The Business of Nature
Risk and Return in Physical and Financial Commodity Investments

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Preface

This thesis marks the ending of our master's degree in business and administration at the Norwegian University of Life Sciences. It is an extended analysis on the topic of commodity investments. This subject caught our interest early the masters program through other financial courses.

The period of writing has been interesting and educational, but also challenging at times. We hope that others may benefit from reading this thesis, and that it may provide an interest in the topic.

We want to use this opportunity to thank our supervisor, Professor Ole Gjølberg at UMB School of Economics and Business, for valuable ideas, guidance and support throughout the studies, but especially during this last semester.

Ås, May 13th 2011

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Executive summary

Recent years have witnessed an increased interest in commodity investments. Commodities have gradually become an investment vehicle on its own, as well as an addition to the investment universe of traditional stocks and bonds. One way to achieve exposure to commodities is buying futures contracts. It is also possible to buy the physical good. Other alternatives are investing in index funds, actively managed funds or exchange traded funds (ETFs). The latter may be the most feasible way.

The goal is twofold; it is desired to analyze historical returns in physical and financial commodities, and by this determine if commodities may be valuable in a portfolio

This thesis consists of three parts. The first includes an analysis of spot prices for five agricultural commodities; sugar, rice, corn, wheat and palm oil, benchmarked against a stock market index, i.e. MSCI World. Weekly spot prices are obtained for the 20 year period, January 1990 – December 2010. Risk and returns are calculated along with analysis of correlation across commodities and stocks, decomposition of risk, seasonal patterns and performance of the assets.

The second part introduces an alternative way of investing in commodities, i.e. through exchange traded funds. An ETF is said to “act like a fund, but trade like a stock”, and its purpose is to provide an easy and cheap way to invest in specific sectors, regions, bonds, futures, or as in this thesis, a definite commodity group. ETFs can be bought at exchanges during the opening hours. Part two also examines if ETFs actually track the underlying index they claim to do.

The last part offers various portfolios of stocks, commodities and ETFs, constructed and compared to the results from previous calculations. This, to evaluate the effects of including commodities or ETFs in a portfolio.

The main questions sought to be answered through this thesis are as follows:

- Does history provide evidence that risk adjusted returns from investing in commodities have been higher than stock investments?
- Have commodity based ETF investments represented a lucrative alternative to investments in physical commodities?
- Does the comprising of commodities in a portfolio provide valuable diversification effects?

Based on the empirical findings from this thesis, it is possible to conclude that commodities have not been sufficient as standalone investments. They have provided lower risk-adjusted returns than stocks over the last 20 year period. The last five years, however, was characterized by increasing commodity returns and decreasing stock returns. If the previous five years were to represent a persistent trend in commodity and stock prices, the conclusions regarding pure commodity investments may have to be reviewed. However, commodity returns are known to be higher in times of recession. Today, developed countries are in a period of early expansion, which could affect the current development of commodity prices.

Analyses indicated that the exchange traded funds tracked their underlying indexes. This opened up to the possibility of using prices of the underlying index to obtain a long time perspective since the ETFs were established as late as 2006/2007. ETFs have performed poorer than spot price returns partly due to costs of rolling the futures contracts are included in the ETF prices, while costs of storing the physicals are not. Results from computing different portfolios proved that including physical commodities in a portfolio lowers risk at a return equal to the stock market. This is due to commodities' risk and return characteristics that are somewhat different from stocks. Commodities have low correlations with both stocks and each other, in addition to low systematic risk. ETFs could contribute to lowering risk at a return lower than the market.

Sammendrag

De siste årene har det vært økt interesse for investering i råvarer. Råvarer har etter hvert blitt et investeringsverktøy i seg selv, samt et tillegg til de tradisjonelle investeringene i aksjer og obligasjoner. En vanlig måte for å oppnå eksponering mot råvarer er å handle futures kontrakter. I tillegg er det mulig å handle den fysiske varen. Andre alternativer er å investere i indeksfond, aktivt forvaltede fond eller børshandlede fond (ETFer). Sistnevnte er antatt å være mest gjennomførbar.

Målet med denne avhandlingen er todelt. Det er ønskelig å analysere historisk avkastning i fysiske og finansielle råvarer. For videre å avgjøre om råvarer kan gi diversifiseringseffekter i en portfølje.

Avhandlingen består av tre deler. Den første inneholder en analyse av prisene for fem landbruksvarer, sukker, ris, mais, hvete og palmeolje testet mot aksjemarkedindeksen, dvs. MSCI World. Ukentlige spotpriser er innhentet for 20årsperioden januar 1990 til desember 2010. Risiko og avkastning ble beregnet sammen med korrelasjon på tvers av råvarer og aksjer, dekomponering av risiko, sesongsvingninger og til slutt evaluering av prestasjonen til investeringene.

