in advance of the current date. The debate behind the actual behaviour of volatility versus time to maturity will be discussed in the next chapter.

The principal reason for studying commodity and petroleum futures prices is due to the fact that investment in spot commodity or oil markets is not practical. Spot market typically means immediate or very-near delivery date of physical cargoes, which implies that the investor has to be a real player in the industry who sells the commodity that it produces, or who buys the commodity for its own consumption, or a trader with committed suppliers and buyers at both ends of the tradeflow. On the other hand, futures market provides exposure to commodity market without the need to transact physical cargoes. As all futures contracts are cash-settled, they attract bigger mix of participants and provide better dissipation of risks among commodity industry players, speculators and arbitrageurs.

CHAPTER 4:

LITERATURE REVIEW

Overview

The proponents for managed commodity futures argued that commodities have certain capabilities that make them suitable to be an asset class of their own. These arguments centered on three parts. Firstly, there is a need to diversify a portfolio against economic events such as high inflation which harms stocks and bonds but favours commodities. Secondly, investors need to find investments that provide alternative source of returns. Agriculture commodities is a good example of this type of investment as their returns are linked closely to weather conditions and inventory levels, which has little connection to capital assets. Thirdly, there are opportunities to exploit price inefficiencies that frequently exist in commodity and commodity-derivative markets.

This study relates closely to numerous papers written for general commodity futures, mainly due to the fact that petroleum futures market is relatively recent as compared to other commodities which has been around since 1940s.

Relationship between risk and return for commodity futures

The first attempt to answer the relationship between systematic risk and return on commodity futures was carried out by Dusak (1973) within CAPM context. She argued that futures contracts are not different in principle from any other risky assets and ran a regression test against S&P500 Index for three commodities. Examining the two-week holding period returns for wheat, corn and soybean futures for the period 1952-1967, she found that commodity futures generally exhibited returns near to zero and beta values of around 0.05. She concluded that these futures contracts had zero returns and near zero systematic risks. Bodie and Rosansky (1980) extended Dusak's work using quarterly returns on buy-and-hold strategy of 23 commodity futures for the timeperiod 1950-1976. For the market portfolio, they employed a benchmark portfolio consisting of equal dollar amount invested in all of the available commodity futures. The mean rate of returns for the benchmark portfolio were found to be positive, but for the individual commodities, the returns were generally positive even though the beta values were negative. This negative slope led them to conclude that their findings were not consistent with CAPM, and suggested that commodities performance should not be measured using methodologies applied to stocks and bonds.

Taking the leads from the two studies, Park, Wei and Frecka (1988) investigated the risk-return relationship of commodity futures using Arbitrage Pricing Theory (APT), on the basis that market portfolio does not play a crucial role in this model. The model starts by assuming that the return on asset i is generated by the following k linear factor model:

$$R_i = E_i + b_{i1}\delta_1 + b_{i2}\delta_2 + \dots + b_{ik}\delta_k + \varepsilon_i \qquad (4)$$

where R_i = return on asset i during a specified period

E_i = expected return for asset i

b_{ik} = reaction in asset i's return to movement in common factor

δ_k = a common factor that influences the return on all assets

ε_i = random error term

Furthermore, if n is infinite, E_i can be approximated as

$$E_i = \lambda_0 + b_{i1}\lambda_1 + b_{i2}\lambda_2 + \dots + b_{ik}\lambda_k \qquad (5)$$

where λ_0 = the expected return on asset with zero systematic risk

λ_k = risk premium related to each of the common factor k

The study collected commodity futures price data for 14 agriculture commodities and 3 metals (platinum, silver, copper) for the period 1967-1982. They used 3 measures as market portfolio: NYSE Index, equal weighted commodity futures index of the 17 commodities that they had collected, and a portfolio of 90% NYSE Index and 10% commodity futures that they constructed. Using quarterly returns on futures contract of the commodities, they found that neither the APT nor CAPM is satisfactory in explaining the risk-relation for the commodity futures contracts. They also suggested that the questions remaining from the results obtained by Dusak and Rosansky were not due to different proxies for the market portfolio, but rather attributed to the inconsistency of risk-return relations with the CAPM and instability of returns yielded by commodity markets.

