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RISK AND RETURN IN COMMODITY FUTURES MARKETS

Master's Thesis in
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ABSTRACT

Historically the average return from futures contracts has been approximately zero and the systematic risk is found to be low. This thesis investigates the relationship between commodity futures betas and realized returns. This study tries to answer three following questions, do commodity futures embody systematic risk as measured within the context of the Capital Asset Pricing Model? Are returns on commodity futures significantly different from zero? Are the returns on futures positions commensurate with the systematic risk of those positions?

This study focuses both single commodity futures and commodity futures as groups. Study contains nine different groups, agricultural, fertilizer, energy, animals, metals, grains and oilseeds, interest rates, index and currency futures. The results are also presented from physical and financial category side. Interest rate, index and currency futures are in financial category and it contains nine different commodity futures. Normally studies on futures concentrates on contracts but this thesis work uses yearly positions.

The data consist of 42 different commodities and market portfolio which is constructed from 90% of S&P500 and 10% of Dow-Jones Industrial Average. The risk-free interest rate used in this thesis is 3 month U.S. Treasury bill. The period of the study expands from January 1987 to December 2006 and the analysis uses daily and yearly observations of the data. The thesis includes more than 181,000 observations. The data is gathered from several difference exchanges around the world.

The empirical results indicate that futures returns are more often positive than negative. Only one was found to have statistically significant positive return, S&P500 index futures. 37 futures had positive and only 5 negative returns. From categories side, index futures were found to have the highest mean yearly return. In the case of systematic risk, 28 positive and 14 negative betas were found. Highest beta were observed nasdaq100 index futures and lowest from propane gas. Energy, currency and metal sector have negative average betas. Relationship between systematic risk and realized return were equally positively and negatively related and the levels of systematic risk were found to be very low. Sharpe and Treynor ratios were also calculate to give some support for the results of this study.

KEYWORDS: risk, return, capital asset pricing model, commodity futures.

1. INTRODUCTION

The world has changed a lot in recent decades. Also financial markets have come more unstable. Therefore the use of derivative instruments has grown rapidly; they can offer protection and certainty for future undesired changes. Originally, futures markets were introduced to eliminate risk for commodities. Futures trading have exploded since 1970. As the number of futures markets has grown and the number of participants increased, numerous policy questions regarding futures markets and their regulation have risen (Carlton 1984: 237). The world first derivative founds from the bible. There is situation where Jakob wants to marry Laaban’s daughter against little compensation. The premium was 7 years work and underlying asset was Rachel (OMX 2006: 3). Futures trading began at the Chicago Board of Trade (CBOT) in the 1860’s. Between then and now, numerous different commodities have, at one time or another, been traded on futures markets. Since 1921, 79 different types of commodities have been listed in the Wall Street Journal.

The origins of much of the mathematics in modern finance can be traced to Louis Bachelier’s 1900 dissertation on theory of speculation, framed as an option pricing problem. Kiyoshi Itô was greatly influenced by Bachelier’s work in his development in the 1940’s and early 1950’s of the stochastic calculus, which later became an essential mathematical tool in finance. Paul A. Samuelson’s theory of rational warrant pricing 1965 was also motivated by Itô. Before the pioneer work of Markowitz, Modigliani, Miller, Sharpe, Lintner, Fama and Samuelson in the late 1950’s and 1960’s, finance theory was little more than a collection of anecdotes, rules of thumb, and shuffling of accounting data. (Merton 1998: 323.)

There are number of factors that contribute to the existence of futures markets. First, there must be enough of the underlying standardized commodity so that economies of scale lower transactions cost sufficiently to allow frequent trading. Second, there must be sufficient price variability in the commodity to create a demand for risk sharing among hedgers and speculators. Third, a “core” of trading activity among present and future commodity owners, trading futures contracts among themselves, must be present before speculators can be attracted. Fourth, the contract must provide a hedging ability that is not available in other markets. Fifth, the contract must be designed accurately and be equally fair for both buyer and seller. (Copeland, Shastri & Weston 2005: 281-282.)

Futures are nowadays widely used, just in CBOT, there were more than 674,000,000 contracts traded in year 2005. Futures contract is an agreement to buy or sell an asset at a certain future time for a certain price. It can be contrasted with a spot contract, which is an agreement to buy or sell an asset today. Fisher Black was the first to suggest The Pricing of commodity contracts in his article in 1976, and it was published in The Journal of Financial Economics. That can be thought as a final breakpoint for the use of futures contracts. A derivative can be defined as a financial instrument whose value depends the values of other, more basic underlying variables. Derivatives can be dependent on almost any variable, from the price of hogs to the amount of snow falling at a certain ski resort. The futures price is a function of underlying asset, time and risk-free rate. With that it is possible to define the price of underlying asset in the future. The first real solution for pricing derivatives came at 1970's from Fisher Black and Myron Scholes. Robert Merton expanded their theory later. The basic idea was to construct a portfolio which earns risk-free interest rate (Black & Scholes 1972: 641). Few years later, John Cox, Stephen Ross and Mark Rubinstein (1979) developed another option pricing model known as a binomial tree, which is based on simple discrete-time calculations.

In recent years there have been many studies from futures contracts. Several of those have shown that futures are not as simple as been thought. Many studies have concentrated to lead-lag correlations, normal backwardation and contango. Futures are often thought as riskless investment. Then they should earn risk-free interest rate. Newer studies have shown that it is possible to do abnormal returns with futures. Very interesting findings have also found from futures correlation, standard deviation and risk-return relationship. Many commodity futures tend to behave otherwise than stocks. For example, when stock prices tend to go down, oil prices tend to go up, and vice versa. Furthermore, Fabozzi, Ma and Briley (1994) found significantly higher preholiday returns in futures contracts compared to nonholiday returns.

This study combines almost two of the most known theories in finance, Capital Asset Pricing Model and derivative instrument. CAPM was first introduced by Jack Treynor, William F. Sharpe, John Lintner and Jan Moss. It is build from earlier work of Harry Markowitz modern portfolio theory. Sharpe received the Nobel Memorial Price in Economics for this contribution to the field of financial economics. CAPM puts together expected return and beta relationship. The higher beta (systematic risk), the higher expected return by investor. Systematic risk is defined by the risk, which cannot be diversified. (Brealey & Myers 2003: 195.)

Since the pioneer paper by Katherine Dusak, the connection between futures returns and beta relationship has been focus of many studies in financial economic literature. Almost all of those studies have given a lot weight to futures contracts. This thesis uses a large data which includes many different commodity futures and weighted index portfolio.

1.1. Purpose of the study and the hypotheses

Futures are widely used for investment and hedging purposes. Many studies have found widely different mean returns for futures. Dusak (1973) reported zero or near zero returns for commodities analyzed. Bodie and Rosansky (1980) found only one commodity with negative mean return in their study Risk and Return in Commodity Futures. 22 commodity futures had positive mean return, even though these were not statistically significant.

This thesis investigates the problem of systematic risk and return in futures markets. There are three main questions in this thesis. First, do commodity futures embody systematic risk as measured within the context of the Capital Asset Pricing Model? Second, are returns on commodity futures significantly different from zero? Third, are the returns on futures positions commensurate with the systematic risk of those positions? Douglas Breeden said (1980) that if futures contracts have no real systematic risk, then its price should do not tend to increase nor decrease as it matures, according to the CAPM.

Research hypotheses

In recent years investible commodity indices and commodity-linked assets have increased the number of available direct commodity-based investment products. In addition, there is increasing evidence that indirect commodity investment, through debt and equity instruments in commodity-linked firms, does not provide direct exposure to commodity price changes. However, there is little information on the expected as well as the actual risk and return performance of a wide variety of investible commodity indices or commodity linked products that have been marketed. (Georgiev 2001:1.)

A number of theoretical frameworks have been proposed for understanding the source of commodity futures returns: the CAPM, the insurance perspective, the hedging pressure hypothesis, and the theory of storage. None of these perspectives is the final word on commodity price determination or prospective returns from investing commodity futures, but they are part of the evolution of thought about commodity futures investing.

Historically the average annualized excess return of the average individual commodity futures has been approximately zero and commodity futures have been largely uncorrelated with one another (Erb & Harvey 2006: 69). In Gorton & Rouwenhorst (2006) out of 36 commodities 18 had positive and also 18 had negative returns. A number of studies have argued that commodity futures are an appealing long-only investment class because they have earned a return similar to that of equities. Accordingly, it is hypothesized:

> H_1: The mean daily percentage return for all observations available for a given commodity equals to zero.

Second, the study tests median return for futures. Therefore, it is hypothesized that:

> H_2: The median return for all observations available is zero.

Futures are usually thought as a risk-free investment, and the third hypothesis concentrates its riskiness with the beta coefficient. Previous studies have examined the beta of futures contract, not yearly. Bessembinder (1992) examined the monthly beta coefficient in the context of futures. Changes in the futures price for a given commodity at a given maturity give rise to gains and losses for investors with long or short position in the corresponding futures contract. An investor with a position in the futures market is therefore bearing risk. If this risk is systematic, the simple market model developed by Markowitz (1959) and Sharpe (1963) can be used to measure systematic risk of commodity futures. The third research hypothesis is:

> H_3: The beta for each year futures is zero.

Subsequent studies have attempted to incorporate equilibrium financial models, notably Capital Asset pricing Model. Dusak (1973) found that futures futures contract had zero systematic risk and commensurate zero returns. Many other studies have also studied this same question. These reports tested different interpretations of the risk premium hypothesis and employed diverse statistical methodologies. In addition, they used data for different commodities and time periods. Their conflicting results leave the issue of risk premium an open question. The last hypothesis tested in this master's thesis concerns the relationship between returns achieved on the futures per year and the degree of systematic risk inherent in holding the futures position. As a central tenet of the CAPM, one would expect a higher degree of realized returns to be associated with greater systematic risk.

It is hypothesized that:

> H_4: There is no relationship between the returns and systematic risk of futures.

The data used in this thesis consists of 42 futures, four of those are currency futures, three are index futures, and two are interest rate futures. Chang, Chen and Chen (1990) investigated the same problems, but their data consist only from copper, platinum and silver futures. Also Kolb (1996) made a research from the same topic with 45 different commodities. The difference between this thesis and Kolb's study is that Kolb used futures contracts, and this study investigates the yearly futures positions. This study tries to find something new from futures as themselves, but also as groups. I am going to analyze the results also from categories and sectors side. The data consist from 33 physical commodities and 9 financial commodities. Several other studies have concentrated only to commodity futures contracts, this study is exception for that. A lot of different futures from different categories are used. The main goal is to provide more comprehensive and wider range of results than previous studies from commodity futures. This study contributes to the existing literature by using the most common futures data.

Some of the futures have underlying assets which includes to "inflation basket", for example energy futures. Then it can be assumed that energy futures might have negative betas. Inflation affects to interest rates, and when inflation rises, interest rates can be expected also to rise, and this will affect to stock prices. So it can be assumed to have connection with some derivative instruments and market portfolio used in this thesis work. Greer (2000) indicates that unexpected inflation should cause concern to every serious investor. It may result in negative returns to stock and equity markets, while often being favourable to increasing commodity prices.

1.2. Previous studies

Dusak (1973) was the first who linked the relationship between systematic risk and return in futures markets with the context of the CAPM. Dusak used heavily traded agricultural commodities: wheat, corn and soybeans. There were five different contracts per year for wheat and corn and six for soybeans. The data range was 1952 – 1967, including approximate 300 observations per contract. The systematic risk was found to be close to zero in all these three cases. Average realized holding period returns on the contracts over the same period were also close to zero. These results were consistent with Capital Asset Pricing Model.

Bodie and Rosansky (1980) investigated the mean returns and variabilities of the 23 individual commodities. They found only one with negative return – eggs- for the 27-year period. The mean rate of return on a well diversified portfolio of commodity futures contracts over the period 1950-76 was well in excess of the average risk-free interest rate. In fact, both the mean and variance of the return on futures portfolio were close to the mean and variance of the return on the Standard & Poor's 500 common stock portfolio. Moreover, futures portfolio served a far better hedge against inflation that the stock portfolio, because futures had more positively skewed return distribution. One of the main findings was also that, commodity futures tended to do well when stocks were doing badly, and vice versa. Almost all of their computed betas were negative, although only sugar had a beta significantly different from zero. They found that, the relationship between means and the corresponding beta coefficients appeared to be inconsistent with the conventional form of the capital asset pricing model. Finally, they also studied correlation between stocks and futures, which were found to be negative. Furthermore, common stock returns are negatively correlated with inflation, whereas commodity futures are positively correlated. What we observe from this is that, randomly chosen portfolio of common stock is a bad hedge against unexpected inflation, but well diversified commodity portfolio is a good hedge.

Carter, Rausser and Schmitz (1983) modified Dusaks (1973) study. Major difference for Dusaks research was the market index portfolio. Carter, Rausser and Schmitz used equally weighted portfolio, which consist of S&P 500 stock index and the Dow Jones commodity futures index. The major purpose for the paper was to evaluate the portfolio interpretation of futures market investment risk. The main findings were that the "non-market" rate of return measure proved to be generally significant. For commodities more closely linked to the general level of economic activity (cotton and live cattle), similar results were obtained. The results for cotton were particularly striking. Investor earns excess returns but the degree of systematic risk is conditioned on whether investor is net short or long.

Inspired by previous studies from Dusak and Carter et al, Baxter, Conine Jr. and Tamarkin (1985) made a research based on both the earlier studies. Baxter, Conine and Tamarkins purpose were to introduce a model based on the logic that only cash commodities be included in the market portfolio, and also compare their results for the previous studies. Their proxy for the market portfolio was constructed of 93.7% of the S&P500 index and 6.3% of the Dow-Jones Commodity Cash Index. Main contribution of the study was that their empirical work replicated Dusak's results and confirmed Marcus' hypothesis that a more proper specification of the market portfolio to include commodities would significantly reduce the size of the estimated systematic coefficients from those on the Carter, Rausser and Schmitz (CSR) study. Estimated betas were found to be near with Dusak's estimated betas, but not with CSR betas.

The relationship between risk and return in cattle and hog futures was studied in 1988 by Elam and Vaught. Purpose of that paper was to provide estimates of systematic risk for cattle and hog futures using a market portfolio based on the weighting scheme suggested by Marcus. Market portfolio consists of 90% S&P index plus the monthly dividend rate of return and 10% of Dow-Jones index of cash commodity prices. End-of-the-month values were used for the S&P and Dow Jones indexes. Systematic risk was estimated for data range 1975-1985. Cattle and hog futures were risky compared to the variance in the risk premium on the market portfolio for the same period. The mean monthly log-relative rates of return on cattle and hog futures were less than the monthly risk premium for the market portfolio. Livestock futures were found to be variable in price and thereby risky, but relatively low rates of return are paid to speculators for bearing that risk. A more consistent explanation of risk and return for livestock futures was provided by the CAPM. The low rates of return for cattle and hog futures were consistent with the low systematic risk for livestock commodities.

Chang, Chen & Chen (1990) introduced a study from risk and return in copper, platinum and silver futures. Their purpose was to extend the investigations into three major metal futures contracts. The characteristics of the underlying commodities of metal futures are quite different in many aspects from those of traditional agricultural and livestock futures. Most metals can be stored indefinitely, while holding times for agricultural commodities are relatively short. Over the sample period from January 1964 to

December 1983, six actively traded futures for copper, and silver, along with four platinum were considered. Following Elam and Vaught (1988), a combination of 90% of the return on the value weighted CRSP (Center for Research in Security Prices) stock index and 10% of the Dow-Jones Cash Commodity Index were as a proxy for the market portfolio in this study's empirical tests. Results based on the standard deviation of returns show that all three futures were riskier than average common stocks. However, Sharpe performance measure indicate that the returns earned for bearing risk per unit of total risk for these contracts are generally less than those of common stocks. When the risks for futures were analyzed within the CAPM, a risk premium, commensurate with the systematic risk for each contract, was identified.

Investigation about systematic skewness in futures contracts were introduced by Junkus (1991). This article tests a three-moment version of the CAPM for futures contracts. Monthly excess rates of return were calculated for twenty futures contracts and for the market portfolio for the 10-year period, January 1978 to December 1987. Futures prices for the nearby contract were from the Commodity Research Bureau. The contracts included interest rate, currency, metals, and commodity futures. Market portfolio was based on the monthly index level of the S&P500 and the Wholesale Price Index for all Farm Products. The results implicate that, both the estimates of systematic co-skewness and systematic risk were shown to change, though not significantly. Systematic risk had little significance in explaining futures returns. One of the main findings was that, the risk of futures contracts, whether measured by covariance or co-skewness with the market return, was fully diversifiable in capital markets.

Kolb made a research from the systematic risk of futures contracts (1996). He investigated futures mean and median returns, and systematic risk of futures positions. He used 45 commodities between years 1969-1992. There were 4735 futures contracts with 600,000 daily observations. The goal was to achieve more comprehensive analysis than previous studies. Mean returns were found to be positive for 19 commodities and negative for 14 commodities. Nine had significantly positive returns, while 3 had significantly negative returns. The mean returns for 21 physical commodities did not differ significantly from zero. Of 12 financial futures, 4 commodities exhibit significantly positive returns, while none had significantly negative mean returns. For the 33 physical commodities, the mean beta was positive for 18 commodities and negative for only four, and the negative results were peculiar to the energy complex. Even though estimated betas tend to be positive more often than negative, betas for most commodities were quite small. For all physical commodities the mean beta was only 0.0463. Realized returns on futures are generally inversely related to systematic risk, as measured by regressing return on the beta for all contracts for a given commodity. Among the 33 physical commodities, there was no significantly positive relationship. By contrast, it appeared to be inverse relationship between for 11 of the 33 physical commodities. Therefore, realized return was not positively related to systematic risk; if anything, the relationship was negative.

Latest research from commodity futures is made by Gorton and Rouwenhorst (2006), facts and fantasies about commodity futures. For this study, they constructed a monthly time series starting in 1959 of an equally weighted index of commodity futures. The whole data range was from July 1959 through December 2004. They showed empirically the large difference between the historical performance of commodity futures and the return an investor in spot commodities would have earned. An investor in their index would have earned an excess return over T-bills of about 5 percent a year. During the sample, commodity futures risk premium was about equal in size to the historical risk premium of stocks and exceeded the risk premium of bonds. Their study also showed that a diversified investment in commodity futures had slightly lower than an investment in stocks as measured in standard deviation. And the distribution of commodity returns was positively skewed relative to equity returns, commodity futures have less downside risk. The correlation with stocks and bonds was found to be negative over most horizons.