Den andre delen introduserer en alternativ måte å investere i råvarer på, gjennom børshandlede fond (ETFer). En ETF sies å "opptre som et fond, men handles som en aksje", der formålet er å kunne gi en enkel og billig måte til å investere i bestemte sektorer, regioner, obligasjoner, futures, eller som i denne oppgaven, en bestemt varegruppe. ETFer kan handles på børsen og kan derfor handles i løpet av børsens åpningstid. Videre ble det undersøkt det om ETFene faktisk fulgte den underliggende indeksen de hevder de gjør.

Den siste delen av avhandlingen presenterer porteføljer av aksjer, råvarer og ETFer, konstruert og sammenlignet med resultatene fra den foregående analysen. Med dette ble effekten av å inkludere råvarer eller ETFer i en portefølje vurdert.

De viktigste spørsmålene som ble forsøkt besvart gjennom denne oppgaven var:

• Har historien bevist at risikojustert avkastning ved å investere i fysiske råvarer har vært høyere enn aksjeinvesteringer?
• Har råvarebaserte investeringer via ETFer representert et lukrativt alternativ til investeringer i fysiske varer?
• Har inkludering av råvarer eller ETfer i en portefølje gitt verdifulle diversifiseringseffekter?

Basert på empiriske funn er det mulig å konkludere med at råvarer ikke er gode som frittstående investeringer. De gav lavere risikojustert avkastning enn aksjer den siste 20-årsperioden. De siste fem årene har vært preget av økende råvarepriser og avtagende aksjeavkastning. Dersom dette har representert starten på en vedvarende trend i råvarepriser og aksjekurser, vil konklusjonene vedrørende råvareinvesteringer måtte revurderes. På den annen side er råvareprisene kjent for å være høyere i tider med lavkonjunktur. I dag er industrialiserte land inne i en vekstperiode, noe som kan påvirke den nåværende utviklingen av råvarepriser.

Analyser tydet på at børshandlede fond fulgte sine underliggende indekser. Dette åpnet opp for muligheten for å bruke prisene på de underliggende indeksene for å oppnå et lengre tidsperspektiv, siden de undersøkte ETFene ble etablert så sent som i 2006/2007. ETFene har prestert enda dårligere enn spotpris, delvis på grunn av at kostnadene ved å rulle futures kontrakter er inkludert i ETF prisene, mens kostnadene ved å lagre de fysiske varene ikke er tatt hensyn til. Resultater fra sammensetting av ulike porteføljer viste at blant annet fysiske råvarer i en portefølje senket risikoen ved en avkastning lik aksjemarkedet. Dette skyldtes råvarenes risiko- og avkastningsegenskaper som er noe forskjellig fra aksjenes, for eksempel har de lav korrelasjon med både aksjer og hverandre, og lav systematisk risiko. ETFene kunne gi diversifiseringseffekter i en portefølje, ved avkastning lavere en markedet.

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1. Introduction

Investing in commodities has received a lot of attention the last years, both as a supplement and as an alternative to standard investment strategies like stocks and bonds. This is assumed to be a consequence of the increased commodity prices the last years. This assumption is the foundation of this thesis which will further examine the risk and return in the commodity market. The goal is twofold; it is desired to analyze historical returns in physical and financial commodities, and by this determine if commodities may be valuable in a portfolio.

Exposure to commodities can be achieved in different ways. The most common exposure is buying commodity futures contracts. Other alternatives are investing in index funds, actively managed funds or commodity based companies. It is also possible to buy the physical good, however, there are high costs related to this. These include e.g. storing, insurance and transportation. Therefore, the topic of investing in commodities brings notice to a relatively new and easy way to trade commodities, trough exchange traded funds (ETFs).

This thesis will offer a presentation of the assets to identify benefits and drawbacks, and proceeds with some basic information on commodity trading. The five major commodities examined are; sugar, corn, rice, wheat and palm oil. Trends and returns in the commodity market are examined by looking at potential seasonal patterns and structural changes across commodities. These figures are then compared with traditional investments in stocks (MSCI World). Performance goals are compared based on historical data over the 20 year period. The focus will be on long-term opportunities in commodity investments, however, the time period is divided into two sub-periods, 1990-2005 and 2006-2010. This is due to two global crises affecting the last years; the food crisis (2007 - 2008) and the financial crisis (2007 - 2010).

The second part of this thesis will present three exchange traded funds together with analysis of their risk and return characteristics. After examining the tracking of the ETFs towards the underlying index, performance goals are compared based on backtracked data of the ETFs. ETF performance is compared to the performance of the underlying physical commodity.

Part three of this thesis will focus on the diversification effects of including commodities into a portfolio with stocks. MSCI W has been used as a measurement of the stock market.

The main questions that will be answered through this thesis are:

- Does history provide evidence that risk adjusted returns from investing in commodities have been higher than stock investments?
- Have commodity based ETF investments represented a lucrative alternative to investments in physical commodities?
- Does the comprising of commodities in a portfolio provide valuable diversification effects?