Kolb (1996) measured the systematic risks of futures contracts for data collected for time period 1969-1992. Using regression of beta values against returns provided by Center of Research in Security Prices (CSRP), the study found that many commodity returns are non-zero over the length of the study, with energy futures (WTI, natural gas and liquid propane) yielding return far in excess of zero percent (7.8%, 16.4% and 21.6% respectively). The study also found that the beta of commodity futures are close to zero, even though a detail look at the energy sector showed that the beta for all energy futures contracts had small negative betas (between –0.1 to –0.2). Furthermore, the study found very little correlation between systematic risks and return for commodity futures, with R^2 less than 6%. However, it should be noted that many petroleum futures contracts were introduced between middle and end 1980's, therefore despite the extensiveness of data collected for many commodity contracts in the study, the analysis on petroleum futures were still based on much smaller timeframe. Our study does not face this problem as all data were available within the range of 1990-99, enabling consistent comparison between various asset classes within the time period.

Relationship between trade volumes, spot and futures prices

Moosa and Al-Loughani (1995) examined the relationship between spot and futures oil prices to see whether or not arbitrage and speculation play a role in determining futures prices. Using WTI spot and futures prices from 1986 to 1991, they used a natural logarithmic model that specified futures price as a function of arbitrage price and the expected spot price. The arbitrage price was derived by adjusting the spot price by a factor accounting for the real and financial cost of carry. The real cost of carry was proxied by OECD monthly inflation rate, while financial component was proxied by 3-month LIBOR rate. The expected spot price was proxied by the actual spot WTI price prevailing at the aturity of the futures contract. They found that the role of arbitrage was more dominant ver the period studied as compared to speculation, as given by the arbitrage coefficient of 925 versus 0.049 for speculation coefficient derived from their model.

ujihara and Mougoue (1997) studied WTI crude oil, unleaded gasoline and heating oil itures contracts to determine whether or not there is any relationship between returns on itures contract and traded volume. This causality test is important as it could provide useful iformation on whether knowledge of past trading volume improves short-term forecasts of urrent and future movement of futures prices. Using daily data for the period 1984 to 1993, iey used Linear Granger Causality Test to see whether there was any relationship between aded volume and returns for all three futures contracts. A process is said to exhibit iranger causality when past information on one variable (eg. volume) improves the rediction of a second variable (eg. return) in a better fashion. The linear test found no elationship between volume and return for heating oil futures. For WTI crude oil and nleaded gasoline, there was a weak linear relationship between their volumes and returns ut not statistically significant. Thus, their test showed that futures return and volume have no redictive power for one another. However, when the data was tested for Non-linear Granger Causality using GARCH-filter data, they found that there was a non-linear lependence in the returns and volumes series arising from the variance of the process. The est showed that large trading volumes caused higher price fluctuations, which would then ffect returns on futures contracts.

Commodity futures prices and maturity effect

Samuelson (1965) postulated that there is a negative relationship between maturity and futures prices volatility. A piece of information released when there is a long time to maturity will have little effect on futures prices, but the same information released just before maturity will have a larger effect. This has become known as Samuelson hypothesis which was further clarified by Anderson and Danthine (1983), who argued that whether the volatility of futures prices rises or falls as maturity approaches is depended upon the amount of uncertainty that has been resolved. If a great deal of uncertainty remain unsolved as maturity approaches, the pattern of time series volatilities in futures prices will increase. Conversely, if much of the underlying uncertainty has been resolved, the futures prices tend to stabilize as maturity approaches.

Galloway and Kolb (1996) studied maturity effect using 4111 futures contracts drawn from 45 commodities over the period 1969-1992, ranging from metals, energy, agriculture and financial commodities. They calculated daily returns and monthly variances of these returns for each of the six months preceding the expiration of the contracts. The argument for limiting to six months contracts was based on the low trading volumes for those contracts beyond this period. The test on maturity effect was carried out by using multiple regression of the following equation

$$\sigma^2_{i,k} \quad = \quad \alpha + \beta k + \gamma \sigma^2_{j,6\text{-month}} + \varepsilon \qquad (6)$$

where $\sigma^2_{j,k}$ = Volatility of returns for futures contract j in kth month

k = time in months remaining prior to maturity

ε = error term

If maturity effect exists for futures return volatilities, then γ is expected to be positive and β is expected to be negative. The study found that maturity effect has a significant influence for agriculture and energy commodities, but not for metals and financials. It therefore concluded that maturity effect is an important source of volatility in futures prices for commodities that experience seasonal demand and supply, but not for commodities for which cost-of-carry works well.