1.3. Structure of the thesis

The remainder of this thesis is organized as follows. This thesis contains theoretical part, empirical part and the conclusions. Chapter two summarise the theory of commodity futures and also the principles of pricing commodity futures. Payoff from futures, main using purposes and basic market mechanism are also introduced. Pricing part consist of five different pricing methods. Also we need to understand known income, known yield, cost of carry, convenience yield and storage costs. Chapter three concentrates on capital asset pricing model with risk and return. We also combine futures and the capital asset pricing model as Katherine Dusak did 1973. Last part contains information from normal backwardation and contango which has been known from 1930.

Next section of this thesis work contains data and methodology. That includes information about the data, how much we have it, what kind of data, which futures are used, number of daily observations, data range and the exchanges where the futures are traded. The methodology section describes how the empirical part of the thesis is going to be carried out. It presents the equations how the returns have calculated and why. Also the regression models used in this study are presented.

Part five is the empirical part where the results are introduced. First the mean and median returns are reported. Second, information about beta estimation is demonstrated and the final part summarise the risk and return relationship. Also descriptive statistics from returns are presented. All of these empirical results are going to be presented both single commodities and commodities as a group. Section six is the conclusions which gather together the information context which this thesis work has achieved.

2. THEORY OF COMMODITY FUTURES

Organized commodity futures trading facilitate two kinds of activity, speculation and hedging. When futures trading in a given commodity exist, the speculator generally finds it advantageous to deal in futures contracts rather than buying the commodity at the current spot price. Futures markets are useful also for hedging operations. An essential feature of commodity hedging is that the trader synchronizes his activities in two markets. One is generally the cash or spot market and the other is generally the futures markets.

Trading theorist has visualized the hedger as a dealer in the actual commodity who desires insurance against the price risk he faces. Speculators role is to take the risks that hedgers desire to transfer from their own shoulders. The futures market is visualized as a convenient mechanism through which price risk can be transferred from one group to another. Hedgers are willing to pay a risk premium to relieve themselves of price risk, while speculators are willing to enter the futures market only if they have the expectation of a collecting a premium. This was found by J.M. Keynes 1930 in A treatise on money. (Johnson 1960: 139-140.)

Adding commodity futures to an otherwise diversified portfolio can significantly enhance the portfolio's performance. In spite of this, commodity futures have not historically been important component of most investor's portfolios. Evidence that the performance of commodity futures is systematically related to economic conditions implies that investors may be able to use economic conditions in tactical asset allocation schemes to effectively guide an allocation to futures. (Jensen, Johnson & Mercer 2002: 100.)

2.1. Introduction to futures contracts

Futures contracts are traded in the exchanges. This means that those are standardized contracts. The market price of futures contract is known as the futures price and each contract specifies a delivery month. When the contract is first negotiated the quoted futures price is the delivery price for the underlying asset. The quoted futures price then varies continuously until the expiry date, when futures price must equal the spot price. The futures exchange sets the size of each contract, the units of price quotation, minimum price fluctuations, the grade and place for delivery, any daily price limits and margin requirements as well as opening hours for trading. The exchange must also set the final trading day for the futures contract, the most common ones are the third Friday of the month or the business day before last business day of the month. The contract size is also important to investors, if it is too small, transaction costs will be relatively high, and if it is too large, then investors cannot hedge relatively small amounts. The trades are monitored by the clearing house. (Cuthbertson & Nitzsche 2001: 27-32; Neftci 2000: 6.)

Initial margin is the amount of money that is needed to invest when taking position in futures contract. That is not payment for futures, in fact that is deposit or insurance that the contract is fair for both parties. When the balance in the margin account falls below the maintenance margin, trader has to deposit extra funds to restore the balance to the initial margin. This is the procedure which makes futures more safe than forwards, because it is insured and the accounts are balanced daily. Closing out futures position means that investor needs to take opposite position to contract that he has now. If he is long, he can close out the position by shorting contract, and vice versa. (Cuthbertson et al. 2001: 33-34; Hull 2003: 24-25.)

The seller of futures makes the choice of whether to deliver, and usually delivery can take place on any of several days in the delivery month. Some financial futures contracts involve the delivery of the underlying asset e.g. T-bills, while others, such as stock index futures are settled in cash. Often cash settled contracts use the settlement price on the last trading day and the positions of the long and short are then closed by clearing house. Another type of delivery is called exchange for physicals. There the holders of long and short position in a contract agree, via their clearing firms, what transaction would clear the contract, taking into account the change in the futures price and delivery costs. (Cuthbertson et al. 2001: 36.)

2.2. The payoff an a futures contract

Usually in the literature, forward and futures contracts are thought as a same. Of course there are large differences between those contracts, but for example to get know in futures, it is better to start analyzing the payoff from futures with same idea as forwards. The basic idea is that futures are an agreement to buy or sell the underlying asset in future, in a certain date and with certain price, which are defined now. Every futures contract has both buyer and seller. The term long is used to describe the buyer and short is used to describe the seller. More generally, a long position is one that makes money when the price goes up and short is one that makes money when the price goes down. The long position is an agreement to buy the asset, and short is agreement to sell it. (McDonald 2006: 23.)

The payoff to a contract is the value of the position at expiration. The payoff to a long futures contract is

$$S_T - K \quad (2.1)$$

where, K is the delivery price and S_T is the spot price of the asset at maturity of the contract. Similarly, the payoff from short position is

$$K - S_T \quad (2.2)$$

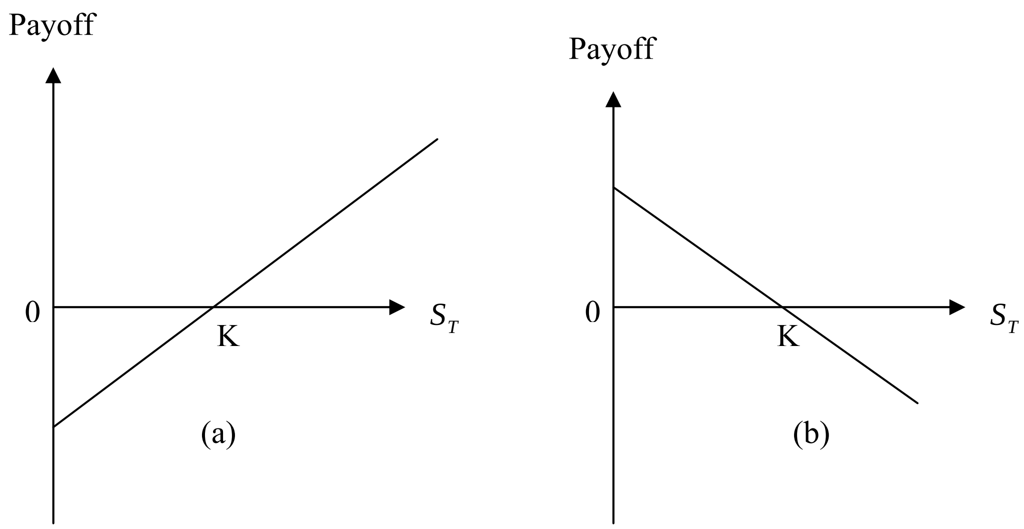

Figure 1. Payoffs from (a) long position and (b) short position. K = Delivery price and S_T = price of the asset at maturity.

These payoffs can be positive or negative (Hull 2003: 3-4). In real world, situation is not as clear as it seems, because futures contracts has daily settlement prices. This is one of the reasons why futures and forward contracts differ from each other.

2.3. Arbitrage, hedging and speculation

In derivatives markets there exists three kinds of traders. They use derivative instruments for different purposes. Arbitrage, which is also known as fundamental theorem of finance, because it plays very strong role in pricing derivatives, involves locking in a riskless profit by entering into transactions in two or more markets simultaneously. Usually arbitrage implies that the investor does not use any of his own capital when making the trade. Arbitrage is often loosely referred as the law of one price for financial assets. More generally, this implies that identical assets must sell for the same price.

Hedging

Many investors use futures for hedging purposes. A company may want to lock their profit in certain range. Then they could use futures contract to realize the profit in the future. This is useful to them, because then they are sure that they will get certainly known income in the future. This holds e.g. with currency futures. Transport companies can hedge against crude oil price fluctuations, and then they know the certain price for the gasoline in the near future. Futures contracts, if held to maturity, neutralise risk by exactly fixing the price that the hedger will pay or receive in the future. Even if the futures contract is not held to maturity much of the risk can be hedged, but some does remain, this is known as basis risk (Cuthbertson et al. 2001: 19). There exist three problems which includes in the basis risk.

1. The asset whose price is to be hedged may not be exactly the same as the asset underlying the futures contract.
2. The hedger may be uncertain as to the exact date when the asset will be bought or sold.
3. The hedge may require the futures contract to be closed out well before its expiration date.

The basis can be defined as follows

Basis = Spot price of asset to be hedged – Futures price of contract used

If the asset to be hedged and the asset underlying the futures contract are the same, the basis should be zero at the expiration of the futures contract. Prior to expiration, the basis may be positive or negative. When the spot price increases by more than futures price, the basis increases. This is referred to as a strengthening of the basis. When futures price increase by more than spot price, the basis declines. This is referred to as a weakening of the basis. (Hull 2003: 75.)

Hedging can be also used to change e.g. portfolios beta. Minimum variance hedge ratio includes to this strongly. The hedge ratio is the ratio of the size of the position taken in futures contracts to the size of the exposure. When the hedger is long the asset and short futures, the change in the value of the hedger's position during the life of the hedge is

(2.3) $$\Delta S - h\Delta F$$

where ΔS is the change in spot price and ΔF is the change in futures price. When investor has long futures (long hedge) the equation is as follows

(2.4) $$h\Delta F - \Delta S$$

In either case the variance, σ, of the change in value of the hedged position is given by

(2.5.) $$\sigma = \sigma_S^2 + h^2\sigma_F^2 - 2h\rho\sigma_S\sigma_F$$

so that

(2.6) $$\frac{\partial\sigma}{\partial h} = 2h\sigma_F^2 - 2\rho\sigma_S\sigma_F$$

Setting this equal to zero, and noting that $\partial^2\sigma / \partial h^2$ is positive, we see that the value of h that minimizes the variance is

(2.7) $$h^* = \rho\frac{\sigma_S}{\sigma_F}$$

where h^* is the hedge ratio that minimizes the variance of the hedger's position, ρ is the coefficient of correlation between δS and δF which are the changes of the spot price and futures price respectively. σ_S and σ_F are the standard deviations of spot price and futures price. The optimal hedge ratio is the product of the coefficient of correlation between δS and δF and the ratio of the standard deviation of δS to the standard deviation of δF (Hull 1993: 38 ;2003: 79). The minimum variance theory previously presented is based on portfolio theory. The difference in this case is that this one has derived from derivative instruments. Results is the same in both situations, key object is to get minimum variance to investors position. Jensen et al. (2000) studied the efficient use of futures in a portfolio context. They found that futures enhanced significantly portfolios returns, and with futures investors were able to optimize the risk return relationship. Figure 2 shows how the variance of the value of the hedger's position depends on the hedge ratio chosen.

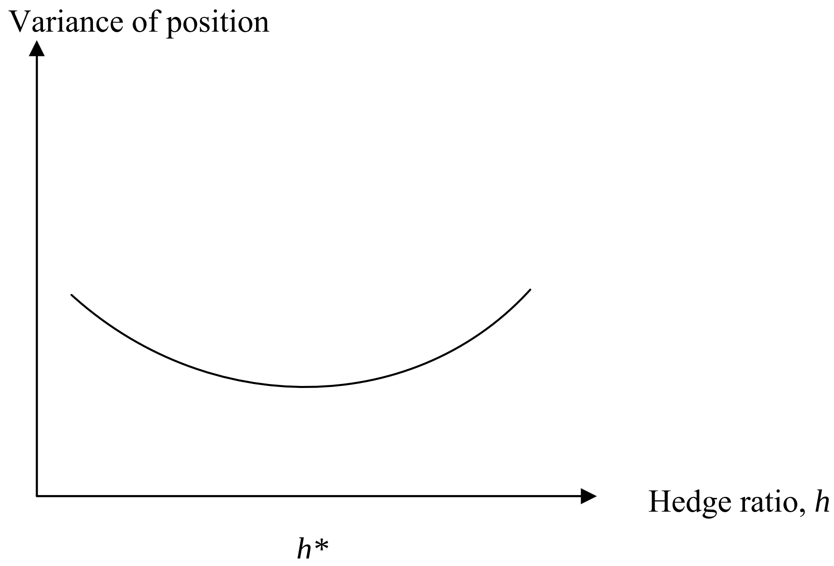

Figure 2. Relationship of variance and hedge ratio.

Stock index futures can be used to hedge the risk in a well-diversified portfolio of stocks. The relationship between the return on a portfolio of stocks and the return on the market is described by a parameter β. This is the slope of the best-fit line obtained when excess return on the market over the risk-free rate. The excess return on the index over the risk-free rate equals the growth rate of futures price. The growth rate of an index futures price can therefore be considered to be equal to the excess return of the market over the risk-free rate. It follows from the CAPM that the expected excess return on a portfolio is its β times the proportional change in an index futures price. To define optimal numbers of contracts we need to know N_A which is the size of position to be hedged, Q_F is the size of one futures contract and N^* is the optimal number of futures contracts for hedging. The futures contracts used should have face value of $h^* N_A$. The number of futures contract required is therefore given by

(2.8) $$N^* = \frac{h^* N_A}{Q_F}$$

With stock index futures it is easy to hedge an equity portfolio and also change its beta. If the portfolio mirrors the index, a hedge ratio of 1.0 is clearly appropriate, and the number of contract that should be shorted can be calculated from the next equation

(2.9) $$N^* = \frac{P}{A}$$

where P is the current value of the portfolio and A is the current value of the stocks underlying one futures contract. A stock index hedge should result in the value of hedged position growing at close to the risk-free interest rate. The excess return on the portfolio is offset by the gain or loss on the futures. If the hedger's objective is to earn the risk-free interest rate, he can simply sell the portfolio and invest the proceeds in e.g. treasury bills. A hedge using index futures removes the risk arising from market moves and leaves the hedger exposed only the performance of the portfolio relative to the market. (Hull 1997: 61-62.)

(2.10) $$N^* = \beta \frac{P}{A}$$

Equation (2.10) assumes that the maturity of the futures contract is close to the maturity of the hedge ratio and ignores the daily settlement of the futures contract. If investor want to change the portfolios beta from β to β^*, where $\beta > \beta^*$, then a short position in

$$(\beta - \beta^*)\frac{P}{A}$$

contracts is required. When $\beta < \beta^*$, a long position in

$$(\beta^* - \beta)\frac{P}{A}$$

contracts is required. (Hull 2003: 83-85.)

Speculation

The last purpose where futures can be used is speculation. By using futures, speculators can make very large losses as well as very large gains. In the case of futures the potential loss equals the potential gain, assuming equal probabilities of a fall and rise. With options the case is slightly different. For example using call options, speculator has limited his downside risk, but the maximum profit is unlimited. In the case of call options writer, the downside risk is unlimited (Cuthbertson et al. 2001: 19-20). Kaldor (1939) was the first ones who made research from speculation. He said that speculative stocks of anything may be defined as the difference between the amount actually held and the amount that would be held, if other things being the same, the price of that thing were expected to remain unchanged, and they can be either positive or negative. The traditional theory of speculation is defined the economic function of speculation as the evening out of price fluctuations due to changes in the conditions of demand or supply. Speculators are people better than average foresight who step in as buyers whenever there is a temporary excess of supply over demand, and thereby moderate the price fall. By thus stabilising prices, or at any rate, moderating the range of price fluctuations, they also automatically act in a way which leads to transfer of goods from uses where they have a lower utility to uses where they yield a higher utility.

Speculators can be defined into three different categories, *scalpers, day traders* and *position traders.* Of all speculators, *scalpers* have the shortest horizon over which they plan to hold futures position. Scalpers aim to foresee the movement of the market over a very short interval, ranging from the next few seconds to the next few minutes. Since their planned holding period is so short, scalpers do not expect to make large profit on each trade. Instead, they hope to make a profit of one or two ticks, the minimum allowable price movement. Many trades by scalpers end in losses or in no profit. If the prices do not move in the scalper’s direction within a few minutes of assuming a position, the scalper will likely close the position and begin looking for a new opportunity. This type of trading strategy means that scalper will generate an enormous number of transactions.

Compared to scalpers, day traders take a very farsighted approach to market. Day traders attempt to profit from the price movements that may take place over the course of one trading day. The day trader closes his position before the end of trading each day so that he has no position in the futures market overnight. The scalper’s strategy of holding a position for a very short interval is motivated by day traders, but it is not so apparent why day traders limit themselves to price movements that will occur only during the interval of one day’s trading. The basic reason is risk. Day traders believe that it is too risky to hold a speculative position overnight, too many disastrous price movements could occur.

Last type of trader is a position trader. A position trader is a speculator who maintains a futures position overnight. On occasion they may hold them for weeks or even months.

There are two types of position traders, those holding an outright position and those holding a spread position. Of the two strategies, the outright position is far riskier. The outright position offers a chance for very large gains is he is correct, but it carries with it the risk of very large losses as well. For most speculators, the risks associated with outright positions are too large. More risk-averse position trader may trade spreads. Intracommodity spreads involve differences between two or more contract maturities for the same underlying deliverable good. In contrast, intercommodity spreads are price differences between two or more contracts written on different, but related underlying goods. The spread trader trades two or more contracts with related price movements. The goal is to profit from changes in the relative prices. (Kolb & Overdahl 2006: 154-160.)

Pricing of Commodity Futures

The contract price on a forward contract stays fixed for the life of the contract, while futures contract is rewritten every day. The value of a futures contract is zero at the start of each day. The expected change in futures price satisfies a formula like capital asset pricing model. If changes in the futures price are independent of the return on the market, the futures price is the expected spot price. The futures market is not unique in its ability to shift risk, since corporations can do that too. The futures market is unique in the guidance it provides for producers, distributors, and users of commodities. These assumptions motivated and helped Black (1976) to derive formulas for the values of forward contracts and commodity options in terms of futures price and other variables. The results are derived from original option formula.

The value of futures markets arises from their ability to forecast cash prices at a specified future date and thus provide agents with mean of managing the risks associated with trading in a given commodity. In an efficient commodity market the futures price will be an optimal forecast of the spot price at contract termination in the sense that it will only be proved wrong to the extent of a random unpredictable zero-mean error (Kellard, Newbold, Rayner & Ennew 1999: 414). There are two popular views of commodity futures prices. The theory of storage of Kaldor (1939), Working (1948), Brennan (1958), and Telser (1958) explains the difference between contemporaneous spot and futures prices in terms of interest forgone in storing a commodity, warehousing costs, and a convenience yield on inventory. Telser developed a theory relating quantity's of inventories held to the expected price change, costs of storage, and the convenience yield from holding the commodity. The theory is based on expected spot prices, however, Hicks and Keynes argued that futures prices are downward biased estimates of expected prices (Cootner 1960: 396). The alternative view splits a futures price into an expected risk premium and forecast of a future spot price. Keynes was first to assert the existence of risk premiums in commodity futures markets (Hazuka 1984: 647). The theory of storage is not controversial. In contrast, there is little agreement on whether futures price contain expected premiums or have power to forecast spot prices. Fama and French (1987) used both models to study behaviour of futures prices for 21 commodities. They found that more powerful statistical tests make the response of futures prices to storage-cost variables easier to detect than evidence that futures prices contain premiums or power to forecast spot prices.