Although it is possible to read each chapter individually, it is recommended that the entire thesis is read continuously. Every chapter will offer a presentation of previous research and calculations based on prices from the last 20 year period, or from origin. Each part offers individual comments and conclusions.

Background

The last decade has been characterized by large fluctuations in the commodity market. The headlines concerning commodities are many, however, some are occurring more frequently than others: increased prices in, especially agricultural commodities. Meyer (2010) states in Financial Times that "Cotton prices have reached 15-year highs", while Blas and Farchy (2010) reports of "further volatility in sugar prices". BBC (2007) reported that during the food crises (March 2007 – March 2008) the prices of wheat, milk and meat more than doubled, the price of soya and corn had an even larger increase

Financial Times 26.10.2010: "huge jump in sugar demand" (Farchy 2010a)

Financial Times 19.10.2010: "strong investor demand is supporting the precious metal" (Farchy 2010b)

Exhibit 1.1 provides a glimpse of the fluctuations of the commodity food price index (CFPI) over the previous 20 year period. The index includes soft commodities as in this thesis. Commodity food price index includes prices of cereal grains, vegetable oils, meat, seafood, sugar, bananas, and oranges and is collected from indexmundi.com (2011). As seen from the graph, different holding-periods of commodities could provide very different returns. E.g., there is no general increase in prices during 1991-1995. In the period 1995-1996 however, an increase of about 25% is evident, followed by a decreased price the next five years. A modest increase continued until 2007/2008, where extreme levels were evident. Prices are most stabile in the period from 2000-2005. The prices at present time

are still much higher than the average over the period. These figures indicate that the 20 year period 1990-2010, may not necessarily represent the development of commodity prices in general.

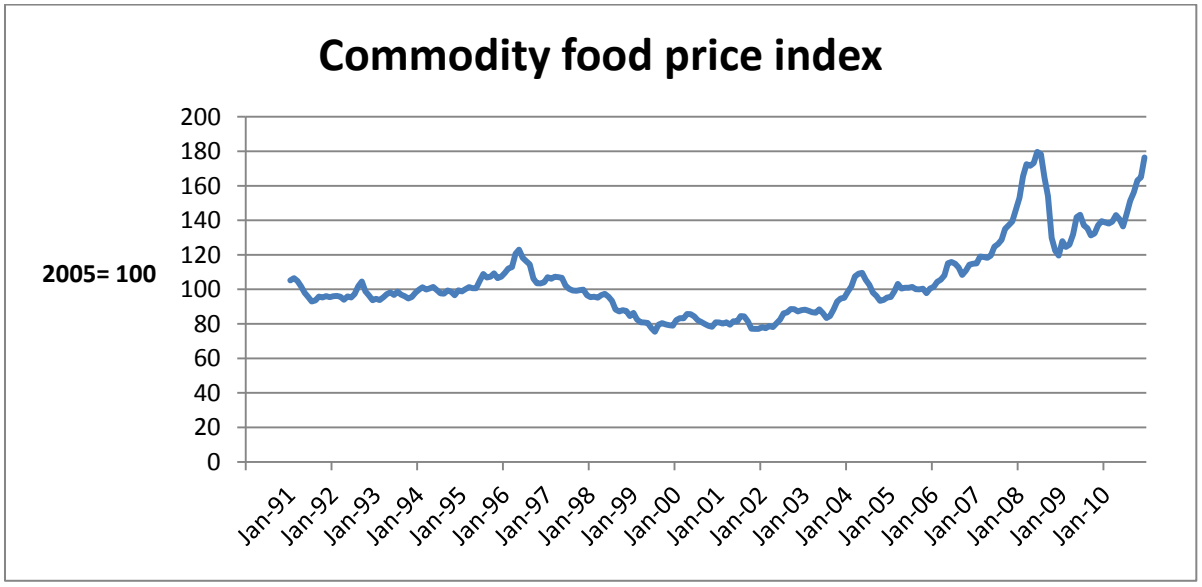


Exhibit 1.1: Commodity Food Price Index, CFPI, January 1991 - January 2011

Previous research, by Deaton and Laroque (1992), amongst others, concluded that commodity prices are very volatile. Economist disagree whether the increasing prices eventually will fall back to "normal", if they will continue to increase until the bubble breaks, or if this is a general price trend change. According to the *commodity super cycle theory* a long lasting upward trend is likely to continue in the future. Most prices are still far below historical average when adjusted for inflation. According to Heap (Fabozzi et al. 2008), a super cycle is a price boom that lasts for about 15-25 years. The boom is usually brought on by industrialization and urbanization in a major economy. By example, United States triggered such a boom in the late nineteenth century. China was in 2005 seen as the driver of this century's commodity boom. Chris Newlands quotes Simon James in the Financial Times (Newlands 2010); "I believe the super cycle arguments still remain intact". If this is true, the expectations are that commodity prices will continue to rise over the next decade. This may lead to larger returns for investors in the commodity market, which again will keep commodities interesting as an investment alternative. Boyde (2010) in Financial Times blamed increasing demand from the BRIC countries (Brazil, Russia, India and China) for the recent price increase. Felicity Smith at Bedlam Asset Management (Grene 2007) says that soft commodities have been in a bear market for 20-30 years, but could now be in a long-term upward trend. A counter argument is that commodities follow

a different trend over the business cycle than stocks do. Gorton and Rouwenhorst (2006) find that commodity returns tend to be higher during periods characterized by slow growth, low interest rate and low inflation. Today's developed markets are in a period of early expansion, which could mean that the latest years price trend is about to turn. As long as the returns from commodities are above the returns on stocks, commodities will still be interesting as an investment vehicle.