Black and Tonks (2000) examined the pattern of volatility over time of a series of commodity futures prices. Their focus was to test under what condition does Samuelson hypothesis – that the variability of futures prices increases as maturity approaches – will be true. Using agriculture commodities as a basis, they employed a three-trade-date rational expectation model to ascertain whether informational efficiency plays a role in determining volatility of futures prices. Date 1 is defined as the start of harvest period where farmers decide how much commodity to produce and how many futures contracts to buy or sell.

\dditionally, there are also noise traders who will participate in buying and selling futures ontract. Date 2 is the re-trade futures market where participants take cue from end of Date and resolve some of the uncertainties regarding supply, demand and prices, allowing armers and traders to revise their holdings of futures contracts. Date 3 is when the ommodity is harvested, sold on the spot market and the futures contracts are delivered.

Their model shows that informational efficiency between Date 1 and Date 2 plays a crucial ole in determining the volatility of futures prices as it approaches maturity (Date 3). The nore farmers who are informed, the more information will be reflected in the prices on Date 2, hence uncertainty will be resolved more quickly. Consequently, there will be less ıncertainty remaining between Date 2 and Date 3, resulting in lower volatility in futures prices as maturity approaches. The study therefore concluded that informational efficiency and uncertainty resolution plays a crucial role whether or not Samuelson hypothesis will be observed in futures markets.

Price linkages between commodity futures

Malliaris and Urrutia (1996) carried out an empirical test to investigate the hypothesis that the prices of six agriculture commodities traded at Chicago Board of Trade move independently of each other. Microeconomy postulates that there are two key economic linkages between any two commodities - substitutability and complementary. An illustrated example of the first linkage is when people are forced to switch from corn to soybean when the price of corn is too expensive as compared to soybean. The second example referring to the other linkage is when more soybean is used to produce soybean oil in the event when soybean oil price is too expensive as compared to soybean. The data used for this study were daily settlement prices for nearby contracts for the following commodities: corn, wheat, oats, soybean, soybean meal and soybean oil. Using Augmented Dicker-Miller (ADF) tests and Error Correction Model (ECM), they tested the cointegration of commodity prices and their relationship with one another. The results indicated that there were price linkages between the commodities, with long-term causality found to be stronger than the short term (less than 3-month). The study concluded by saying that commodity futures market ınctioned as commodity price-discovery and provide opportunities for cross-hedging and ɔeculation between the various commodities.

;ommodity futures as hedging tools

'root (1995) studied the hedging properties of real assets for a variety of diversified ıortfolios of stocks and bonds. He defined real assets as those that at least partially hedged gainst inflation, or tend to increase in nominal value in the face of inflation. Using this ırinciple, he classified conventional bonds as non-real assets, and through observations of ıerformance of stock market in relation to inflation, he argued that stocks too did not belong ɔ real asset category. Only CPI-link T-bills or bonds qualified to be real assets by lefinition, and observations on the price of real-estates and commodities led him to classify hem as real assets. Using the concept of pre-existing exposure and target exposure of ɔortfolio (defined as the % change in value of the existing asset or portfolio in response to .% change in the candidate asset), he uses data for timeperiod 1970-1993 and ran a egression to determine the exposures of stocks, bonds and currencies against various ;ommodities (gold, oil), commodity indexes (CRB, GSCI), real-estate series (REITS) and nflation. His results showed that gold, CRB Index, commodity-linked equities and real-ɜstate index provide weak hedges for broadly diversified portfolios. However, commodity ndex with high energy sector weightage (GSCI) and oil exhibit strong hedging properties ѕuch that they can reduce portfolio variance significantly.

Schneeweis, Spurgin and Potter (1996) studied the use of managed futures as hedging tools for downside equity risk management. Using 1985 to 1995 data of investment returns achieved by commodity trading advisors (CTA), a term used to describe managed futures managers, he calculated the Sharpe Ratios of various CTA portfolios and compared them against S&P500, Morgan Stanley Commodity and Magellan Fund indexes. He found that CTA portfolios generated returns in excess of the breakeven rate required to be a portfolio diversification asset candidate. This was principally due to the fact that the correlations between CTA portfolios and S&P500 was approximately zero (0.12). However, when the data are segmented according to whether the equity market rose or fell, CTA returns were