Usually forward and future price are thought as a same in theory. They have so much common that it makes sense to price those instruments with the same method. In next section we are going to look how investment, stock index, currency, commodity and interest rate futures are priced. In some cases it is easier to start the theory of pricing with forward contracts. I also use prepaid theory for some cases, because it helps to understand the official pricing theory.

2.4. Futures price for an investment asset

Easiest way to look futures price for an investment asset, is to suppose that the underlying asset is stock. First we are going to look prepaid forward contract on stock. In this case, prepaid means paying today to receive something in the future. Similarly, the sale of a prepaid forward contract permits the owner to sell an asset while retaining physical possession for a period of time. Three different methods are going to used, first, pricing by analogy, second, pricing by present value and third, pricing by arbitrage.

In the absence of dividends, whether investor receives physical possession today or at time T is irrelevant, in either case investor own the stock, and at time T it will be exactly as if he had owned the stock the whole time. Therefore, when there are no dividends, the price of the prepaid forward contract is the stock price today.

(2.11) $$F_0 = S_0$$

We can also derive the price of prepaid forward using present value. First is necessary to calculate the expected value of the stock at time T and then discount that value at an appropriate rate of return. The stock price at time T is uncertain. With risk neutral valuation theory, the correct discount rate is the risk-free interest rate. If the expected stock price at time T is $E\ (S_T)$, then the prepaid forward price is given by

(2.12) $$F_0 = E(S_T)e^{-rT}$$

From previous equation we get

(2.13) $$E(S_T) = S_0 e^{rT}$$

With combining two previous equations we get that for a non-dividend paying stock the prepaid forward price is the stock price.

(2.14) $$F_0 = E(S_T)e^{-rT} = S_0 e^{rT} e^{-rT} = S_0$$

Classical arbitrage describes a situation where investor can generate a positive cash flow either today or in the future by simultaneously buying and selling related assets, with no net investment of funds and with no risk. Arbitrage can be expressed as a free lunch, i.e. if you see $100 dollar on the ground, soon someone will pick it up. An extremely important pricing principle which is often used is that the price of a derivative should be such that no arbitrage is possible.

If $F_0 > S_0$ the arbitrager will buy low and sell high. He buys the stock for S_0 and sells the prepaid forward for F_0. This transaction makes money and it is also risk-free. Selling the prepaid forward requires that investor deliver the stock at time T and buying the stock today ensures that he has the stock to deliver. The income is $F_0 - S_0$ today and at expiration investor supply the stock to the buyer of prepaid forward. Now investor has earned positive profit and has offset all future risk. In the case where situation is opposite $F_0 < S_0$, investor buys prepaid forward contract and shorts the stock. He makes profit $S_0 - F_0$, and after contract is matured investor gets the stock and delivers it to the person whom he was short. (McDonald 2006: 128-130.)

Now that we have analyzed prepaid forward contracts, it is easy to derive forward or futures prices. The only difference between the prepaid and "normal" contract is the timing of the payment for the underlying asset. Thus, the forward price is just the future value of the prepaid forward. Investment asset that provides no income is the easiest futures contract to value, and that is the reason why we start the theory of futures pricing from that point. As we know, futures price is the expected future spot price.

(2.15) $$F_0 = S_0 e^{rT}$$

The equation (2.15) illustrates formally how futures price is calculated. F_0 = futures price, S_0 = spot price, r = risk-free interest rate and T = time to maturity (Hull 2003: 46). For another way of seeing the equation (2.15) is correct, we can think the situation from another perspective. Lets consider strategy where investor buy one unit of underlying asset and enters into a short futures contract to sell it for F_0 at time T. This costs S_0 and is certain to lead to a cash inflow of F_0 at time T. Therefore S_0 must equal the present value of F_0. Formally that is

(2.16) $$S_0 = F_0 e^{-rT}$$

At expiry of the futures contracts the futures price must equal the spot price $F_T = S_T$. This is because the investor with a long futures position can obtain immediate delivery of one stock at a price of F_T. If the spot price of T were higher, then the investor holding the long futures can take the stock and immediately sell it in the cash market for S_T, making riskless profit. At the expiration, unless the price of a futures contract equals the spot price, then riskless arbitrage profits are possible. If we take natural logarithm from equation (2.15) we get

(2.17) $$\text{Ln } F = \text{Ln } S + rT$$

If, r is constant and the time interval considered is small, which means that T hardly changes, then small proportionate changes in S will result in the same proportionate change in the futures price F. This is the basis for using futures to hedge a position in the underlying asset since the correlation between F and S is likely to be high. (Cuthbertson et al. 2001: 42.)

Known Income

Last section introduced futures price from asset that pays no dividends. Usually for example stock pays dividends, so another type of formula is needed.

(2.18) $$F_0 = (S_0 - I)e^{rT}$$

The notation is same as earlier, but now I is defined as present value of dividends. To get some support for the formula, we can think same kind of situation as before. If investor buys one unit of asset and enters into a short futures contract to sell it for F_0 at time T. This costs S_0 and is certain to lead to cash inflow of F_0 at time T. The initial outflow is S_0. The present value of the inflows is $I + F_0 e^{-rT}$. From that we can define

(2.19) $$S_0 = I + F_0 e^{-rT}$$

2.5. Stock index and currency futures

Stock index futures are contracts traded on an underlying stock market index such as the S&P500 and FTSE100. Such futures are widely used in hedging, speculation and index arbitrage. In a well-diversified portfolio of stocks all non-systematic risk of individual stocks has been eliminated and only market risk remains. Stock index futures can be used to eliminate the market risk of the portfolio of stocks. (Cuthbertson et al. 2001: 59.)

A stock index is assumed to pay known yield, rather than known cash income. This means that the income is known when expressed as a percent of the asset's price at the time the income is paid. A stock index can be regarded as the price of an investment asset that pays dividends. The equation is as follows

(2.20) $$F_0 = S_0 e^{(r-q)T}$$

where q is the dividend yield rate. In practice the dividend yield on the portfolio underlying an index varies week by week throughout the year. The chosen value of q should represent the average annualized dividend yield during the life of the contract. The dividends used for estimating q should be those for which the ex-dividend date during the life of the futures contract. (Hull 2003: 54.)

Currency futures

We can also examine currency futures in the context of prepaid currency forward. Suppose that investor wants foreign currency in the future. A prepaid forward allows him to pay domestic currency today to acquire foreign currency in the future. The present value of foreign currency needed today is

(2.21) $$S_0 e^{-r_f}$$

From that we can derive the prepaid forward price

(2.22) $$F_0 = S_0 e^{-r_f T}$$

The economic principle governing the pricing of a prepaid forward on currency is the same as that for a prepaid forward on the stock. By deferring delivery of the underlying asset, investor loses income. In the case of currency, if investor receives the currency immediately, he could buy a bond denominated in that currency and earn interest. The prepaid forward price reflects loss of interest from deferring delivery, just as the prepaid forward price for stock reflects the loss of dividend income. (McDonald 2006: 155.)

Currency futures are mainly used for companies who want protection against undesired currency changes. Using those futures contracts, they lock the exchange rate and ensure the cash position in the future. The underlying asset in currency futures contracts is a certain number of units of the foreign currency. A foreign currency has the property that the holder of the currency can earn interest at the risk-free interest rate prevailing in the foreign country. The holder can i.e. invest the currency in a foreign-denominated bond. In equation (2.23), r is the domestic risk-free rate and r_f is the foreign risk-free rate.

(2.23) $$F_0 = S_0 e^{(r - r_f)T}$$

This is the interest rate parity relationship from international finance. When the foreign interest rate is greater than domestic interest rate $(r_f > r)$, F_0 is always less than S_0 and that F_0 decreases as the time to maturity of the contract, T, increases. Similarly, when $(r > r_f)$ domestic is greater than foreign risk-free rate, F_0 is always greater than S_0 and that F_0 increases as T increases (Hull 2003: 56). A foreign currency can also be regarded as an asset providing known yield. The yield is the risk-free rate of interest in the foreign currency. Only change necessary in the equation is to replace q with r_f.

2.6. Commodity Futures

In the case of commodity futures, the pricing differs from previously demonstrated futures. Commodity futures can be storage which affects costs. They can also give financial benefits to the owner of the underlying asset. As we know, futures price is the expected future spot price, and if the owner earns or loses money because of storing that product, those variables should be included to the pricing calculations. In fact, the case is very similar as in the case where underlying asset is stock and the stock pays dividends. The person who gets dividends benefit from that and the person who is buying that stock in the future lose those dividends. So the dividends must be eliminated from the final futures price.

As forward prices on financial assets, commodity forward prices are the result of a present value calculation. To understand this, it is helpful to consider synthetic commodities. To create synthetic forward, forward contract and zero-coupon bond are needed. First investor enters into a long commodity forward contract at the price F_0 and buys a zero-coupon bond that pays F_0 at time *T*. Since the forward is costless, the cost of this investment strategy at time 0 is just the cost of the bond, or $-e^{-rT}F_0$. At time *T*, the strategy pays $S_T - F_0 + F_0 = S_T$. The term $S_T - F_0$ is the payoff from the forward contract, and the F_0 is the bonds payoff. This investment strategy creates a synthetic commodity.

Valuing synthetic commodity is easy when forward price is known. However, if the forward price is unknown, by discounting the expected commodity price we get today's value. Then the present value is

(2.24) $$E(S_T)e^{-rT}$$

The important point is that equation (2.24) and the cost of investment strategy represents the same value. Both reflect what investor would pay today to receive one unit of the commodity at time *T*. Equating the two expression, we have

(2.25) $$e^{-rT}F_0 = E(S_T)e^{-rT}$$

Rearranging this equation, we can write the forward price as

(2.26) $$F_0 = e^{rT}E(S_T)e^{-rT} = E(S_T)e^{(r-r)T}$$

When moving from risk-neutral world to real world, the expected spot price is discounted with investors expected return. We can define that with π. If we change that in the equation (2.26) we get

(2.27) $$F_0 = E(S_T)e^{(\pi-r)T}$$

Now we see that the forward price is a biased estimate of the expected spot price, with the bias due to the risk premium on the commodity, $\pi - r$. This is exactly what Bodie and Rosanky (1980) and Gorton & Rouwenhorst (2006) examined. Both constructed portfolios of synthetic commodities with T-bills and commodity futures, and find that these portfolios earn the same average return as stocks, are on average negatively correlated with stocks, and are positively correlated with inflation. These findings imply that a portfolio of stocks and synthetic commodities would have the same expected return and less risk than a diversified stock portfolio alone. (see, e.g. McDonald 2006; Gorton et al. 2006; Bodie et al. 1980.)

2.6.1. Storage cost

It is a familiar proposition that the amount of a commodity held in storage is determined by the equality of the marginal cost of storage and the temporal price spread. During any period there will be firms carrying stocks of a commodity from that period into next. Producers and wholesalers carry finished inventories from periods of seasonally high production to the periods of low production. Processors carry stocks of raw materials. Speculators possess title to stocks held in warehouses. These firms may be considered as supplying inventory stocks or supplying storage. The supply of storage refers not to the supply of storage space but to the supply of commodities as inventories. In general, a supplier of storage is anyone who holds title to stocks with a view to their future sale, either in their present or in a modified form. (Brennan 1958: 50-51.)

Storage costs can be regarded as negative income. If we define U as the present value of all storage costs that will be incurred during the life of a futures contract, we get equation

(2.28) $$F_0 = (S_0 + U)e^{rT}$$

U can be calculated from $U = Xe^{-rT}$, where X is the storage cost. If the storage costs incurred at any time are proportional to the price of the commodity, they can be regarded as providing a negative yield. In this case, equation is form as follows

(2.29) $$F_0 = S_0 e^{(r+u)T}$$

where u denotes the storage costs per annum as a proportion of the spot price.

For commodities that are consumption assets rather than investment assets, the arbitrage arguments used to determine futures prices need to be reviewed carefully. If the situation is $F_0 > (S_0 + U)e^{rT}$, investor should purchase the commodity and pay the storage costs, and short one futures contract. In this case futures contract is assumed to be same as forward contract. Then the strategy leads to a profit $F_0 - (S_0 + U)e^{rT}$ at time *T*. In opposite situation where $F_0 < (S_0 + U)e^{rT}$, the investor should sell the commodity, save the storage costs and invest those at risk-free interest rate and take a long position in futures contract. At maturity the strategy gains profit $(S_0 + U)e^{rT} - F_0$ relative to the position the investor would have been in if he had held the commodity. For commodities that are not to any significant extent held for investment, this argument cannot be used. If a commodity cannot be physically stored e.g. electricity, then no arbitrage pricing principles cannot be used to obtain futures price. (Hull 2003:58-59; McDonald 2006: 172.)

2.6.2. Cost of carry

The cost of carry or carrying charge is the total cost to carry a good forward in time. Carrying charges fall into four basic categories, *storage costs, insurance costs, transportation costs and financial costs.* Storage costs include the cost of warehousing the commodity in the appropriate facility, as we defined earlier. While storage seems to apply most clearly to physical goods, it is also possible to store financial instruments. In many cases, the owner of a financial instrument will leave the instrument in a bank vault. For many goods, insurance is also necessary. The carrying charges also include transportation costs. It must be stored until the appropriate delivery time for a given contract, but it must also be physically carried to the appropriate place for delivery. In almost all cases, the most significant carrying charge in the futures market is the financing cost. For most situations, financing the good under storage overwhelms the other costs. The carrying charge reflects only the charges involved in carrying a commodity from one time or one place to another.

Cost of carry model has six different rules in perfect markets. If these rules do not hold, there will always be arbitrage opportunities. These equations are derived from following assumptions, there are no transaction costs and no restrictions on the use of proceeds from short sales, and borrowing and lending rates are equal. First rule, the futures price must be less than or equal to the spot price of the commodity plus the carrying charges necessary to carry the spot commodity forward to delivery. Mathematically expressed it is

(2.30) $$F_{0,t} \le S_0(1+C)$$

where, C is the cost of carry. Second, the futures price must be equal to or greater than the spot price plus the cost of carrying the good to the futures delivery date.

(2.31) $$F_{0,t} \ge S_0(1+C)$$

Third, the futures price must be equal the spot price plus the cost of carrying the spot commodity forward to the delivery date of the futures contract.

(2.32) $$F_{0,t} = S_0(1+C)$$

Fourth, the distant futures price must be less than or equal to the nearby futures price plus the cost of carrying the commodity from the nearby delivery date to the distant delivery date.

(2.33) $$F_{0,d} \le F_{0,n}(1+C) \qquad d > n$$

Fifth, the nearby futures price plus the cost of carrying the commodity from the nearby delivery date to the distant delivery date cannot exceed the distant futures price.

(2.34) $$F_{0,d} \ge F_{0,n}(1+C) \qquad d > n$$

Sixth, the distant futures price must equal the nearby futures price plus the cost of carrying the commodity from the nearby to the distant delivery date.

(2.35) $$F_{0,d} = F_{0,n}(1+C) \qquad d > n$$

The relationship between futures prices and spot prices can be summarized in terms of the cost of carry. This measures the storage cost plus the interest that is paid to finance the asset less the income earned on the asset. For a non-dividend paying stock, the cost of carry is r, because there are no storage costs and no income earned. For a stock index it is $r-q$, because income is earned at rate q on the asset. For a currency it is $r-r_f$ and for a commodity with storage costs that are a proportion u of the price it is $r+u$. Define the cost of carry as c, for an investment asset the futures price is

(2.36) $$F_0 = S_0 e^{cT}$$

For a consumption asset it is

(2.37) $$F_0 = S_0 e^{(c-y)T}$$

,where y is the convenience yield. If futures price is an increasing function of time to maturity, it can be seen from equation (2.37) that $c > y$ so that benefits from holding the asset are less than the risk-free interest rate. It is usually optimal in such a case for the party with short position to deliver as early as possible, because the interest earned on the cash received outweighs the benefits of holding the asset. If futures prices are decreasing as time to maturity increases $c < y$, the reverse is true. It is then usually optimal for the party with the short position to deliver as late as possible. (Hull 2003: 60-61.)

2.6.3. Convenience yield

Commodity price determination has long been an important aspect of investigation by academic researchers as well as industry practitioners. At the center of the rationality of commodity pricing lays concept of convenience yield, which was initially put forth by Kaldor (1939). Working (1949) provided some first evidence of the existence of convenience yield from the U.S. wheat market. The convenience yield is found to be economically significant and it explains the futures and spot price relationships, especially when commodity prices are in backwardation. The convenience yield is the benefit of holding the storage of commodity. Theoretically it depends on several factors. Pindyck (2001) argues that the convenience yield depends on the current price level, the price volatility and the level of storage. A high spot price reflects the imbalance between supply and demand. As the shortage of supply increases, the demand for storage will increase, driving up the value of storage. When market volatility is higher, the demand for storage is higher as well due to the greater need to buffer fluctuations in production and consumption. The amount of storage is also important in determining the marginal value of storage. The lower the storage level is, the higher the value will be for the marginal storage. (Wei & Zhu 2006: 524-525.)

In general, the cost of carry model fails to apply when an asset has a convenience yield. When holding an asset has a convenience yield, the futures price will be below full carry. In an extreme case, the market can be so far below full carry that the cash price can exceed the futures price. When the cash exceeds the futures price, or when the nearby futures price exceeds the distant futures price, the market is in backwardation.

An asset has a convenience yield when traders are willing to pay a premium to hold the physical asset at a certain time. (Kolb et al 2006: 125.)

If the dollar amount of storage costs is known and has a present value *U*, the convenience yield, *y*, is defined so that

(2.38) $$F_0 e^{yT} = (S_0 + U)e^{rT}$$

If the storage costs per unit are a constant proportion *u* of the spot price, *y* is defined so that

(2.39) $$F_0 e^{yT} = S_0 e^{(r+u)T}$$

or

(2.40) $$F_0 = S_0 e^{(r+u-y)T}$$

For investment assets the convenience yield must be zero, otherwise there exist arbitrage opportunities. The convenience yield reflects market's expectations concerning the future availability of the commodity. (Hull 2003: 59-60.)