Trader's possibilities of investing in commodities have been limited by the fact that they are physical goods that need transportation and storing, and are normally traded in large quantities. For example, what will an investor do with 112,000 pounds of sugar? It is possible to store it at home, or at a warehouse. The problem is that you would have to worry about renting a place, having insurance, and more important; getting rid of it before it expires. For decades, these problems have limited individual investors' possibility of investing in commodities. Only a very small percentage (under 1%) of futures contracts actually result in delivery of the underlying asset (Fabozzi et al. 2008).

Exchange traded products developed recent years, makes it possible to gain direct exposure to commodities in a much simpler and cost efficient way. An ETF is constructed to track an underlying index but is traded like any other stock on the stock market. As this investment alternative is relatively new, historical data are only available a few years back, and is also somewhat deficient. However, this thesis will illuminate if ETFs do in fact track their underlying index, and if so, how their performance would have been, compared to the single commodities. Different performance measure methods have been calculated to evaluate the performance over the period.

ETFs simplify sector investing, making it easier and more cost efficient (annual fees are low) to focus on one sector of the market. An exchange traded fund is in some ways like a mutual fund. They are both traded on stock exchanges, meaning that information about the prices is available any time. ETFs have its net-asset value (NAV) calculated every day, and the expenses are lower than that of the average mutual fund. The ETF consists of stocks and other securities, tracking an underlying index. There exists an ETF for any sector of the market.

It is important to distinguish between actively and passively traded funds. Active traded funds use commodity stock/futures indexes as a benchmark, while passively traded funds track an index. ETFs are meant to follow but not outperform an index, which lowers risk and management fees. In this thesis, three DJ-UBS sub-indexes (DJ-UBS soft, DJ-UBS sugar and DJ-UBS wheat) have been compared to the respective index and later to the respective commodity. These indexes roll futures contracts of the underlying assets (sugar, wheat, coffee and cotton), meaning that a new establishment is opened when maturity day approaches.

The commodity and index prices are weekly prices retrieved from January 1990 until December 2010. The data has been divided into different periods for comparison. The last five years is the most important sub-period due to the development of ETFs and increased commodity prices. However, these last years may not be the most representative years due to the influence the crises. Features that have been examined are mainly risk and returns, decomposition of risk, and also normality of the data, with a subsequent counting of "fat tails". Furthermore, the data has been examined looking for trends and seasonal patterns, in addition to correlation between commodity and stock returns. According to Greer (2000), commodity indexes have negative correlation with stocks and bonds and could therefore provide valuable diversification in a portfolio. It is interesting to see what level of risk the commodities bear. If the volatility of physical commodities alone makes them "too" risky and costly to invest in, could investing in a commodity-based ETF be a better alternative?

Portfolios are created with the aim of optimizing shares to reduce risk. Calculating the beta of commodities related to a commodity index may provide useful information on how to diversify a portfolio. The results may also provide information about the decomposition of risk.

Previous work on commodity investments has given motivation to continue and expand the research. The latest year's large increase in many agricultural commodity prices along with increased interest in ETFs, made the topic even more exciting. As ETFs are relatively new investment alternatives, historical data are only available a few years back. However, if the reality is that these products do follow the underlying index, it is possible to backtrack values from the original index.

Those with an interest in the performance of alternative asset classes are, amongst other, financial planners, portfolio managers and individual investors. Hence, everyone curious about commodity investments could benefit from reading this thesis. There are also others that could be interested in reading about commodities and the volatility of their prices. For example will commodity producers normally have an interest in hedging against future unfavorable prices by taking a short position in the investment. By doing so, they pass on the risk to for instance manufacturing industries, interested in taking the opposite position, to hedge against higher future prices. While commodity producers and the manufacturing industry try to avoid susceptibility to unfavorable price development, speculators' intention is to take a distinct market position and speculate for a price change. Their main task is to provide liquidity on one hand, while balancing the long and short hedges on the other hand. They make profit by taking the risk of the others. Speculators are exposed to both large losses and large gains. For speculators, it is important to have knowledge about the market, what affects the prices and by using all available information, they take their market position. Analyses of commodity prices might also be of interest for politicians, deciding on

import/export restrictions in relation to a poor harvest season, or in general. Countries that count for a large part of a commodity's production, as Brazil does for sugar, may affect the world market prices by implying heavy export regulations.

2. The commodities analyzed

Commodities, unlike stocks, have an intrinsic value and provide utility by being real assets - primarily for consumption and not investments. The quality of commodities varies from and in between crops, while the quality of a stock always remains the same. Commodities are usually categorized as soft or hard commodities. Hard commodities are e.g. precious metals while soft commodities are normally weather-dependent, like sugar and rice. This may lead to a seasonal harvesting pattern, ultimately creating seasonal patterns in prices. It is also common to distinguish between storable and non-storable goods. Rice and sugar are easily stored, which again may smooth seasonal price patterns.

The five commodities analyzed are traded on exchanges worldwide. They are produced on different scales; sugar, corn, rice and wheat are the four most produced commodities (in metric ton) worldwide (Indexmundi.com 2011). Palm oil is produced in much smaller scale, but production in Malaysia only has increased by 250% over the past 20 year period.

Basic facts about the analyzed commodities

Sugar is produced from two plants; sugar cane and sugar beet. The sugar prices used in this thesis are the price of sugar from sugar cane which counts for about 70% of the global sugar production. Canes are produced in tropical areas mainly in Asia and South Africa. The plant belongs to the grass family, however it may look like bamboo when growing tall. Sugar cane is mainly used for sugar, alcohol and bio-fuel.

Brazil is the world's largest producer of sugar, with 37% of total world production shown in Exhibit 2.1. The total production in 2008 was 1,736,271,147 metric ton, MT. Together with Brazil; India, China, Thailand and Pakistan accounted for 72% of the global sugar production in 2008 (Faostat 2011).

Sugar prices more than doubled from January 2009 to January 2010. In January 2010 it reached the highest price since 1981. Common factors affecting the demand of sugar for consumption are income and price on alternative sweeteners (especially fructose). The sugar consumption is decreasing in developed countries, while increasing in developing countries. This is due to sugar being an important source of calories. Bio-fuel can be made out of remaining substances, therefore the increased demand for bio-fuel may not have a direct effect on the prices. The sugar crisis, caused by

poor weather and a subsequent large decrease in production around 2008/2009 had major effects on the prices.

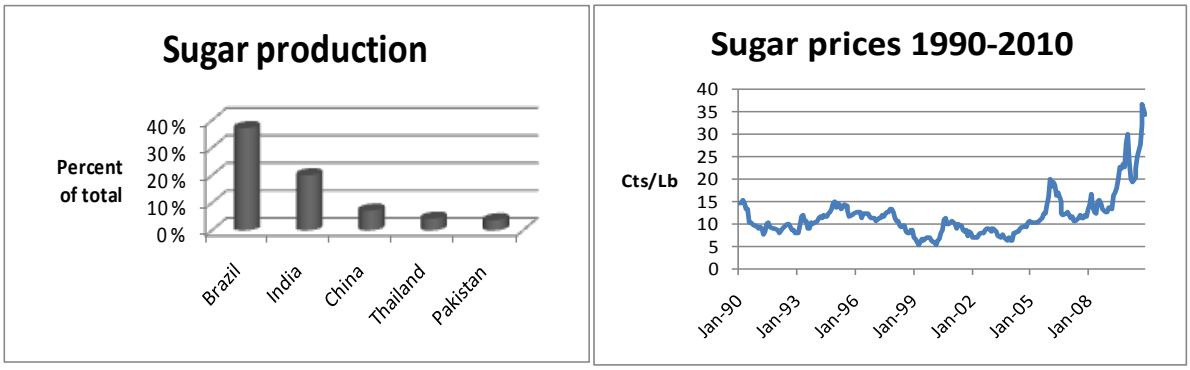


Exhibit 2.1: A: Five biggest sugar producing countries, 2008.
B: The price development of sugar the last 20 years, denoted in cents/pound. (Indexmundi.com 2011). Raw sugar is traded at, amongst others, The Ice.

Rice is a cereal grain. It is the most important staple food for a large part of the human population (Faostat 2011). Rice can be grown practically anywhere, even on steep hills or mountains. Cultivation is well suited in countries and regions with low labor costs and high rainfall, this because it is labor-intensive to cultivate and requires ample water. The rice traded on stocks is called rough rice or paddy rice.

The five biggest rice producing countries are China, India, Indonesia, Bangladesh and Vietnam shown in Exhibit 2.2. In 2008 these countries accounted for 71% of the global production, which was 685,874,696 MT. China and India alone account for 50% of global production (Faostat 2011).

The food crisis had a major influence on rice prices. From April 2007 to April 2008 the price increased by 215% (see Exhibit 2.2). The Worlds Food program reported in 2007 that 57 countries worldwide had experienced floods, at the same time that South-Asia, China, Europe and Sudan experienced draughts. Australia's rice production fell 98% from 2002-2008 because of draughts. This led farmers to grow less water-intensive products, for instance wine grapes and wheat.