2.7. Interest rate futures

Interest rate futures became increasingly important in the late 1970's and early 1980's when the volatility of interest rate increased. This was partly because of higher inflation and consequent attempts by Central Banks to control the money supply and exchange rates by altering interest rates. There were also debt crises as some governments defaulted on interest payments on foreign debt. In spite of a number of relatively unsuccessful contracts that have been introduced, the market has been a huge success. Pioneered in the U.S. at the CBOT and CME, interest rate futures have spread to the world's major financial markets. Almost all of the activity in the U.S. interest rate futures is concentrated in two exchanges, the CBOT and International Monetary Market (IMM) of the CME.

Eurodollar deposits are U.S. dollar deposits held in a commercial bank outside the United States. These banks may be either foreign banks or foreign branches of U.S.

banks. The deposits are normally non-transferable and cannot be used as collateral for loans. Because the short-term interest rate e.g. 3 month Eurodollar futures delivers a tangible asset, it is possible to undertake cash and carry arbitrage between the short-term interest rate futures market and the cash market. The no arbitrage condition without continuous compounding method for the cost of carry model is

(2.41) $$F_0 = S_0(1+r)^T$$

where *r* is the actual cost of finance. If

(2.42) $$F_0 > S_0(1+r)^T$$

then the cash and carry arbitrage is profitable. This means that investor should borrow money with rate *r* and buy the spot asset and short futures contract. One might say that the NPV of the cash and carry arbitrage is positive. Let's look at this arbitrage strategy in a slightly different way. At $t = 0$ investor purchase the spot asset at S_0 and receive F_0 at $t = T$, giving a gross compound annual return of

(2.43) $$\hat{r} = (F_0 / S_0)^{1/T} - 1$$

where $\hat{r}$ is known as the implied repo rate. If equation (2.42) holds then it is easily seen that this implies $\hat{r} > r$, hence: *When the implied repo rate exceeds the actual cost of finance r, then arbitrage profits can be made by shorting the futures and purchasing the spot asset.* Using the implied repo rate is like using internal rate of return criterion. The implied repo rate is the internal rate of return from the cash and carry arbitrage and this must exceed the cost of finance to ensure positive arbitrage profits. The financing cost will usually be undertaken by using actual repo. If the situation is opposite, then

(2.44) $$F_0 < S_0(1+r)^T$$

this implies that $\hat{r} < r$. Then reverse cash and carry arbitrage is profitable. *When actual repo rate r exceeds the implied repo rate, then arbitrage profits can be made by buying the futures, short selling the spot asset and investing the funds at r.* (Cuthbertson et al. 2001: 111-112.)

T-Bond Futures

Some of the practical details using T-bond futures are quite intricate. But, as with all futures contracts, they can be used for speculation, arbitrage and hedging. A long T-bond futures position allows the holder to take delivery of a long maturity T-bond at expiration. If a speculator thinks long rates will fall in the future then he can purchase a T-bond future, since a rise in the cash market price implies a rise in the futures price. The investor gains leverage by purchasing the futures contract rather than purchasing the bonds outright in the cash market, because for the futures he only has to pay the initial margin. Transactions costs in the futures market might also be lower than those in the cash market.

The simplest way to start looking the pricing of T-bond futures is to consider *zero coupon bond*. The usual risk free arbitrage argument ensures that

(2.45) $$F_0 = S_0 e^{rT}$$

The implied repo rate is the return from selling the futures at $t = 0$ for F_0 and simultaneously buying the underlying spot for S_0, so that $\hat{r} = \left(F_0 / S_0\right)^{1/T} - 1$. In this case riskless arbitrage is possible if the implied repo rate exceeds the cost of financing using the actual repo market r, that is if $\hat{r} > r$.

In practice there is not a futures contract on a zero coupon bond. Unfortunately, it is difficult to accurately calculate the fair futures price, when the underlying is a coupon paying bond. This is because of the flexibility of the short's decision over the delivery date T and the invoice price of the cheapest to deliver (CTD) bond (= S). The first way is to create synthetic bond future. The net cost of carrying the bond in cash market can be expressed as

(2.46) $$S_T e^{r(T-t)} - FVC_T$$

where S_T is the invoice price of bond in cash market and FVC is the future expected value of coupon payment. Previous strategy creates a synthetic bond future since it ensures that the bond purchased in the cash market at t is available against futures contract at T. The invoice price the long pays the short futures at t, with quoted price of F_T. The invoice futures price (IPF) is

(2.47) $$IPF = F_T CF_t + AI_T$$

where AI_T is the accrued interest on the CTD bond at time *T*. Since the actual futures contract and the synthetic futures both deliver one bond at *T* then their cost must be equal, otherwise riskless arbitrage profits would be possible.

(2.48) $$F_t CF_t + AI_T = S_T e^{r(T-t)} - FVC_T$$

or

(2.49) $$F_t = (1/CF_t)\left(S_T e^{r(T-t)} - FVC_T - AI_T\right)$$

If there were no coupon payments over the arbitrage period (i.e. $FVC_T = 0$) and no accrued interest ($AI_T = 0$) and the deliverable bond were one specific in the futures contract (CF = 1), then not surprisingly the above formula for *F* reduces to that for the futures price on zero coupon bond.

Profitable arbitrage opportunities are usually expressed in terms of the implied repo rate. If the implied repo rate on cash and carry arbitrage exceeds or is less than the actual cost of borrowing then profitable arbitrage is possible. The principle is the same as before with Eurodollar case, but the algebra for T-bond is little more complex. The implied repo rate is the return from buying the underlying bond spot, at *t = 0* for $(B_0 + AI_0)$ and simultaneously selling the futures for delivery at *T*. The return or implied repo rate using *discrete compounding* is

(2.50) $$(1 + \text{implied repo rate}) = \left(\frac{\text{Cash received at T from futures}}{\text{cash paid out at t = 0 for the underlying bond}}\right)^{1/T}$$

or

(2.51) $$1 + \hat{r} = \left(\frac{F_0 CF_0 + AI_T + FVC_T}{B_0 + AI_0}\right)^{1/T}$$

The arbitrageur holds the underlying bond and therefore will receive any coupon payments which can be reinvested over the investment period. The underlying spot bond has an invoice price of $(B_0 + AI_0)$ at time *t = 0* and this is financed by borrowing at an actual repo rate of *r*. Because of this, *the cash and carry arbitrage is profitable if implied repo rate* $\hat{r} > r$. (Cuthbertson et al. 2001: 155-158.)

2.8. Seasonality in futures prices

Samuelsson (1965) demonstrated that even though there may be a known seasonal pattern in spot prices, the futures price will fluctuate randomly. He also showed the intuition for why the variance of futures prices may not be constant over the life of the contract (Copeland et al. 2005: 282). Next we are going to look seasonality's in corn, natural gas and oil market.

Corn in the U.S. is harvested primarily in the fall, from September through November. The U.S. is a leading corn producer, generally exporting rather than importing corn. Corn is produced at one time of the year, but consumed throughout the year. In order to be consumed when it is not being produced, corn must be stored, which affects to storage costs. Equilibrium with some current selling and some storage requires that corn prices be expected to rise at the interest rate plus storage costs, which implies that there will be an upward trend in the price between harvests. While corn is being stored, the futures price should raise interest rate plus storage cost. Once the harvest begins, storage is no longer necessary, if supply and demand remain constant from year to year, the harvest price will be the same every year. The corn price will fall to that level at harvest, only to begin rising again after the harvest. Between the harvests, the futures price of corn rises to reward storage, and it falls at each harvest. Farmers will plant in anticipation of receiving the harvest price, which means that it is the harvest price that reflects the cost of producing corn. The price during the rest of the year equals the harvest price plus storage. This is the case in theory, in reality the supply of corn varies from year to year. When there is a large crop, farmers will expect corn to be stored not just over the current year, but into next year as well. (McDonald 2006: 189-190.)

Natural gas is also another where seasonality's and storage costs are affecting. The natural gas futures were introduced in 1990, and they have become one of the most heavily traded contracts in the U.S. The asset underlying one contract is 1 month's worth of gas, delivered at a specific location. Natural gas has interesting characteristics. First, gas is costly to transport internationally, so prices vary regionally. Second, gas is costly to store. Third, demand for gas is highly seasonal, with peak demand arising in winter months. Thus, there is a relatively steady stream of production with variable demand, which leads to large and predictable price swings. Whereas corn has seasonal production and relatively constant demand, gas has relatively constant supply and demand. Because of the expense in transporting gas internationally, the seasonal behaviour of the futures curve can vary in different parts of the world. In tropical areas where gas is used for cooking and electricity generation, the futures curve is relatively flat because demand is relatively flat. In Southern hemisphere, where seasons are reversed from Northern hemisphere, the futures curve will peak in June and July rather than December and January. Recent developments in energy markets could alter the behaviour of the natural gas futures curve in the U.S. Power producers have made greater use of gas-fired peak-load electricity plants. These plants have increased summer demand for natural gas and may permanently alter seasonality. Both oil and natural gas produce energy and are extracted from wells, but the different physical characteristics and uses of oil lead to a vary different futures curve than that for gas. Oil is easier to transport than gas. Transportation of oil takes time, but oil has a global market. Oil is also easier to store than gas. Thus, seasonality in the price of crude oil is relatively unimportant. Prior 1970's the oil industry was highly concentrated and vertically integrated. During this time prices were relatively low and stable. (Chen, Sears & Tzang 1987: 501; McDonald 2006: 193-194.)

Gay and Kim (1987) investigated seasonality in the futures market. Their objective was to fully explore several aspects of futures market seasonality by analyzing 29 year history of the Commodity Research Bureau future price index. They found that Wednesday's and Friday's returns were significantly positive. Friday's return were the most highest of all, and Monday's return were found to be the lowest and negative. From monthly view, January return were found to be highest and positive, and December lowest and negative. These results were consistent with stock market, despite significant institutional differences between these two markets. Further investigation showed that January's return over the five day period involving the last trading day in December and the first four trading days in January constitutes more than 59 % of January's return. This result was also found from stock market.

2.9. Statistical characteristics of futures prices

Most statistical tests of futures prices rely on the assumption that the underlying price changes are normally distributed. Studies have found that the distribution of future price changes is leptokurtic. Figure 3 illustrates leptokurtosis, the tendency for a distribution to have too many extreme observations relative to normal distribution. In the figure, the solid line shows a normal distribution. The dotted line shows a leptokurtic distribution. The greater frequency of extreme observations makes the tails of a leptokurtic distribution have *fat tails*. Second question has been what distribution futures price will follow if they are not normal. Two different candidates have been nominating. First, the distribution may be stable Paretian. This distribution is symmetrical like normal distribution, but it is leptokurtic relative to a normal distribution. Second, futures price changes have seemed to be similar mixture of two or more normal distributions. The main point is that, it requires extra caution making statistical inferences about futures prices.

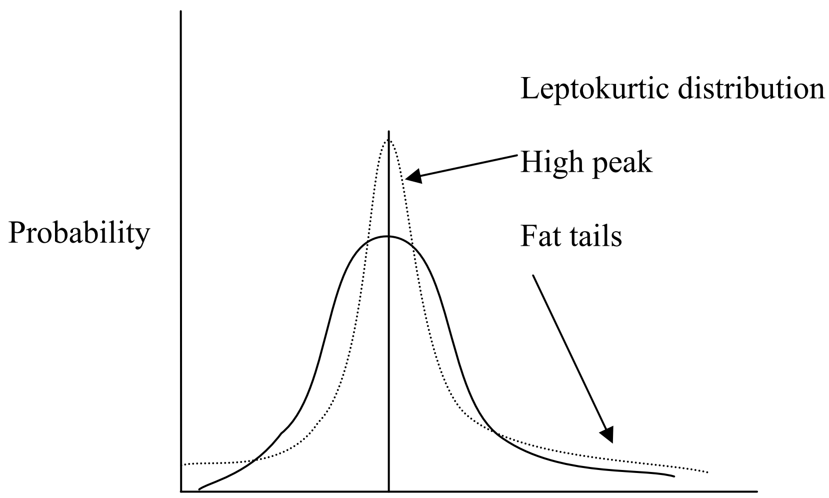

Figure 3. Normality and Leptokurtosis.

In addition to testing the distribution of futures price changes, several studies have examined whether the time series of futures price changes is autocorrelated. A time series is autocorrelated if the value of one observation in the series is statistically related to another. In first-order autocorrelation, one observation is related to the immediately preceding observation. This question has considerable practical importance. If futures price exhibit positive first-order autocorrelation, then positive returns in one period tend to be followed by positive returns in the next period. Similarly, negative returns tend to be followed by subsequent negative returns. If the correlation were strong enough, it would be possible to devise trading strategies to profit from this follow on tendency. Almost all studies have found that futures prices exhibit statistically significant first-order autocorrelation. While autocorrelation appears to be statistically significant, it does not appear to be important economically. The autocorrelation is not strong enough to allow profitable trading strategies after we consider transactions costs. Also the volatility of futures prices, futures trading and cash market volatility and time to expiration and futures price volatility has been long a central tenet in studies. (Kolb et al. 2006: 137-139.)

3. CAPITAL ASSET PRICING MODEL

In real world, investors can see risk everywhere, the main question is how much they can tolerate it? When money plays important role, there will always be risks. Stock markets, derivative markets, real estate markets, the list could be continued forever. With derivative instruments, it is possible to share risk with someone. The other investor is prepared to pay for having less risk, and the other one is getting paid premium to get the risk. The term risk and return refers to the potential financial loss or gain experienced through investment in securities. An investor who has registered a profit is said to have seen a return on his investment. The risk of the investment denotes the possibility or likelihood that the investor could lose money. If an investor decides to invest in a security that has a relatively low risk, the potential return on that investment is typically small. Other side of the coin is that, high risk factor has the potential to garner higher returns. Risks affects to prices and investment decisions. There exist many kinds of risks like business risk, liquidity risk and market risk. Major breakthrough for risk and return came in 1952 from Harry Markowitz. His paper “Portfolio selection” introduced a theory on how risk-averse investor can construct portfolio in order to optimize market risk for expected returns. (www.answers.com).

Investors familiar with the capital asset pricing model will know that there are two types of risk in the economy, systematic and non-systematic. Non-systematic risk should not be important to an investor, because it can be almost completely eliminated with well-diversified portfolio. An investor should not therefore require higher expected return for bearing non-systematic risk. Systematic risk cannot be diversified away. It arises from a correlation between returns from the investment and return from the stock market as a whole. Usually investors require higher expected return than risk-free interest rate, when they are bearing systematic risk. In other words, investor is prepared to accept a lower expected return than risk-free interest rate when systematic risk in an investment is negative. (Hull 2003: 61.)

Asset pricing models are integral part of portfolio management. Many market timing models and measures of portfolio performance rely on some form of risk adjusted benchmark from which to undertake decisions. For portfolios that comprise of assets from different markets, the ability of asset pricing models to provide accurate measures of the risk-return trade-off depends crucially on the assumption; the prices of risk in different markets are the same. (Miffre & Priestley 2000: 933.)

3.1. Underlying Assumptions

At 1960's there was no theory describing the manner in which the price of risk results from the basic influences of investor's preferences, the physical attributes of capital assets, etc. Lacking such a theory, it is difficult to give any real meaning to the relationship between the price of a single asset and its risk. Through diversification, some of the risk inherent in an asset can be avoided so that its total risk is obviously not the relevant influence on its price. This was the main problem and main inspiration for William F. Sharpe to his study Capital asset prices: a theory of market equilibrium under conditions of risk, which was published in Journal of Finance 1964.

A Central problem in finance has been that of evaluating the performance of the portfolios of risky investments. The concept of portfolio performance has at least two dimensions:

1) The ability of the portfolio manager or security analyst to increase returns on the portfolio through successful prediction of future security prices and,

2) The ability of portfolio manager to minimize the amount of insurable risk born by the holders of the portfolio. (Jensen 1968: 389.)

Capital asset pricing model includes many assumptions, and those have been criticised as long as the model has been in existence. Roll argued the model in 1977 because investors cannot know the real market index, and therefore estimating CAPM is impossible. Stephen Ross developed the arbitrage pricing theory (APT) in 1976. This model is alternative for using CAPM. The thrust of capital asset pricing model assumptions is that they try to ensure that individuals are as alike as possible, with the notable exceptions of initial wealth and risk aversion.

1) There are many investors, each with an endowment that is small compared to the total endowment of all investors. Investors are price takers, in that they act as though security prices are unaffected by their own trades. This is the usual perfect competition assumption of microeconomics.

2) All investors plan for one identical holding period.

3) Investments are limited to a universe of publicly traded financial assets, such as stock and bonds, and to risk-free borrowing and lending arrangements. It is assumed that investors may borrow or lend any amount at a fixed risk-free rate.

4) Investors pay no taxes on returns and no transaction cost on traded in securities. In reality, we know that investors are in different tax brackets and that this may govern the type of assets in which they invest. Furthermore, actual trading is costly, and commissions and fees depend on the size of the trade and the good standing of the individual investor.

5) All investors are rational mean-variance optimizers, meaning that they all use the Markowitz portfolio selection model.

6) All investors analyze securities in the same way and share the same economic view of the world. Given a set of security prices and the risk-free interest rate, all investors use the same expected returns and covariance matrix of security returns to generate the efficient frontier and the unique optimal risky portfolio.

Obviously these assumptions ignore many real-world complexities. With these assumptions, however, we can gain some powerful insights into the nature of equilibrium in security markets. (Bodie, Kane & Marcus 2002: 264; Lintner 1965: 15.)

3.2. Expected return and market price of risk in CAPM

Capital asset pricing model consist from four different components, r is the expected return on investment, r_f is the risk-free interest rate, r_m is the return from the market index, and β coefficient which measures the market risk which cannot be diversified. Financial assets consist from two kind of risk component, and those are market risk which was previously defined and unique risk which can be diversified away. Sometimes they are also called systematic risk and unsystematic risk. Capital asset pricing model is based on that assumption. (Brealey et al. 2003: 195-196.)

To understand capital asset pricing model we need to look the basic principles of portfolio selection. First, investors like high expected return and low standard deviation. This is keenly related to efficient frontier. Second, if the investor can lend or borrow at the risk-free rate of interest, one efficient portfolio is better than all others: the portfolio that offers the highest ratio of risk premium to standard deviation. A risk-averse investor will put part of his money in this efficient portfolio and part in the risk-free asset. More risk-tolerant will put all in the risky assets and he can also borrow more money to invest. The composition of this best efficient portfolio depends on the investor's assessments of expected returns, standard deviations and correlations. But if we suppose everybody to have same information and the same assessments, then each investor should hold the same portfolio as everybody else, in other words, everyone holds the market portfolio. We also need to recognize the risk of individual investment. Fourth, investor should not look at the risk of individual asset in isolation, but at its contribution to portfolio risk. This contribution depends on the individual assets sensitivity to changes in the value of the portfolio. Fifth, assets sensitivity to changes in the value of the market portfolio is known as beta. Beta, therefore measures the marginal contribution of a stock to the risk of the market portfolio. Now if everyone holds the market portfolio, and if beta measures each security's contribution to the market portfolio risk, then it's no surprise that the risk premium demanded by investors is proportional to beta. That is what the capital asset pricing model exactly says. (Brealey et al. 2003: 196-197.)

With equation, CAPM can be present as follows

(3.1) $$E(R)-r=\frac{Cov(r,r_m)}{Var(r_m)}(E(r_m)-r)$$

where r_m is a solution of the mean-variance portfolio problem and r is the return of an arbitrary portfolio. The relationship is quite important, because in a world of mean-variance investors there is often a portfolio which can be assumed to be a solution of minimize $Var(r)$ subject to $E(R)=\rho$ and whose mean return can be estimated, thereby giving via (3.1) estimates of the mean return of arbitrary portfolios. (Pliska 2000: 49.)

Usually capital asset pricing model is expressed in equation form as follows

(3.2) $$E(R)=r_f+\beta\lfloor E(r_m)-r_f\rfloor$$

where β is defined as $\frac{Cov(r,r_m)}{Var(r_m)}=\frac{\sigma_{im}}{\sigma_m^2}$. As we know, from variance, standard deviation can be calculated from equation

(3.3) $$Var(r_m) = \sigma_m^2 \Rightarrow \sqrt{Var(r_m)} = \sigma_m$$

As explained above, the CAPM has been criticised a lots of reason. The risk-free rate is always difficult to define. Usually Treasury bills can be thought as risk-free investments, as also euribor[1] and libor[2]. Treasury bills short-term nature makes their values insensitive to interest rate fluctuations. An investor can lock in a short-term nominal return by buying a bill and holding it to maturity. (Bodie et al. 2002: 186.)

Capital allocation line, capital market line and security market line

The straight line in the figure 4 is called capital allocation line (CAL). It depicts all the risk-return combinations available to investor. CAL is a graph showing all feasible risk-return combinations of a risky and risk-free asset.

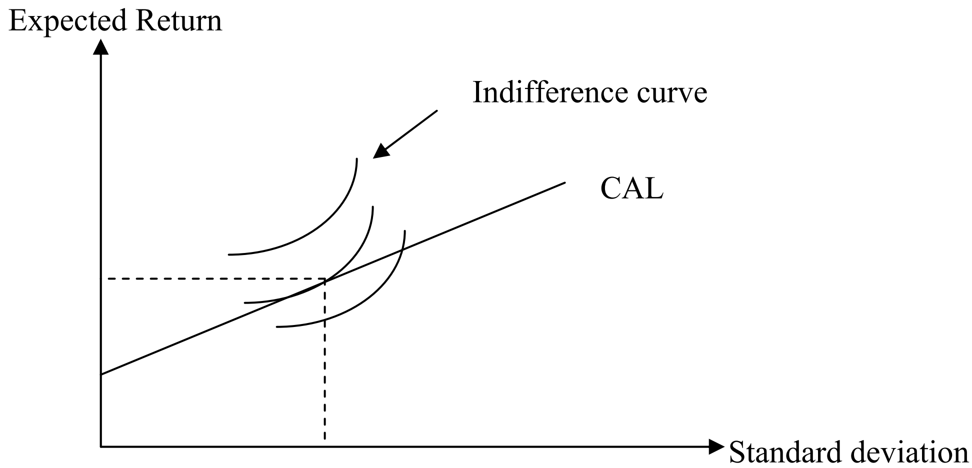

Figure 4. Capital allocation line with investors indifference curves.

The slope of CAL equals the increase in the expected return of the complete portfolio per unit of additional standard deviation. The CAL is also called the reward-to-variability ratio. The studies have shown that, diversification benefits only until a cer-

[1] Euribor (Euro Interbank Offered Rate) is a daily reference rate based on the averaged interest rates at which banks offer to lend unsecured funds to other banks in the euro wholesale money market.
[2] Libor (London Interbank Offered Rate) is an interest rate at which banks can borrow funds from other banks in the London interbank market. The Libor is fixed on a daily basis by the British Babker's Association.

tain point. After that break-point there is no benefit to take more assets to the portfolio. The expected return depends a lot from investors risk preferences, in other words, investor's indifference curves. Investor should use that strategy, where his indifference curve touches CAL. Portfolios on higher indifference curves offer higher expected return for any given level of risk. (Bodie et al. 2002: 191-194.)

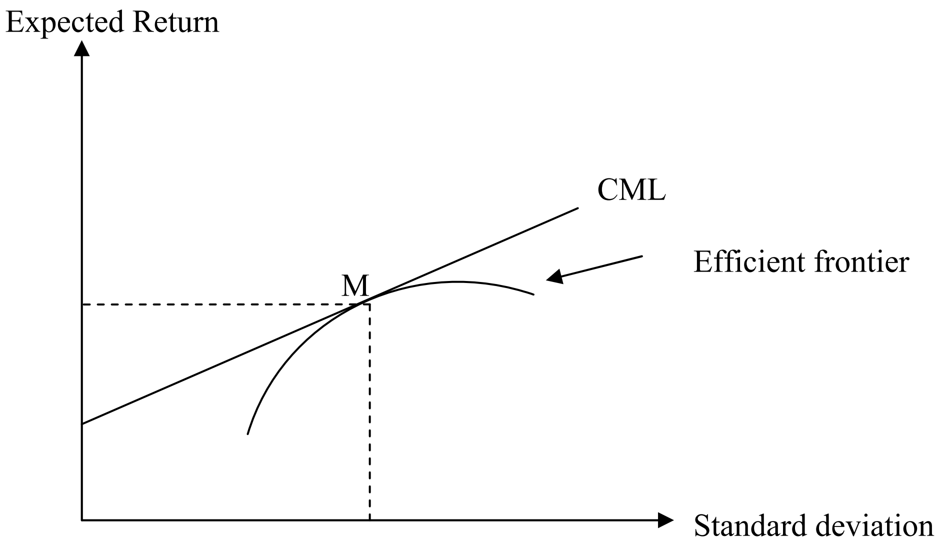

Figure 5. Capital market line and efficient frontier.

Capital market line can be defined as a capital allocation line provided by the market index portfolio. In figure 5, M is the optimal tangency portfolio on the efficient frontier. Efficient frontier represents the portfolios that maximize expected return at each level of portfolios risk. Market portfolio includes all assets, and that is exactly what Roll criticised. The passive strategy of investing in a market index portfolio is efficient. For this reason, this result is called a mutual fund theorem. Assuming that all investors choose to hold a market index fund, it is possible to separate portfolio into two components, a technological problem and a personal problem. The practical significance of the mutual fund theorem is that a passive investor may view the market index as a reasonable first approximation to an efficient risky portfolio. (Bodie et al. 2002: 266-267.)

We can view the expected return-beta relationship as a reward-risk equation. The beta of a security is the appropriate measure of its risk because beta is proportional to the risk that the security contributes to the optimal risky portfolio. Risk-averse investor measure the risk of the optimal risky portfolio by its variance. The beta of a stock measures the stock's contribution to the variance of the market portfolio. The CAPM states that the security's risk premium is directly proportional to both the beta and the risk premium of the market portfolio, this means that risk premium equals $\beta\lfloor E(r_m) - r_f \rfloor$. The expected return-beta relationship can be portrayed graphically as the security market line (SML). Roll and Ross (1994) has argued the use of expected return-beta relationship in every situation. Sometimes the index might be inefficient, and then other variables can have better explanatory power. A possible explanation is that market portfolio proxies are mean-variance inefficient.

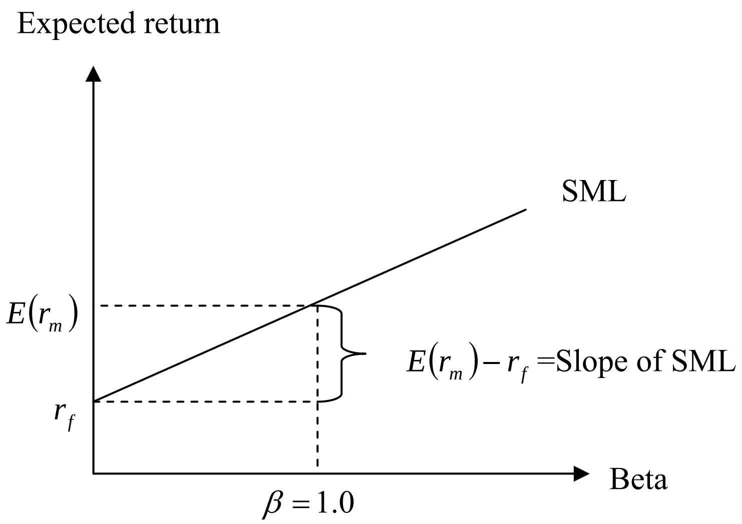

Figure 6. Security market line.

The differences between CML and SML is that, CML graphs the risk premiums of efficient portfolios as a function of portfolio standard deviation. The SML graphs individual asset risk premiums as a function of asset risk. The SML is valid for both efficient portfolios and individual assets. All securities must lie on the security market line in market equilibrium. The reason is that SML is the graphic presentation of the expected return-beta relationship, and fairly priced assets plots exactly on the SML. If the asset lies below the SML it can be assumed to be overpriced, then its return-beta relationship is unstable. Assets beta compared to expected return are smaller than calculated with capital asset pricing model. Under priced assets therefore plot above the security market line. (Bodie et al. 2002: 272-273.)

3.3. Futures price and CAPM

The two major approaches to the analysis of commodity futures risk premia can be distinguished by their assumptions about the marketability of assets. What can be called the perfect market approach leads under conventional assumptions to the traditional capital asset pricing model, which predicts that risk premia will be proportional to the covariance of futures return with return on the market portfolio of all assets. The alternative imperfect markets approach is based upon the premise that market imperfections, such as adverse selection or moral hazard, limit the issuance of equity shares by agricultural producers. If so, the risk premia on agricultural futures contracts will depend not only on the covariance with the market portfolio of all assets but also on their covariance with nonmarketed endowments. (Hirshleifer 1988: 173-174.)

One way of explaining commodity futures prices posits that the futures price can be divided into the expected futures spot price plus an expected risk premium based on the capital asset pricing model. Dusak (1973) relates the CAPM to commodity futures in a one-period-framework. Now we begin by writing out the CAPM:

(3.4)
$$E(R) = r_f \left[\frac{E(r_m) - r_f}{\sigma(r_m)} \right] \frac{Cov(r, r_m)}{\sigma(r_m)}$$

Next, we define one period rate of return for an investor who holds the risky commodity. S_0 is the current spot price of the commodity and $E(S_T)$ is the expected spot price at the time of delivery, T, we have

(3.5)
$$E(R) = \frac{E(S_T) - S_0}{S_0}$$

If we combine two previous equations, we will have a certainty equivalent model for the spot price of the commodity

(3.6)
$$S_0 = \frac{E(S_T) - \lfloor E(r_m) - r_f \rfloor S_0 \beta}{1 + r_f}$$

where beta coefficient is the same as previously defined

(3.7)
$$\beta = \frac{Cov(r, r_m)}{Var(r_m)}$$

A futures contract allows an investor to purchase an asset now but to transfer payment for one period, therefore the current price of the futures contract, F_0, must be the current spot price multiplied by a future value factor

(3.8) $$F_0 = S_0(1 + r_f).$$

Multiplying both sides of the certainty equivalent model, equation (3.6), by $(1 + r_f)$, and noting that the result is equivalent to equation (3.8), we have

(3.9) $$F_0 = S_0(1 + r_f) = E(S_T) - [E(r_m) - r_f]S_0\beta.$$

The futures price, F_0, equals the expected spot price minus a risk premium based on the systematic risk of the commodity. The CAPM approach, equation (3.9), argues that systematic risk should be important in the pricing of futures contracts but leaves out storage costs and convenience yields. The traditional approach, for riskless securities, ignores the possibility that systematic risk may affect the equilibrium prices of commodity futures contracts. (Copeland et al. 2005: 286-291.)

Futures market trading does not require any investment. Trading futures does require margin payments, but these are not investments. With no fund invested, there is no capital to earn the risk-free interest rate. Therefore, a futures position should have zero return if $\beta = 0$. If the beta of a futures position exceeds zero, a long position in the futures contract should earn a positive return. Positive betas for futures contract lead to the expectation of rising futures prices. Zero betas would be consistent with futures prices that neither rise nor fall. A negative beta would imply that futures prices should fall. (Kolb et al. 2006: 133-134.)

3.4. Return in commodity futures

Historically returns in futures contracts have been good. Gorton and Rouwenhorst (2006) showed that commodity futures have offered same return and sharpe ratio as U.S. equities. Erb and Harvey (2006) showed mathematically that when asset variances are high and correlations are low, the diversification return from rebalancing can be high. The average correlation of individual commodities with one another was 9% and the standard deviation was 25%.

The explanation of the sources of returns for a long commodity futures program usually takes the following form. The two factors underlying such a program's returns are the desire of commodity inventory holders to hedge and the continuation of just-in-time inventory policies. Significantly, the returns to a commodity futures investment do not rely on a predicted increase in spot commodity prices. In addition to a long commodity program's collateral returns, risk premium is the main reliable source of return for commodity investors. The other factor driving commodity returns is the continuation of just-in-time inventory policies, which cause temporary shortages in individual commodities, leading to temporary spot commodity price spikes. By continuously investing in front-month futures contracts, one captures these returns. (Till & Eagleeye 2006:4.)

According to Georgiev (2001) in futures markets, there exist three separate sources of return. First, price return derives from changes in commodity futures prices. Second, roll return arises from rolling long futures positions forward through time. Third, collateral return assumes the full value of the underlying the futures contracts are invested at a risk-free interest rate. Till (2006) expanded concept of futures returns in her studies. Investors should examine the relative price differences of futures contracts across delivery months, this is also called term structure. Typically when there are low inventories for a commodity, its commodity futures contract trades normally in backwardation: consumers are willing to pay a premium for the immediately deliverable contract relative to deferred-delivery months.

Ma, Mercer and Walker (1992) studied rolling over futures contracts. They found that, when choosing a method of rolling over contracts, the first decision to be made is the selection of a point in time to roll over, i.e. to switch from the maturing contract to the next contract. The most common methods include switching at the delivery date, the first notice day or some arbitrary length of time before the delivery date. An equally important dimension to consider when rolling over contracts is the difference in the price levels between the two contracts, which is often observed at the rollover dates.

If there exist returns in commodity futures, there must be also risks. Correlations among commodities vary both seasonally and during eventful periods. It is said that, one of the best things of commodities is their natural internal diversification. While even unrelated equities have a beta to the overall market, many commodities such as sugar and aluminium, traditionally have no correlation at all. Extreme weather events can also be risks for commodity prices. In the U.S. example hurricane season in fall can change dramatically the prices. Futures products are typically marketed as equity investment diversifiers. Therefore one job of risk management is to attempt to ensure that a futures investment will not be too correlated to the equity market during periods of dramatic equity losses. (Till 2006: 9-10.)

It should not be controversial to note that the prices of some commodity futures contracts are biased estimators of future spot commodity prices. After all, a futures market is not a forecasting agency, it also facilitates risk sharing and the efficient allocation resources. To expect futures prices to only reflect predictions of future prices ignores its other functions. However, Krehbiel and Collier (1996) said that interest rate futures contract prices provide forecasts of spot market interest rates. Very interesting studies exist also from futures prices and weather. There is evidence from that the future prices are good estimators from future weather. This is actually true, because investors are taking weather forecasts from many difference sources and far away from past, and they use that information when investing in futures market, especially in agricultural sector.

3.5. Normal backwardation and contango

Normal backwardation is one of the most studied concepts of futures contracts. Miffre (2000) indicates that in recent year's tests of normal backwardation has focused on the presence of a risk premium in futures markets. The theory of normal backwardation is originated with John Maynard Keynes (1930) in his *Treatise on Money*. The theory holds that the futures price is less than the expected future spot price and that the futures price should rise over time to equal the expected future spot price at expiration (Kolb 1992: 75). Keynes and Hicks showed that, futures price tend to rise over the life of a futures contract because hedgers tend to be short in the futures market. That is, hedgers sold short positions as insurance against their cash position and pay speculators a return to hold long positions in order to offset their risk. In other words, Keynes and Hicks saw normal backwardation to be the equivalent of a positive risk premium. Keynes therefore suggested that "The quoted forward price, though above the present spot price, must fall below the anticipated future spot price by at least the amount of normal backwardation". This theory follows essentially from the view that hedgers as a group take a short futures position whilst speculators collectively adopt a long position (Allen, Cruickshank, Morkel-Kingsbury & Souness 2000: 2).

Chang (1985) said that normal backwardation is supposed to describe the profits of marginal speculators who posses no forecasting ability. Therefore he has defined backwardation as the returns earned by a hypothetical speculator who follows a naive strategy of being long when hedgers are net short and short when hedgers are net long. Conversely, if hedgers are net long, then futures price would lie above the expected future spot price, and the price of the futures contract would fall over its life. This pattern of falling prices is known as a *contango.*

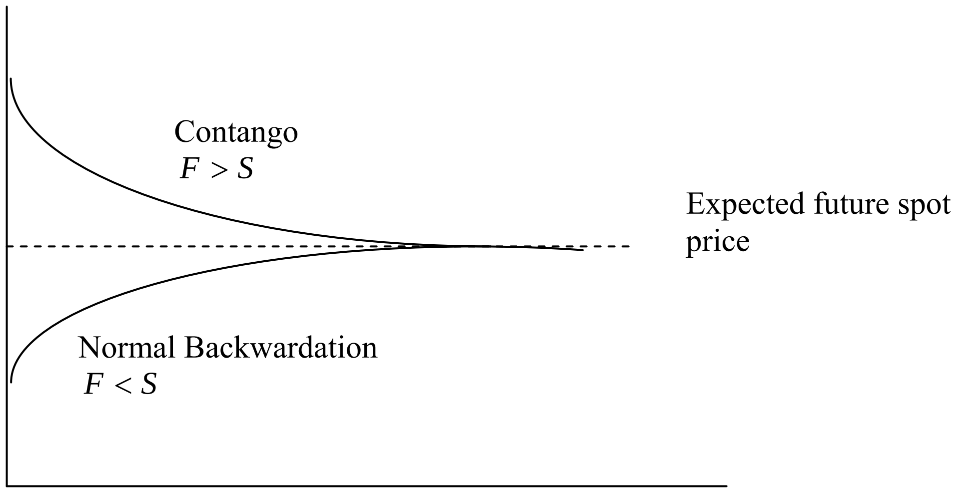

Figure 7. Patterns of futures prices.