Rice differs from other staple foods because almost 90% of the production is sold in domestic markets. However, an increase in foreign price, due to shortage, result in farmers selling their crops to foreign market. This, however, can result in a domestic shortage in the exporting country, further increasing the prices.

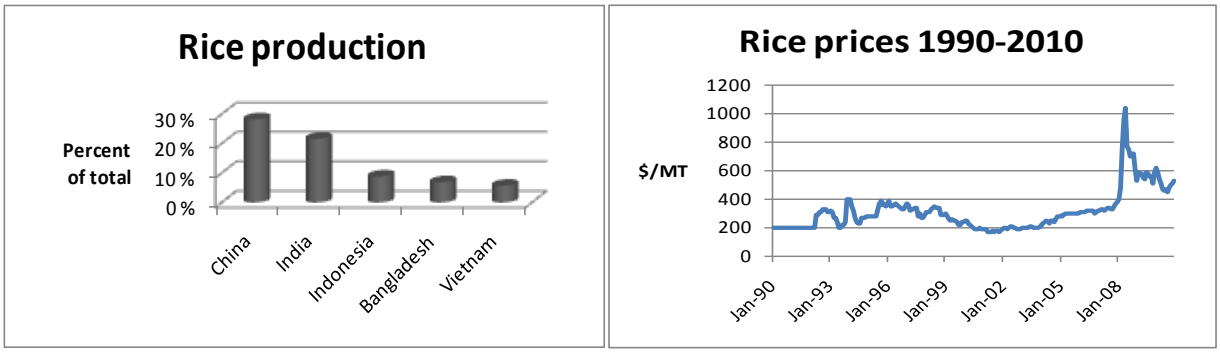


Exhibit 2.2: A: Five biggest rice-producing countries, 2008 (Faostat 2011).
B: The price development of rice the last 20 years, denoted in dollar/metric ton (Indexmundi.com 2011). Rice is traded at, amongst others, New York Mercentile Exchange (NYMEX).

Corn is the second largest produced grain worldwide. It is a one-year plant which normally reaches three meters tall, but can grow up to six meters. There are thousands of varieties of corn grown under different conditions and for different purposes.

The largest corn producing countries are USA and China shown in Exhibit 2.3. These two countries accounted 57% of the global corn production of 826,224,247 MT in 2008 (Faostat 2011). Corn is primarily used as food for human and livestock. In addition, corn is used for gasoline, glue, cooking oil, margarine and sweeteners. Dry weather conditions in the Midwest and China in 1996 in addition to the food crisis had a large impact on corn prices. Prices increased by 45% from December 2007 to December 2010. The demand for corn increased because of use in bio-fuels. The proportion of corn used for this purpose increased from 0.5% in 1980 to 11% in 2004 (Grene 2007). In February 2007, as much as 20% of the harvested corn was used for ethanol production (Herbst 2007).

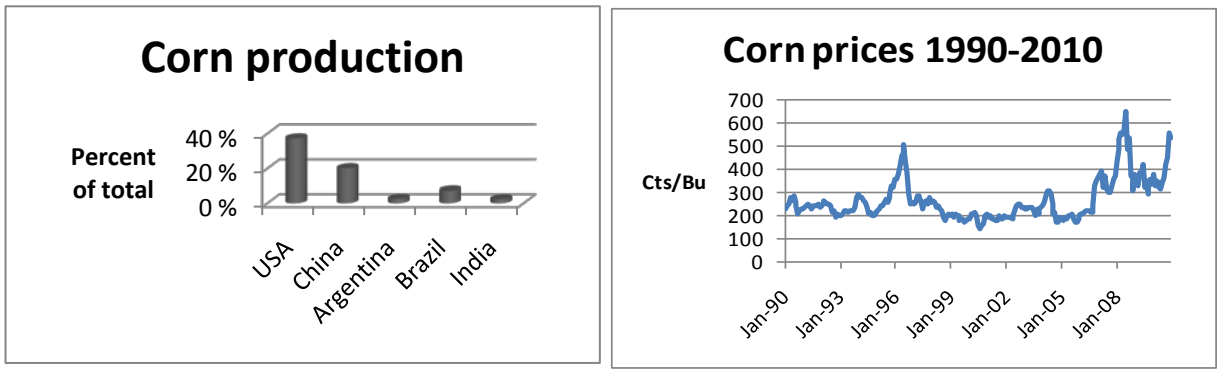


Exhibit 2.3: A: Five biggest corn-producing countries, 2008.
B: The price development of corn the last 20 years, denoted in cents/bushel. (Indexmundi.com 2011). The largest futures market is at NYMEX.

Wheat is a grass grown worldwide. It is a staple food applied to produce flour, beer, alcoholic beverages and bio-fuel. Wheat is the third most produced cereal after corn and rice, and has the leading role of supplying vegetable protein to human food (Faostat 2011). For the overall world population, wheat supplies approximately 20% of the calories.