Figure 7 illustrates the price patterns for futures that might expect under different scenarios. If the futures price equals the expected future spot price, then the futures price will lie on the dotted line. When the futures price follows normal backwardation, the futures price rises over its life, and investors with long position earns return for bearing risk. If investors, in Keynes situation speculators, are net short and receiving compensation for bearing risk, futures price must follow a contango. The fall in futures prices, as the contract approaches maturity, gives the short speculators the compensation that induced them to enter the market. (Kolb et al. 2006: 131-132.)

When commodity futures contract is in backwardation, an investor has two potential sources of returns. One is on the correct side of a potential price spike in the commodity by being long at that time. Second includes in roll yield, which was mentioned in previous chapter. In a backwardated futures market, a futures contract converges to the spot price. This is the *roll yield* that a futures investor captures. The spot price can stay constant, but investor will still earn returns from buying discounted futures contracts, which continuously roll up to the constant spot price. In a contango market, an investor continuously locks in losses from futures contract converging to a lower spot price. (Till 2006: 6-7.)

4. DATA AND METHODOLOGY

Changes in the futures price for a given commodity at a given maturity give rise to gains and losses for investors with long or short positions in the corresponding futures contracts. An investor with a position in the futures markets is bearing risk even though the value of his position at the end of each day is zero. His position may also have positive or negative expected money amount return, even though his investment in the position is zero. Since his investment is zero, it is not possible to talk about the percentage or fractional return on the investor's position in the futures markets. Both his risk and his expected return must be defined in amounts of money. (Black 1976: 171.)

Previous literature has shown that futures returns are zero or at least near zero. Also the betas estimated have found to be near zero. This confirms the statement that futures are less risky investments. Black derived the behaviour of futures prices within context of capital asset pricing model. He found that expected change in futures price is proportional to the "dollar" beta of the futures price, and if the covariance of the change in the futures price with the return on the market portfolio is zero, then the expected change in the futures price will be zero. The classic economic rationale for the existence of futures markets is that they facilitate the transfer of risk to those most able or willing to bear it. The market price, or risk premium, for this transfer is the expected change over time in a contract's settlement price. Several empirical studies document that futures price changes are not entirely random, a finding which is consistent with the existence of risk premia. (Bessembinder 1993: 611.)

4.1. Commodity exchanges

Chicago Board of Trade (CBOT): CBOT was established in 1848 and it is leading futures and futures-options exchange. More than 3,600 member trade 50 different futures by open auction and electronically. 2006 volume surpassed 805 million contracts, and it is the highest in history. At the beginning of its history, CBOT only traded agricultural commodities because of its location. Nowadays a lot of instruments are traded there, for example U.S. Treasury bonds and stock indexes. First electronic trading system was introduced in 1994, before that traders made the open auction trading. The CBOT's primary role is to provide transparent and liquid contract markets for its member and customers to use for price discovery, risk management and investment purposes. (http://www.cbot.com).

Chicago Mercantile Exchange (CME): The Chicago Butter and Egg Board was founded in 1898 and evolved into Chicago Mercantile Exchange (CME) in 1919. At that time, futures contracts were offered only on agricultural products. In 1992 CME was the first exchange who introduced global electronic futures trading platform. 2006 1,403 billion contracts were traded in CME, and those were valued $827 trillion. CME created the world's first financial futures contracts by introducing futures on seven currencies in May 1972. (http://www.cme.com).

October 17 2006 CME and CBOT announced that they had signed a definitive agreement to merge the two organizations to create the most extensive and diverse global derivatives exchange. The combined company is named CME Group Inc., a CME/Chicago Board of Trade Company. The combined company will provide one of the world's most liquid marketplaces, with average daily trading volume approaching 9 million contracts per day, representing approximately $4.2 trillion in notional value. It will provide fir its customers many different derivatives such as equity indexes, agricultural, foreign exchange, weather and real estate. (http://www.cme.com)

Euronext Liffe, Amsterdam: Euronext is the first genuinely cross-border exchange. It provides international services for regulated cash markets and derivative markets in Belgium, France, United Kingdom, Netherlands and Portugal. In September 2000 the exchanges of Amsterdam, Brussels and Paris merge to from Euronext N.V. In January 2002 Euronext expanded by acquiring LIFFE (London International Financial Futures and Options Exchange). 2005 there were 1,259 listed companies in Euronext, and also 162 million contracts traded worth 1,829 billion euros. (http://www.euronext.com).

New York Board of Trade (NYBOT): NYBOT is a wholly-owned subsidiary of International Exchange (NYSE:ICE), and it provides world's premiere futures and options markets for several internationally traded agricultural commodities. Its history began with the founding of New York Cotton Exchange (NYCE) in 1870. Past years several other exchanges have joined together, and in 1998 The Coffee, Sugar & Cocoa Exchange (CSCE) and NYCE formed the Board of Trade of the City of New York, Inc. as a parent company. A merger process completed in June 2004 when the two exchanges became the New York Board of Trade. (http://www.nybot.com).

New York Mercantile Exchange (NYMEX): NYMEX is the world's largest physical commodity futures exchange and the pre-eminent trading forum for energy and precious metals. The exchange pioneered the development of energy futures and options 26 years ago as means of bringing price transparency and risk management to market. The Butter and Cheese Exchange of New York were founded in 1872 by a group of dairy merchants who were trying to bring order standardization to the chaotic conditions that existed in their Industry. 10 years later from the product base were broadened and the name was changed to the New York Mercantile Exchange. In 2006 the annual volume for futures and options were over 276 million contracts, just with futures NYMEX reached over 216 million contracts. The COMEX division traded futures and options 25 million and 5.5 million respectively. (http://www.nymex.com).

4.2. Data description

The data used in this thesis were obtained from the Datastream service from database of the University of Vaasa and it covers the time period from 1.1.1987 to 29.12.2006, for most of the futures. Datastream has been used for the source of information, since it is widely recognized as a good historical financial information provider, offering quality and the latest data. Database includes key sets from developed and emerging markets – equities, market indices, company accounts, macroeconomics, bonds, foreign exchange, interest rates, commodities and derivatives. Nowadays datastream service is owned by Thomson Financial which is one of the leading data service companies in the world. The data in this thesis includes end of the day daily settlement prices. The daily settlement price is defined as the price established by the clearing house at the end of a trading session as the closing price that will be used in determining profits and losses for the mark-to-market process for margin accounts. The settlement price is not always the last trade price of the day, as it would be with stocks. In this study it is used 42 different commodity futures from different categories. The market portfolio consists from two different indexes, and they are weighted. Table 1 explains what commodities and what data range have been used in this study.

Table 1. Data Range.

Commodity	Data Range	Exchange
Agricultural		
Butter	24.10.1996-29.12.2006	Chicago Mercantile Exchange
Cocoa	1.1.1987-29.12.2006	New York Board of Trade
Coffee	1.1.1987-29.12.2006	New York Board of Trade
Cotton	1.1.1987-29.12.2006	New York Board of Trade
Lumber	1.1.1987-29.12.2006	Chicago Mercantile Exchange

Commodity	Data Range	Exchange
Milk	25.3.1996-29.12.2006	Chicago Mercantile Exchange
Orange Juice	1.1.1987-29.12.2006	New York Board of Trade
Sugar	1.1.1987-29.12.2006	New York Board of Trade
Fertilizer		
Diammonium Phosphate	7.6.2004-29.12.2006	Chicago Mercantile Exchange
Energy		
Coal	22.3.2004-29.12.2006	New York Mercantile Exchange
Crude Oil (Light Sweet)	1.1.1987-29.12.2006	New York Mercantile Exchange
Electricity	22.3.2004-29.12.2006	New York Mercantile Exchange
Gasoline Unleaded	1.1.1987-29.12.2006	New York Mercantile Exchange
Heating Oil	1.1.1987-29.12.2006	New York Mercantile Exchange
Natural Gas	1.11.1990-29.12.2006	New York Mercantile Exchange
Propane Gas	28.6.1989-29.12.2006	New York Mercantile Exchange
Animals		
Cattle (Feeder)	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Cattle (Live)	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Hogs (Lean)	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Pork Bellies (Frozen)	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Metals		
Copper (High Grade)	1.9.1989-29.12.2006	New York Mercantile Exchange
Gold	1.1.1987-22.10.1992	New York Mercantile Exchange
Palladium	1.1.1987-29.12.2006	New York Mercantile Exchange
Platinum	1.1.1987-29.12.2006	New York Mercantile Exchange
Silver	23.5.1998-29.12.2006	New York Mercantile Exchange
Corn	1.1.1987-29.12.2006	Chicago Board of Trade
Oats	1.1.1987-29.12.2006	Chicago Board of Trade
Rice (Rough)	7.1.2000-29.12.2006	Chicago Board of Trade
Soybean Meal	1.1.1987-29.12.2006	Chicago Board of Trade
Soybean Oil	1.1.1987-29.12.2006	Chicago Board of Trade
Soybeans	1.1.1987-29.12.2006	Chicago Board of Trade
Wheat	1.1.1987-29.12.2006	Chicago Board of Trade
Interest Rate Futures		
30 Year T-Bond	1.1.1987-29.12.2006	Chicago Board of Trade
3 Month Eurodollar	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Index Futures		
DJ Industrial	6.10.1997-29.12.2006	Chicago Board of Trade
Nasdaq 100 Index	12.4.1996-29.12.2006	Chicago Mercantile Exchange
S&P500 Index	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Currency Futures		
Australian Dollar	18.3.1987-29.12.2006	Chicago Mercantile Exchange

Commodity	Data Range	Exchange
British Pound	1.1.1987-29.12.2006	Chicago Mercantile Exchange
Canadian Dollar	30.11.1987-29.12.2006	Chicago Mercantile Exchange
Japanese Yen	1.1.1987-29.12.2006	Chicago Mercantile Exchange

For most commodities, open interest is low and trading volume is thin. In this kind of situations settlement prices may be stabile for couple of trading days.

Market Portfolio

Dow-Jones: Dow Jones index is created by Wall Street Journal editor Charles Dow. The index consists of 30 of the largest and most widely held public companies in the United States. The index made its debut May 26, 1896. Dow Jones index is widely used in several studies as a one part of the proxy for the market portfolio. In this study DJ index is given 10% weight for the portfolio. (http://www.djindexes.com).

S&P 500: Standard and Poor's 500 index includes 500 leading companies in the United States. It covers approximately 75% of U.S. equities, so it is an ideal proxy for the total market. It is very commonly used to describe the market portfolio in studies before. In this study the index is given 90% weight for the market portfolio. (http://www.standardandpoors.com).

As mentioned above, the market portfolio used in this thesis includes 90% of S&P500 and 10% of Dow-Jones industrial average. These weightings are going to affect the results of this study. When estimating beta coefficients, it is natural to assume that S&P500 index futures mirror the index. The situation is assumed to be same, maybe not so strong but still, with the DJ index futures. There have been as many market portfolios as there have been researchers. Almost all of them have used S&P500 because it is the world's largest and most comprehensive stock index. Marcus (1984) has argued about the weights in the market portfolio. He recommended a value-weighted index with 90% of the common stock index and 10% of the commodity futures index. Using this value-weighted index e.g. Baxter et al. (1985) and So (1986) found no evidence of a risk premium. Because of that I chose to use 10% of Dow-Jones index in this thesis. Earlier studies have almost every time given the largest weight to the S&P500 and so do I. This thesis uses for describing the risk-free interest rate 3 month U.S. Treasury bill. And those are taking account when calculating the returns for market portfolio.

Commodity Futures

Agricultural: Agricultural futures consist from 9 different commodities: Butter, cocoa, coffee, cotton, lumber, milk, orange juice, potatoes and sugar. The agricultural futures are the oldest ones. Those were introduced to reduce farmers risk when they were harvesting. These agricultural products used in this thesis are traded in Chicago Mercantile Exchange, New York Board of Trade and Euronext Amsterdam.

Fertilizer: This group contains only one commodity, diammonium phosphate. It is traded in Chicago mercantile exchange.

Energy: Energy sector includes maybe the most popular derivatives in area of finance. In this sector this study includes seven different commodities: coal, crude oil, electricity, gasoline unleaded, heating oil, natural gas and propane gas. These futures have very high open interest and daily volume in the exchange. For example OPEC has very big affect in oil prices. They can manage the size of storages and they can also decide how much oil is produced. This sectors futures includes also in inflation basket and with this they affect to interest rates and stock prices. About 70% of mineral value added in 1997 was oil and natural gas (Adelman & Watkins 2005: 553). All of these seven commodities are traded in New York Mercantile Exchange.

Animals: Cattle live, cattle feeder, hogs and pork bellies are used in this study. CME trades these products.

Metals: Copper, gold, palladium, platinum and silver are the futures in metal sector which are used in this thesis work. For example gold and silver are both consumption and investment assets. It means that those can be used for both purposes. Normally gold and silver are held only for investment purposes, but they can be used also in jewellery. For these commodities, copper, gold and silver are traded in the New York Mercantile Exchange COMEX division.

Grains and Oilseeds: Seven different commodities form this group, corn, oats, rice, soybean mean, soybean oil, soybeans and wheat. All of these daily settlement prices are gathered from Chicago Board of Trade.

Interest rate futures: This group has only two futures, 30 year T-bond and 3 month Eurodollar. The Eurodollar futures reflect the London Interbank Offered Rate (LIBOR) for a three-month, 1$ million offshore deposit. Eurodollar deposits are direct obligations of the commercial banks accepting the deposits and are not guaranteed by any government. Chicago Board of Trade trades 30 year t-bond and Chicago Mercantile Exchange trades 3 month Eurodollar futures. (http://www.tkfutures.com/eurodollar.htm).

Index futures: DJ industrial, Nasdaq 100 and S&P500 index futures are used. These futures are also widely used for hedging purposes in stock portfolios. It is easy to change the portfolios beta with these futures because they reflects almost whole markets opinion. Stoll and Whaley (1990) found that index futures returns lead stock index return. This indicates that index futures might have predicting power what supports of using those instruments. Nasdaq and S&P500 are traded in CME and DJ industrial is traded CBOT.

Currency futures: Australian dollar, British pound, Canadian dollar and Japanese yen futures are studied in this thesis. Han & Ozocak (2002) studied risk-return relationship in foreign currency futures following macroeconomic announcements. They found that risk-return tradeoff ratios differ across currencies. CME organises the trading of these four currency futures which are used in this study.

What we observed previous is that there exist many different commodity futures and that there are several different exchanges where futures contracts are traded. Futures contracts provide protection against market movements and those are also very liquid which makes trading more easily. If we still add those to the calculations, we would observe that futures markets have much larger volumes than options. Futures have a long and successful history and their popularity is still rising. Many companies and private investors use those for different purposes. One problem which they have owned is that the margins might have been too large for smaller market participants. But nowadays so called mini futures are traded on the exchanges and smaller investors can easily utilize those for their purposes.

4.3. Methodology

Calculation of returns

If a random variable Y_t is drawn from the conditional density function $f\left(Y_t \mid Y_{t-1}\right)$, the forecast of today's value based upon the past information, under standard assumptions, is simply $E(Y_t \mid Y_{t-1})$, which depends upon the value of the conditioning variable Y_{t-1}. The variance of this one-period forecast is given by $V(Y_t \mid Y_{t-1})$ (Engle 1982: 987). This leads to the return and standard deviation calculations for this thesis. The return from futures has long been problematic because a futures position requires no investment. There are two ways to calculate it from the daily settlement price. First way is used for example in the Robert W. Kolb's study.

(4.1)
$$FR_t = \left(\frac{SP_t}{SP_{t-1}} \right) - 1$$

where SP_t is the settlement price for the futures contract on day t and FR_t is return from futures position. In this study as also in Chang, Chen & Chen (1990) return has calculated from following equation:

(4.2)
$$FR_t = \text{Ln} \left(\frac{SP_t}{SP_{t-1}} \right)$$

where SP_t is the settlement price on the futures on day t. The difference between these equations is that the last one uses natural logarithm. The logarithm is the logarithm to the base e, where e is certain constant approximately equal to 2.718, this is also known as neper ratio, and name is derived from John Napier, the inventor of logarithms. Equation (4.2) has strong connection on hypothesis one and two. First hypothesis is tested with conventional *t*-test. Second hypothesis, which concentrates on median returns, is tested with *wilcoxon-signed rank test.*

In theoretical part there were introduced reward-to-variability ratio and reward-to-volatility ratio. They are also known as Sharpe's ratio and Treynor's ratio. A Sharpe ratio (SR) is developed by Nobel Laureate Bill Sharpe to measure risk-adjusted performance. It is calculated by subtracting the risk-free rate from the rate of return and dividing the result by the volatility of underlying asset. The greater the ratio, the better its risk-adjusted performance has been. The equation is as follows

(4.3)
$$SR = \frac{(r_c - r_f)}{\sigma_c}$$

where r_c is the return from the commodity, r_f is the risk-free interest rate and σ_c is the standard deviation of the commodity.

A Treynor ratio is developed by Jack Treynor and it measures returns earned in excess of that which could have been earned on a riskless investment per each unit of market risk. In other words, the Treynor ratio (TR) is a risk-adjusted measure of return based on systematic risk. It is similar to Sharpe ratio, with difference being that the Treynor ratio uses beta as the measurement of volatility. Following equation is used to calculate Treynor's ratio

$$TR = \frac{\left(r_c - r_f\right)}{\beta_c} \tag{4.4}$$

where β_c is the average beta of the commodity.

Regression models

In statistics linear regression is a regression method of modelling the conditional expected value of one variable y given the values of some other variable or variables x. Linear regression is called linear because the relation of the response to the explanatory variables is assumed to be a linear function of some parameters. The earliest form of linear regression was the method of least squares, which was published by Legendre in 1805, and by Gauss in 1809.

Using the familiar mean-variance criterion, a general equilibrium model of the pricing of capital assets under uncertainty has been developed Sharpe and Lintner. The model's underlying assumptions require either a quadratic utility function or a Freund-type utility function and normally distributed market returns, either of which are quite restrictive assumptions. The empirical counterpart of CAPM is employd by Dusak (1973).

$$P_t = \alpha_j + \beta_j x_t + \varepsilon_t \qquad t = 1, 2, 3, \ldots, T, \tag{4.5}$$

where P_t is the 1-period return on an individual asset *j*, x_t is the 1-period return on the efficient portfolio, α_j is the normalized systematic risk of asset *j*. The term ε_t is the residual error in period *t*. This relationship is often referred to as the market model. In a portfolio framework, Dusak argued that the risk premium of futures contract should depend only on beta in equation (4.5). This portfolio measure of risk is viewed as being more important than the measure of non-market risk α because the level of nonmarket risk can be diversified away. (See e.g. Carter et al. 1983: 321 ; So 1987: 314.)

In this thesis, to examine the systematic risk of futures in every year between 1987-2006, the following regression is performed for each year, *j*, available for each commodity:

(4.6) $$FR_{j,t} = \alpha_j + \beta_j R_t + \varepsilon_{j,t}$$

,where $FR_{j,t}$ is the futures return for the *j*th year on day *t*, α_j is the *j*th year regression intercept for commodity future, R_t is the return on the value-weighted portfolio[3] for day *t* and $\varepsilon_{j,t}$ is the residual error for commodity future. β_j is the futures systematic risk. The portfolio consists of 90% S&P 500 index and 10% Dow-Jones Industrial average. From this regression we get the beta coefficient to futures. Regression model (4.6) studies hypothesis three and it is tested for each year using *t*-test.

Fourth hypothesis is tested by computing the mean daily return for each year futures and regressing this mean return against the beta for that year. Betas enter here as explanatory variables in order to estimate the coefficients λ_0 and λ_1. The CAPM restrictions are tested by standard *t*-tests. Modern asset pricing models predict a linear relation between expected asset returns and asset systematic risk. In the last hypothesis tested, the following regression is used:

(4.7) $$FR_j = \lambda_0 + \lambda_1 \beta_j + \varepsilon_j$$

where FR_j is the futures yearly return, λ_0 is a constant (the zero-beta rate), β_j is the estimated beta coefficient for year *t* and λ_1 explains the systematic risk. In addition, we want to ensure that there are no other parameters next to beta which explains the cross-section of expected returns.

[3] R_t is the excess rate of return of the market portfolio in period *t*

5. EMPIRICAL RESULTS

This study explores the risk and return in futures markets on 42 different futures from the biggest exchanges. A regression framework is utilized in order to explore the impact of futures markets. The regression results are obtained by using EViews5 econometric software package. The regression results are made with Newey-West test, and if there has been autocorrelation or heteroscedasticity, they are removed with EViews, more precisely with ARCH and AR terms. Basic starting point was to do the regression with OLS settings every time when possible. The thesis work includes over 700 regression results so there are no raw data results informed, all the results are showed together in the tables. Table 2 provides descriptive statistics from every different futures.

Table 2. Descriptive statistics for single commodities.

Commodity	Mean Return (Daily)	Mini-mum (Daily)	Maxi-mum (Daily)	Std.Dev (Daily)	Std.Dev (Yearly)	Skew-ness	Kur-tosis	Daily Observa-tions
Agricultural								
Butter	0.0138	-55.00	8.70	1.97	31.26	1.05	3.75	2656
Cocoa	-0.0032	-11.97	12.56	1.91	30.35	0.30	2.86	5216
Coffee	-0.0016	-19.20	23.77	2.47	39.15	0.99	4.31	5216
Cotton	-0.0010	-30.48	16.71	1.66	26.33	0.45	3.73	5216
Lumber	0.0091	-13.07	10.93	1.75	27.75	0.24	2.08	5216
Milk	0.0008	-17.92	15.92	1.74	27.63	0.64	3.07	2809
Orange Juice	0.0096	-13.82	23.90	1.92	30.41	0.83	2.89	5216
Potatoes	0.0275	-105.86	100.33	5.51	87.39	0.02	2.77	1421
Sugar	0.0149	-48.55	132.18	3.10	49.14	0.48	3.05	5216
Fertilizer								
Diammonium Phosphate	0.0334	-4.06	4.33	0.59	9.43	-0.53	1.92	669
Energy								
Coal	-0.0368	-5.74	12.61	1.28	20.39	-0.77	2.70	724
Crude Oil (Light Sweet)	0.0235	-40.05	14.23	2.31	36.73	1.87	5.81	5216
Electricity	0.0131	-36.50	25.42	4.11	65.26	1.08	4.38	724
Gasoline Un-leaded	0.0224	-30.99	19.49	2.42	38.48	1.93	6.47	5216
Heating Oil	0.0227	-39.09	13.99	2.38	37.85	1.94	5.98	5216
Natural Gas	0.0234	-37.57	32.44	3.66	58.12	1.65	6.04	4216
Propane Gas	0.0321	-38.87	23.97	2.39	37.88	1.38	4.08	4567

Commodity	Mean Return (Daily)	Minimum (Daily)	Maximum (Daily)	Std.Dev (Daily)	Std.Dev (Yearly)	Skewness	Kurtosis	Daily Observations
Cattle (Live)	0.0098	-8.58	6.16	1.00	15.88	0.73	3.29	5216
Hogs (Lean)	0.0051	-26.37	29.18	2.02	32.11	0.54	2.70	5216
Pork Bellies (Frozen)	0.0061	-34.18	57.31	2.58	40.93	0.21	2.06	5216
Metals								
Copper (High Grade)	0.0179	-11.52	11.19	1.50	23.83	2.86	11.92	4520
Gold	-0.0110	-7.73	3.87	0.89	14.15	0.54	2.14	1515
Palladium	0.0201	-13.20	15.25	1.88	29.85	2.20	8.35	5216
Platinum	0.0169	-14.42	18.68	1.31	20.86	1.62	5.08	5216
Silver	0.0132	-14.79	9.29	1.54	24.45	2.62	10.83	4854
Grains and Oilseeds								
Corn	0.0171	-21.65	9.80	1.46	23.22	1.74	8.27	5216
Oats	0.0097	-20.02	12.94	2.07	32.89	1.14	4.74	5216
Rice (Rough)	0.0218	-21.92	13.68	1.84	29.15	0.06	2.26	1820
Soybean Meal	0.0056	-14.98	8.88	1.52	24.06	1.14	4.13	5216
Soybean Oil	0.0126	-7.23	8.72	1.46	23.10	0.11	2.53	5216
Soybeans	0.0064	-12.41	7.54	1.38	21.98	0.97	4.09	5216
Wheat	0.0115	-15.93	9.05	1.56	24.82	0.88	3.99	5216
Interest Rate Futures								
30 Year T-Bond	0.0060	-2.98	3.78	0.60	9.45	-0.06	1.90	5216
3 Month Eurodollar	0.0002	-0.87	1.27	0.07	1.05	0.08	2.48	5233
Index Futures								
DJ Industrial	0.0178	-7.71	6.38	1.15	18.23	-0.46	2.52	2409
Nasdaq 100 Index	0.0382	-12.23	15.44	2.13	33.88	1.65	5.48	2795
S&P500 Index	0.0340	-33.70	17.75	1.19	18.95	0.17	1.48	5216
Currency Futures								
Australian Dollar	0.0038	-3.74	5.17	0.64	10.16	-0.80	2.78	5162
British Pound	0.0055	-4.48	3.47	0.62	9.77	0.38	2.34	5216
Canadian Dollar	0.0024	-1.90	1.99	0.37	5.84	0.06	1.80	4955
Japanese Yen	0.0055	-4.21	8.27	0.71	11.32	0.43	3.51	5216

First column reports the mean percent return per day. Interesting finding is that 37 futures have positive returns between the data range, and only five has negative returns. Three of these negative return futures are from agricultural category, cocoa, coffee and cotton. The highest return is provided by Nasdaq 100 index futures, and the lowest one is from the coal. The median was found to be zero almost for all commodities, expect electricity, S&P500 and Australian dollar. Second and third column reports minimum and maximum percent changes in one day. Potatoes and sugar has maximum change over 100 % percent, and potatoes have also minimum change over 100 %. Average minimum percent per day change is -20.75 % for all futures, and maximum change is 18.62 %. Fourth and fifth columns provide results from daily and yearly standard deviation respectively. Yearly volatility is calculated assuming 252 trading days. The equation is as follows

(5.1) $$\sigma_{yearly} = \sigma_{day}\sqrt{252}$$

From table 3 can be observed that average yearly volatility for all is 27.78 %. The highest volatility from single commodities is for potatoes as well. The lowest one is 3 month Eurodollar, and it is only 1.05%. The potatoes futures have only 1421 daily observations and there exist several same settlement prices in sequential days, so it is not very liquid and that has affected the results. For e.g. natural gas is highly liquid and in this study it consists from 4216 daily observations, it has standard deviation 58.12 %. The median standard deviation for all commodities is 25.58 %. The average standard deviation for whole energy category was found to be 42.10%, and it is the highest one when categories are compared. For example currency and interest rate futures have volatility only 9.27% and 5.25% respectively. Agricultural products standard deviation was also found to be as high as 38.82%. Without potatoes it is still 32.75%. Sixth and seventh columns report the skewness and kurtosis[4]. These rows illustrate that financial returns are not completely characterized by the mean and standard deviation of returns. In theory section it was said that futures price distribution is normally leptokurtic. More precisely, leptokurtic means that kurtosis is positive and it is more "peaked" and it has "fat tails". Every single futures kurtosis is observed to positive. 5 futures have negative skewness. The highest values are observed in copper. And from sectors side, the highest skewness and kurtosis are observed in metal sectory. Gorton and Rouwenhorst found also positive skewness from futures and negative skewness from equities. The average skewness and kurtosis for all futures is 0.79 and 4.05 respectively. Gorton et al. found those to be 0.71 and 4.53. Last column from table 1 reports the number daily observations.

[4] Normal distribution have skewness 0 and kurtosis 3.

Table 3. Descriptive statistics for categories.

Commodity	Mean (Daily)	Mean Return (Yearly)	Std.Dev (Daily)	Std.Dev (Yearly)	Skewness	Kurtosis
Agricultural	0.0078	2.0045	2.45	38.82	0.55	3.17
Fertilizer	0.0334	8.7672	0.59	9.43	-0.53	1.92
Energy	0.0143	3.8260	2.65	42.10	1.30	5.07
Animals	0.0076	1.9391	1.61	25.54	0.54	2.90
Metals	0.0114	2.9665	1.43	22.63	1.97	7.66
Grains and Oilseeds	0.0121	3.1052	1.61	25.60	0.86	4.29
Interest Rate Futures	0.0031	0.7746	0.33	5.25	0.01	2.19
Index Futures	0.0300	7.8757	1.49	23.69	0.45	3.16
Currency Futures	0.0043	1.0926	0.58	9.27	0.02	2.60
Physical	0.0114	2.9671	2.00	31.76	0.96	4.42
Financial	0.0126	3.2830	0.83	13.18	0.16	2.70
All Futures	0.0116	3.0348	1.75	27.78	0.79	4.05

Fertilizer group is also presented in the categories table, but it includes only one commodity, so it needs to be analyzed with special care. Financial futures seem to have higher return than physical, but also much lower standard deviation. Maybe the most interesting finding is that, none of the groups in table 3 has negative mean return. This indicates strongly that futures returns are usually positive. With good diversification it is possible to construct a good investment portfolio from commodity futures. The 3 month Treasury bill had mean percent per day return exactly 0 and mean return per year 0.01%, and those were calculated with same methods as the futures returns. That risk-free return is also used when calculated excess return for market portfolio and Sharpe's and Treynor's ratio.

5.1. Return

Table 4 reports the mean returns from futures. First column reports the mean return on percent per days, and it is also viewed in the table 2. Second column reports the percent per year mean returns in every futures. The figures are computed directly from the first. The yearly returns are calculated as follows

(5.2) $$R_{yearly} = (1 + R_{daily})^{252} - 1$$

where R_{daily} is the average daily return from futures. Kolb has used same method calculating yearly returns in his study. The average yearly return for all futures is 3.04% and the median 2.72%. 20 futures have higher yearly return than the average.

Table 4. Mean return.

Commodity	Mean Return (Percent Per Day)	Mean Return (Percent per Year)	t-statistic	Wilcoxon Signed Rank Test
Agricultural				
Butter	0.014	3.549	0.362	1.76
Cocoa	-0.003	-0.811	-0.122	1.04
Coffee	-0.002	-0.390	-0.045	0.03
Cotton	-0.001	-0.258	-0.045	0.07
Lumber	0.009	2.308	0.374	0.01
Milk	0.001	0.193	0.023	1.41
Orange Juice	0.010	2.448	0.362	0.04
Potatoes	0.028	7.184	0.189	0.40
Sugar	0.015	3.818	0.347	1.35
Fertilizer				
Diammonium Phosphate	0.033	8.767	1.452	1.33
Energy				
Coal	-0.037	-8.855	-0.771	2.26*
Gasoline Unleaded	0.022	5.810	0.668	2.04*
Heating Oil	0.023	5.887	0.688	1.90
Natural Gas	0.023	6.070	0.415	0.45
Propane Gas	0.032	8.421	0.909	3.05*
Animals				
Cattle (feeder)	0.009	2.420	0.822	2.00*
Cattle (Live)	0.010	2.497	0.707	1.98*
Hogs (Lean)	0.005	1.298	0.183	0.84
Pork Bellies (Frozen)	0.006	1.543	0.170	0.49
Metals				
Copper (High Grade)	0.018	4.622	0.803	1.27
Gold	-0.011	-2.722	-0.478	0.29
Palladium	0.020	5.186	0.771	1.00
Platinum	0.017	4.363	0.932	2.20*
Silver	0.013	3.384	0.597	2.02*
Grains and Oilseeds				
Corn	0.017	4.401	0.844	0.36
Oats	0.010	2.479	0.339	0.12
Rice (Rough)	0.022	5.652	0.507	0.66
Soybean Meal	0.006	1.421	0.267	0.64

Commodity	Mean Return (Percent Per Day)	Mean Return (Percent per Year)	t-statistic	Wilcoxon Signed Rank Test
Soybean Oil	0.013	3.221	0.624	0.51
Soybeans	0.006	1.613	0.331	1.44
Wheat	0.012	2.949	0.533	0.74
Interest Rate Futures				
30 Year T-Bond	0.006	1.511	0.722	2.26*
3 Month Eurodollar	0.000	0.038	0.167	0.72
Index Futures				
DJ Industrial	0.018	4.581	0.760	1.20
Nasdaq 100 Index	0.038	10.095	0.946	2.09*
S&P500 Index	0.034	8.951	2.058*	4.29*
Currency Futures				
Australian Dollar	0.004	0.970	0.430	2.69*
British Pound	0.005	1.386	0.641	1.67
Canadian Dollar	0.002	0.608	0.462	0.85
Japanese Yen	0.006	1.407	0.561	1.00

*Significant at 0.05 level.

Animal, grain and oilseed, interest rate, index and currency futures have all positive returns in their own categories. The highest return is provided by index futures category. Nasdaq 100 is the only which has over 10% yearly return. The third column of figures, *t*-statistic, presents the result of a *t*-test of the null hypothesis that the mean return across futures for a given commodity is zero. A "*" indicates *t*-values that are significantly different from zero at the 5% significance level in a two-tailed test. If we think the hypothesis 1, S&P500 is only futures with statistical significance and it is also the only one where the hypothesis can be rejected. After all, 3 month Eurodollar is the only futures with zero return, but statistical significance is the main criteria in this thesis work. The final column in table 4 presents the results of the Wilcoxon signed-rank test of the hypothesis that the median return for each futures is zero. The Wilcoxon signed-rank test pertains directly to the median. There exist 11 futures which have statistically significant result in this study. Again, S&P500 index futures have the highest value. 3 from the energy sector has median different from zero at 5% level of significance, two from animals and two also from metals. 30 year T-Bond, Nasdaq100 and Australian dollar have also statistical significance. This tells us that hypothesis two can be also rejected in the case of these 11 futures. The tests are made with eviews5, and more precisely using the tests for descriptive statistics.

Table 4 shows that many commodity returns are nonzero over the lengthy period of this study. Interesting found was that none of the futures had statistically significant negative returns. There are 10 futures which has median returns different from zero, although the mean return for these futures is not significantly different from zero. From the correlation coefficient side of view, gold has the lowest correlation when compared to the portfolio used in this study. Naturally, the highest one is observed from S&P500 index futures. Average correlation was 0.07 and the median -0.01. 27 seven futures has positive correlation, and 15 has negative when they were compared to the portfolio used in this study. From category view, three has negative correlation, energy, metals and currency.

5.2. Beta

Table 5 presents information from estimated beta coefficients. There are more than 700 estimates of beta based on equation (4.6). The raw returns for each commodity are regressed against the excess returns on a proxy of the market portfolio. The average beta for all futures is 0.094 and the median is 0.02. The first column of figures reports the mean beta estimated for all futures. Second column informs the median beta, third and fourth column the minimum and maximum betas, indicating the range of estimated betas. When each beta is estimated for individual year, the *t*-statistic that is used to test a departure of beta from zero is recorded.

Table 5. Beta coefficient for single commodities.

Commodity	Average Beta	Median Beta	Minimum Beta	Maximum Beta	Percentage of t-Statistics <-2.0	Percentage of t-Statistics >2.0	Average R^2	Wilcoxon Signed-Rank Test
Agricultural								
Butter	0.025	0.039	-0.321	0.266	0.00	9.09	0.0055	0.7557
Cocoa	0.000	-0.010	-0.325	0.320	5.00	0.00	0.0046	0.0560
Coffee	0.065	0.033	-0.162	0.337	0.00	5.00	0.0045	1.5493
Cotton	0.043	0.024	-0.230	0.284	0.00	5.00	0.0052	1.5866
Lumber	0.172	0.140	-0.097	0.691	0.00	30.00	0.0129	3.7519*
Milk	-0.075	-0.071	-0.289	0.144	0.00	0.00	0.0050	1.8227
Orange Juice	0.087	0.028	-0.193	0.575	0.00	10.00	0.0049	1.6986
Potatoes	0.147	0.050	-0.045	0.491	0.00	0.00	0.0015	1.4676

Commodity	Average Beta	Median Beta	Minimum Beta	Maximum Beta	Percentage of t-Statistics <-2.0	Percentage of t-Statistics >2.0	Average R^2	Wilcoxon Signed-Rank Test
Sugar	-0.033	-0.040	-0.705	1.051	10.00	0.00	0.0067	0.6533
Energy								
Coal	0.044	0.061	-0.011	0.082	0.00	0.00	0.0008	0.8018
Crude Oil (Light Sweet)	-0.209	-0.095	-1.366	0.216	15.00	5.00	0.0175	2.3706*
Electricity	0.394	0.520	0.116	0.544	0.00	0.00	0.0058	1.3363
Gasoline Unleaded	-0.124	-0.051	-1.307	0.340	15.00	5.00	0.0167	0.7653
Heating Oil	-0.172	-0.024	-1.437	0.189	5.00	5.00	0.0142	1.3626
Natural Gas	-0.022	-0.028	-0.614	0.878	5.88	0.00	0.0077	0.5681
Propane Gas	-0.227	-0.100	-1.512	0.157	22.22	5.56	0.0143	2.4388
Animals								
Cattle (feeder)	0.013	0.015	-0.074	0.106	5.00	5.00	0.0048	1.1013
Cattle (Live)	0.024	0.030	-0.084	0.151	0.00	10.00	0.0041	1.7733
Hogs (Lean)	0.014	-0.014	-0.337	0.306	0.00	10.00	0.0048	0.2800
Pork Bellies (Frozen)	0.017	0.019	-0.409	0.625	0.00	5.00	0.0174	0.3173
Palladium	-0.045	-0.032	-0.458	0.198	10.00	0.00	0.0065	1.1760
Platinum	-0.067	-0.094	-0.296	0.226	30.00	0.00	0.0107	1.8853
Silver	-0.100	-0.108	-0.596	0.377	26.32	0.00	0.0133	1.8713
Grains and Oilseeds								
Corn	0.050	0.068	-0.266	0.280	0.00	5.00	0.0071	1.6613
Oats	0.076	0.027	-0.257	0.483	0.00	10.00	0.0067	1.1760
Rice (Rough)	0.064	0.007	-0.192	0.305	0.00	14.29	0.0053	0.9297
Soybean Meal	0.045	0.046	-0.223	0.244	0.00	10.00	0.0059	1.4746
Soybean Oil	-0.002	0.012	-0.384	0.155	5.00	5.00	0.0054	0.5040
Soybeans	0.038	0.062	-0.214	0.214	0.00	10.00	0.0075	1.4000
Wheat	0.042	0.070	-0.261	0.176	0.00	5.00	0.0058	1.7733

Commodity	Average Beta	Median Beta	Minimum Beta	Maximum Beta	Percentage of t-Statistics <-2.0	Percentage of t-Statistics >2.0	Average R^2	Wilcoxon Signed-Rank Test
Interest Rate Futures								
30 Year T-Bond	0.152	0.133	-0.232	0.675	15.00	55.00	0.1308	2.3706*
3 Month Eurodollar	0.011	0.007	-0.006	0.053	10.00	45.00	0.0486	2.1093
Index Futures								
DJ Industrial	0.943	0.931	0.855	1.072	0.00	100.00	0.8697	2.7521*
Nasdaq 100 Index	1.476	1.369	1.073	2.106	0.00	100.00	0.6853	2.8896*
S&P500 Index	1.037	1.007	0.952	1.318	0.00	100.00	0.9270	3.9013*
Currency Futures								
Australian Dollar	0.009	0.006	-0.130	0.202	5.00	10.00	0.0081	0.1680
British Pound	-0.058	-0.070	-0.224	0.146	50.00	0.00	0.0254	2.6693*
Canadian Dollar	0.033	0.034	-0.066	0.084	5.26	36.84	0.0188	2.7968*
Japanese Yen	-0.028	-0.029	-0.369	0.184	30.00	15.00	0.0227	0.6907

*Significant at 0.05 level.