The five largest wheat producing countries accounted in 2008 for 51% of the total world production, which was 683,406,527 MT (Faostat 2011). These five countries were China, India, USA, Russia and France, shown in Exhibit 2.4. The food crisis had a major influence on wheat prices, in addition, increased demand for corn led to farmers producing corn instead of wheat, pressing the prices further. The price increase was also affected by a period of drought on the southern hemisphere, and periods of freeze and flooding on the northern hemisphere. From April 2007 to April 2008 the price increased by 83%.

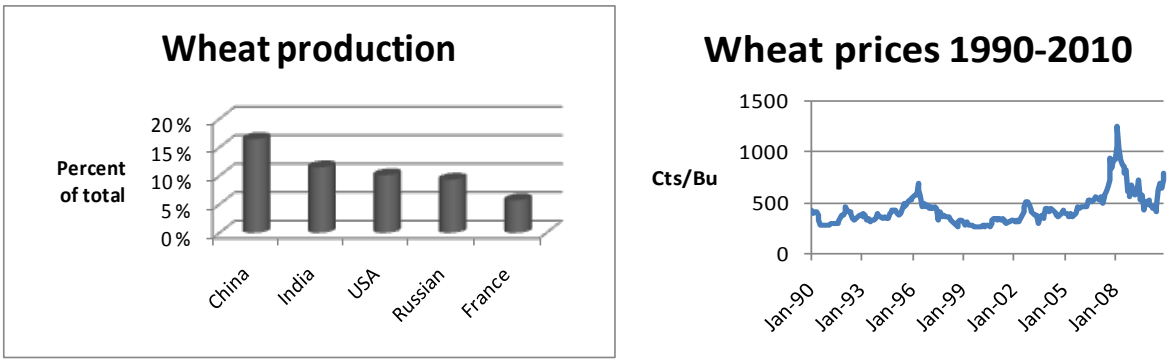


Exhibit 2.4: A: Five biggest wheat-producing countries, 2008.
B: The price development of wheat the last 20 years, denoted in cents/bushel (Indexmundi.com 2011). Futures are traded at, amongst others, NYMEX.

Palm oil is a vegetable fat extracted from the pulp of the fruits of the oil tree. It is a common cooking ingredient in Southeast Asia and the tropical belt of Africa. In addition it is used in for example soap, cosmetics and bio-fuels. The use in commercial food is increasing because of its low cost. From 1996 to 2008 the production more than doubled.

Malaysia and Indonesia are the largest palm oil producing countries. These countries alone accounted for as much as 72% of the global production shown in Exhibit 2.5, which was 48,000,000 MT in 2008 (Faostat 2011). The price variations for palm oil have been larger than for other goods. This is mainly caused by rapid growth in demand, while supply has grown more slowly. The demand for cooking oil has increased in China and India, while the Western countries have increased demand

for bio-fuel. This is in addition to the large price jump connected to the food crisis. The price increased by 184% from June 2006 until June 2008.

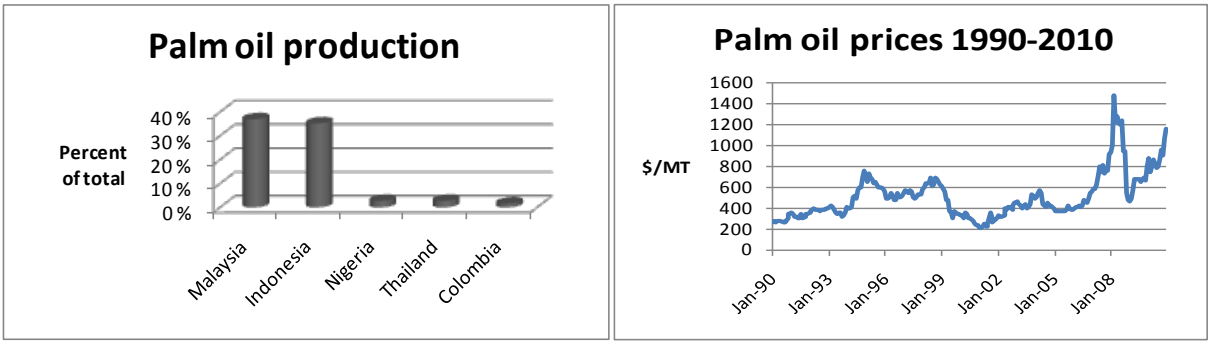


Exhibit 2.5: A: Five biggest palm oil-producing countries, 2008.
B: The price of palm oil the last 20 years, counts in dollar/metric ton (Indexmundi.com 2011). Crude palm oil is traded at, for instance, Bursa Malaysia.

Exhibit 2.6 provides a graph of relative price development for the five presented commodities. As pointed out, the weather has huge impact on the crops, and hence the prices of commodities. This is one of the largest differences of volatility between commodities and stocks. Palm oil and rice had steep peaks around 2008. The period 1995-1999 palm oil also had large volatility. The period between 2000 and 2005 is the most stable for all five commodities. This period will therefore to some extent be compared to the other periods.