The fifth and sixth columns of figures in table 4 record the percentage of those estimated betas with *t*-statistic below -2.0 and above +2.0. These values show how frequently betas significantly different from zero are encountered. The seventh column shows the average R^2 for the regressions for each commodity. The final column reports the Wilcoxon-Signed rank statistic testing whether the median beta for each commodity equals to zero. 28 futures have positive betas and 14 have negative betas. Electricity and all three index futures are the only futures which have positive betas every estimated year. Highest beta is observed for Nasdaq 100, and the lowest is for propane gas.

Table 6. Beta coefficients for categories.

Commodity	Average Beta
Agricultural	0.048
Fertilizer	0.037
Energy	-0.045
Animals	0.017
Metals	-0.035
Grains and Oilseeds	0.045
Interest Rate Futures	0.082
Index Futures	1.152
Currency Futures	-0.011
Physical	0.011
Financial	0.397
All Futures	0.094

If we compare the sectors, three has negative average beta, energy, metals and currency. The rest has positive betas and again index futures sector has the highest one, 1.152. All of index sector betas estimated have *t*-value above +2.0. That implies statistically significant betas for every year and every futures. Interesting finding was that in metal sector, copper is the only one with positive beta. There exist only few commodities which do not have either over +2.0 or under -2.0 betas. So in that sense, hypothesis three can be rejected for almost all commodity futures. The average R^2 informs support the conclusion that systematic risk is not an important determinant of futures returns. Only index futures have average R^2 over 10%, in fact it is 83 percent. The rest futures have very low R^2 which suggest that they have very little systematic risk. In Wilcoxon-signed rank test, nine futures have statistical significance. Again, all three index futures are included this category. If we compare these results for earlier studies, Dusak (1973) found mean betas of 0.0602 for wheat, 0.0410 for corn, and 0.0730 for soybeans. Kolb (1996) found 0.0689 for wheat, 0.0258 for corn and 0.0733 for soybeans. In this study same coefficient for wheat, corn and soybeans were, 0.0419, 0.0503 and 0.0385, respectively. Kolb found mean beta for all commodities to be 0.0463 which is lower than this studies betas. After all, these results seem to be in the same direction as in the Kolb's study.

5.3. Realized return and systematic risk

Table 7 presents the results of the last hypothesis tested; the relationship between returns and estimated systematic risk. The first column reports estimates for the intercept in equation (4.7), while the second column reports results of a *t*-test. Columns three and four report the estimated slope coefficient (λ_1) and a test of null hypothesis that $\lambda_1 = 0$. The fifth column reports the R^2 for the regression, and the final column presents the number of observations.

Table 7. Risk and return.

Commodity	λ_0	λ_0 t- Statistic	λ_1	λ_1 t-Statistic	R^2	Observations
Agricultural						
Butter	0.0002	1.30	-0.0008	-0.56	0.0247	11
Cocoa	0.0000	-0.20	-0.0022	-1.89	0.1146	20
Coffee	-0.0002	-0.77	0.0023	1.53	0.0567	20
Cotton	0.0000	-0.27	0.0001	0.05	0.0001	20
Lumber	-0.0003	-0.79	0.0019	1.07	0.0688	20
Milk	0.0001	0.93	0.0009	0.62	0.0249	11
Orange Juice	-0.0001	-0.72	0.0023	1.70	0.1306	20
Potatoes	0.0026	2.15	-0.0156	-4.97*	0.7242	6
Sugar	0.0003	0.73	0.0031	1.37	0.2125	20
Fertilizer						
Diammonium Phosphate	0.0005	1.03	-0.0016	-0.43	0.0577	3
Energy						
Coal	-0.0005	-1.36	0.0057	0.37	0.0568	3
Crude Oil (Light Sweet)	0.0002	1.15	0.0001	0.24	0.0011	20
Electricity	-0.0032	-10.66	0.0087	4.24	0.8346	3
Gasoline Unleaded	0.0001	0.72	-0.0002	-0.58	0.0064	20
Heating Oil	0.0004	1.61	0.0011	2.86*	0.1117	20
Natural Gas	0.0000	0.05	0.0008	0.50	0.0127	17
Propane Gas	0.0008	1.37	0.0008	0.94	0.0157	18
Animals						
Cattle (feeder)	0.0001	1.09	-0.0011	-0.51	0.0132	20
Cattle (Live)	0.0001	1.69	-0.0010	-0.90	0.0204	20
Hogs (Lean)	0.0001	0.53	-0.0005	-0.40	0.0066	20
Pork Bellies (Frozen)	0.0000	0.29	0.0005	0.48	0.0074	20
Metals						
Copper (High Grade)	-0.0002	-0.75	0.0018	2.23*	0.0827	18
Gold	-0.0002	-1.93	-0.0009	-0.79	0.1154	6
Palladium	0.0002	0.47	0.0000	0.00	0.0000	20

Commodity	λ_0	λ_0 t- Statistic	λ_1	λ_1 t-Statistic	R^2	Observations
Silver	0.0002	0.68	0.0005	0.42	0.0222	19
Grains and Oilseeds						
Corn	0.0001	0.56	0.0013	0.79	0.0378	20
Oats	0.0000	-0.17	0.0021	1.39	0.1160	20
Rice (Rough)	0.0001	0.19	0.0019	0.65	0.0487	7
Soybean Meal	0.0000	0.03	0.0006	0.39	0.0063	20
Soybean Oil	0.0001	0.58	-0.0003	-0.13	0.0019	20
Soybeans	0.0000	0.03	0.0008	0.64	0.0136	20
Wheat	0.0002	1.08	-0.0014	-1.11	0.0300	20
Interest Rate Futures						
30 Year T-Bond	0.0001	1.89	-0.0002	-0.68	0.0104	20
3 Month Eurodollar	0.0000	0.45	-0.0006	-0.63	0.0262	20
Index Futures						
DJ Industrial	0.0016	1.06	-0.0016	-0.97	0.0358	10
Nasdaq 100 Index	0.0039	2.55*	-0.0023	-2.63*	0.2164	11
S&P500 Index	-0.0002	-0.14	0.0005	0.41	0.0049	20
Currency Futures						
Australian Dollar	0.0001	0.48	-0.0009	-0.74	0.0209	20
British Pound	0.0000	0.56	-0.0002	-0.40	0.0017	20
Canadian Dollar	0.0001	1.06	-0.0027	-1.68	0.1721	19
Japanese Yen	0.0001	0.59	-0.0002	-0.54	0.0033	20

*Significant at 0.05 level.

According to the CAPM, one would expect generally positive relationship between realized return and the level of systematic risk, which would be evidenced by positive estimated values for λ_1 in equation (4.7). Across all 42 commodities 23 estimated betas are positive and 19 are negative. Only four is observed to be statistically significant, and two from those are positive and two negative. Currency futures category is the only one where all futures are negative. The results of table 7 provide evidence that systematic risk in futures is not rewarded by additional return. Further, there appears to be an inverse relationship between systematic risk and realized return. However, given the low levels of systematic risk in most futures, this negative result for the CAPM must be interpreted with special care. Bodie and Rosanky (1980) and Kolb (1996) found a similar inverse relationship between realized return and beta.

Table 8. Risk and return in categories.

Commodity	λ_0	λ_0 t- Statistic	λ_1	λ_1 t-Statistic	R^2	Observations
Agricultural	0.0000	-0.75	0.0005	1.27	0.1635	148
Fertilizer	0.0005	1.03	-0.0016	-0.43	0.0577	3
Energy	0.0003	3.10*	0.0003	0.95	0.1046	101
Animals	0.0001	1.30	-0.0008	-1.46	0.0365	80
Metals	0.0002	1.48	0.0005	0.94	0.0450	83
Grains and Oilseeds	0.0001	1.23	0.0008	1.29	0.1194	127
Interest Rate Futures	0.0000	1.00	0.0000	0.06	0.3886	40
Index Futures	-0.0004	-0.55	0.0007	1.07	0.1335	41
Currency Futures	0.0000	1.06	-0.0004	-1.49	0.0100	79
Physical	0.0001	2.11*	0.0003	1.99	0.0609	542
Financial	0.0001	1.73	0.0002	0.97	0.0224	160
All Futures	0.0000	2.76*	0.0001	2.92*	0.0731	702

*Significance at 0.05 level.

When comparing the regression results in the categories side, there is none statistically significant results in the λ_1. Only one have significant constant beta rate, energy. If we put together all physical commodity observations, we found also significance from λ_0. In the case of all futures, both estimators were found to be statistically significant. The hypothesis four, we can reject the hypothesis because there exists relationship between realized return and systematic risk. On some cases the number of observations is very low, i.e. electricity and that is the reason why it is not statistically significant, although it has a very high t-value. The last regression model is also used to test normal backwardation and contango. Kolb (1992) and Miffre (2000) studied the commodity futures risk premium with this model. In this study it is not optimal to analyze those questions because we do not have contracts from commodity futures, only continues daily settlement prices, and contracts are needed to test backwardation and contango. Normally when $\lambda_1 < 0$ the futures contract is normal backwardated, and if the case were opposite, $\lambda_1 > 0$ the contract would be in contango.

Table 9 and 10 presents the results of Sharpe and Treynor ratios for both, single commodities and commodities as a group. Chang et al (1990) used also Sharpe's ratio to present the results. The average Sharpe ratio for all single futures is 0.12. The highest one is observed for diammonium phosphate and S&P500 index futures. On the other hand, the lowest one is observed for coal. Only five futures have negative Sharpe ratio out of 42. Again the highest Treynor ratio is observed for diammonium phosphate. The lowest ones are for soybean oil and cocoa. But their both estimated average betas were zero, and that of course affects to these results. Seventeen futures out of 42 have negative Treynor ratio.

Table 9. Sharpe and Treynor ratios for single futures.

Commodity	Sharpe	Treynor
Agricultural		
Butter	0.11	1.42
Cocoa	-0.03	-150.52
Coffee	-0.01	-0.06
Cotton	-0.01	-0.06
Lumber	0.08	0.13
Milk	0.01	-0.02
Orange Juice	0.08	0.28
Potatoes	0.08	0.49
Sugar	0.08	-1.16
Fertilizer		
Diammonium Phosphate	0.93	2.40
Energy		
Coal	-0.43	-2.02
Crude Oil (Light Sweet)	0.17	-0.29
Electricity	0.05	0.09
Gasoline Unleaded	0.15	-0.47
Heating Oil	0.16	-0.34
Natural Gas	0.10	-2.81
Propane Gas	0.22	-0.37
Animals		
Cattle (feeder)	0.18	1.88
Cattle (Live)	0.16	1.02
Hogs (Lean)	0.04	0.92
Pork Bellies (Frozen)	0.04	0.88
Metals		
Copper (High Grade)	0.19	0.32
Gold	-0.19	0.25
Palladium	0.17	-1.15
Platinum	0.21	-0.65
Silver	0.14	-0.34
Grains and Oilseeds		
Corn	0.19	0.87
Oats	0.08	0.33
Rice (Rough)	0.19	0.88
Soybean Meal	0.06	0.32
Soybean Oil	0.14	-14.85

Commodity	Sharpe	Treynor
Wheat	0.12	0.70
Interest Rate Futures		
30 Year T-Bond	0.16	0.10
3 Month Eurodollar	0.03	0.03
Index Futures		
DJ Industrial	0.25	0.05
Nasdaq 100 Index	0.30	0.07
S&P500 Index	0.47	0.09
Currency Futures		
Australian Dollar	0.09	1.09
British Pound	0.14	-0.24
Canadian Dollar	0.10	0.18
Japanese Yen	0.12	-0.50

From categories side, when fertilizer group is not taken into account, index futures have the highest Sharpe ratio 0.47. None of the categories have negative ratio, and the physical commodities average is 0.09 and financial 0.25, when all futures ending for the 0.11. Highest Treynor ratio is observed for fertilizer again, and the second highest to animals. Currency, energy and metals are the only ones with negative ratio, and of course that depends from their negative beta coefficients.

Table 10. Sharpe and Treynor ratios for commodity categories.

Commodity	Sharpe	Treynor
Agricultural	0.05	0.42
Fertilizer	0.93	2.40
Energy	0.09	-0.84
Animals	0.08	1.13
Metals	0.13	-0.84
Grains and Oilseeds	0.12	0.69
Interest Rate Futures	0.15	0.09
Index Futures	0.33	0.07
Currency Futures	0.12	-0.97
Physical	0.09	2.74
Financial	0.25	0.08
All Futures	0.11	0.32

Some of the observations based on the Sharpe and Treynor performance measures in the above paragraph should be interpreted with special care. Erb and Harvey (2006) used also Sharpe measure in their study. 4 out of 12 futures were negative. The highest one is observed for live cattle and it is 0.36 and the lowest one is for silver 0.32. The results in this study presented are consistent also with Erb and Harvey's study. After all, Sharpe and Treynor measures give more comprehensive results presented in this thesis work and they also support them. The results would be even more interesting if they were compared for example to stocks and bonds.

6. CONCLUSION

This thesis contains three main questions, first, do commodity futures embody systematic risk as measured within the context of the CAPM? Second, are returns on commodity futures significantly different from zero? And third, are the returns on futures positions commensurate with the systematic risk of those positions? More precisely, this thesis work examines four different hypotheses regarding the risk and return characteristics of futures returns. The first hypothesis is that the mean return for all futures equals zero. Second, the median return equals zero. Third, this thesis tests the null hypothesis that the systematic risk of futures is zero, as evaluated in capital asset pricing model setting. Fourth, this study tests for the relationship between realized returns and systematic risk.

To examine these hypotheses, this study uses large data, with many commodities and observations. Market portfolio used in this study is constructed from 90% of S&P500 and 10% of Dow-Jones. The data set analyzed in this thesis includes 42 different commodities, over 181,000 daily observations between time ranges 1987 to 2007 for most of the futures. 33 commodities are in the physical category and the rest 9 are in the financial category. More precisely, there exist very old futures as well very new ones. Agricultural sector futures have been living for centuries, and on the other hand energy sector products are quite young. So the tests give very interesting and comprehensive results.

First major observation from empirical tests was that the mean return is positive for 37 and negative just only 5 commodities. All financial commodities have positive returns. Just only one futures, S&P500, had statistically significant return. The median return was observed statistically significant for 11 commodities, and seven from those were from physical category. None of the futures had statistically significant negative mean returns. All futures, when divided to categories, were found to have positive mean returns, which was very interesting. From those, index futures had 7.88% mean return and 23.69 yearly volatility. Lowest standard deviation was interest rate futures and currency futures, 5.25 and 9.27 respectively. Energy sectors volatility was as high as 42.10.

Hypothesis three was estimated with the beta coefficient. In this study there are over 700 estimated beta coefficients. 28 commodities had positive beta while 14 had negative. From financial category, 7 have positive and only 2 negative betas, British pound and Japanese yen. Metals and energy sector have 9 negative betas out of 12 futures.

Copper, electricity and coal are the commodities with positive betas. As we know, negative beta coefficient indicates that the commodity tends to move another direction than our market portfolio in this study. Almost all beta values were nearer zero than 1 or -1. Only the index futures have beta over 1, and the main reason for that is the market portfolio. Average beta for all futures was found to be 0.094. The highest beta, when compared average betas between sectors, was observed of course in index futures. The lowest one was energy with -0.045. I also calculated the correlation coefficients with every futures against the market portfolio. 27 were found to be positive and 15 negative. Lowest correlation was found from gold, and the highest one from S&P500.

The last question concerns about systematic risk and realized return. Realized returns on futures are generally inversely related to systematic risk, as measured by regressing return on beta for all years for a given commodity. Among the 33 physical commodities, there is two significantly positive relationship, heating oil and copper. Potatoes futures have the only statistically significant negative value. From financial products side of view, Nasdaq were the only one with significance and it was also negative. When I compared the results in groups, the results were in the same direction as with single futures. None of those groups held statistically significant relationship when analysing systematic risk and realized return. 3 out of 9 had negative λ_1. In this study realized return seems to be equally positively and negatively related to systematic risk. However, given the very low levels of systematic risk for most commodities, the findings of relationship between realized return and systematic risk must be interpreted cautiously.

In general, the results of this thesis show that futures are interesting and good alternative choice for stocks and bonds. Most of these futures earn positive return and their standard deviation is also normal when compared to stocks. They can also provide protection for the market movements, i.e. energy and metal sector products have negative betas. Earlier studies have provided evidence that futures are good for hedging and risk management purposes.

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