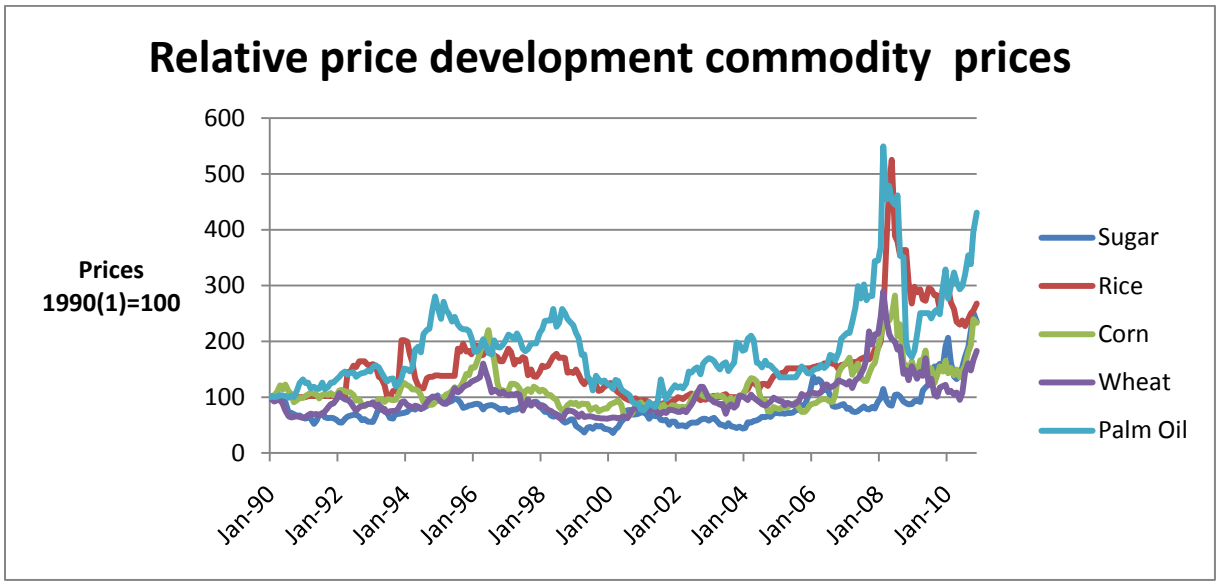


Exhibit 2.6: Relative price development for the five commodities analyzed. 1990-2010

Commodity and stock market indexes

Commodity indexes are normally used to track commodity prices and to represent a portfolio. Since commodities are extremely heterogeneous the behavior of a particular index, and a comparison of the index performance, may be very sensitive to how the index is constructed. The indexes that are applied in this study are total return indexes.

Dow Jones UBS Commodity index (DJ-UBS CI) (previously known as DJ AIG) is one of the most widely used indexes in structuring tradable commodity index products. DJ-UBS selects components based on the liquidity of the futures contract (Fabozzi et al. 2008). The futures contract rolling calendar is offered in Appendix 5.1. Rolling is implemented over a five-day period, increasing the weighting of the new contract from 0% to 20%, 40%, 60%, 80% and finally 100%. These five days are called the "hedge roll period" and begins on the fifth business day of the month the contract changes. There is no single commodity or sector dominating the index, but it rather provides a broad exposure to commodities as an asset class (djindexes.com 2010). Under this commodity index, there are several sub indexes. DJ-UBS Sugar Sub index, DJ-UBS Wheat Sub index and DJ-UBS Soft Sub index will be studied closer in this thesis. Both DJ-UBS CI and its sub's are total return indexes.

Standard & Poor Goldman Sachs Commodity Index (S&P GSCI) is a leading measure of general price movements and inflation in the world economy. It is a publicly available benchmark for investments in commodity markets, and is designed to be a "tradable" index (standardandpoors.com 2011). Global production determines the investment weights of the futures included in the index, thus the content changes over time (Ankrim & Hensel 1993). This index contains metals, energy, agricultural commodities and livestock, and the contents are reviewed on a monthly basis. The index is a total return index.

Morgan Stanley Capital International (MSCI World) is a stock market index consisting of 1,500 stocks. This index has been calculated since 1969 and is often used as a benchmark for global stock funds in developed markets. Recently, investors had the possibility of buying an ETF tracking the return of the MSCI W index, instead of the 1,500 stocks individually. MSCI World is also a total return index.

The graph in Exhibit 2.7 clarifies the difference between the indexes. Naturally, the values of the two commodity indexes, S&P GSCI and DJ-UBS CI, have higher correlations to each other than to the stock market index, MSCI World. All three indexes are characterized by stable growth the first eight to ten years. A few decreases may be seen, especially for the stock index. Furthermore, the values drop drastically around 2008.

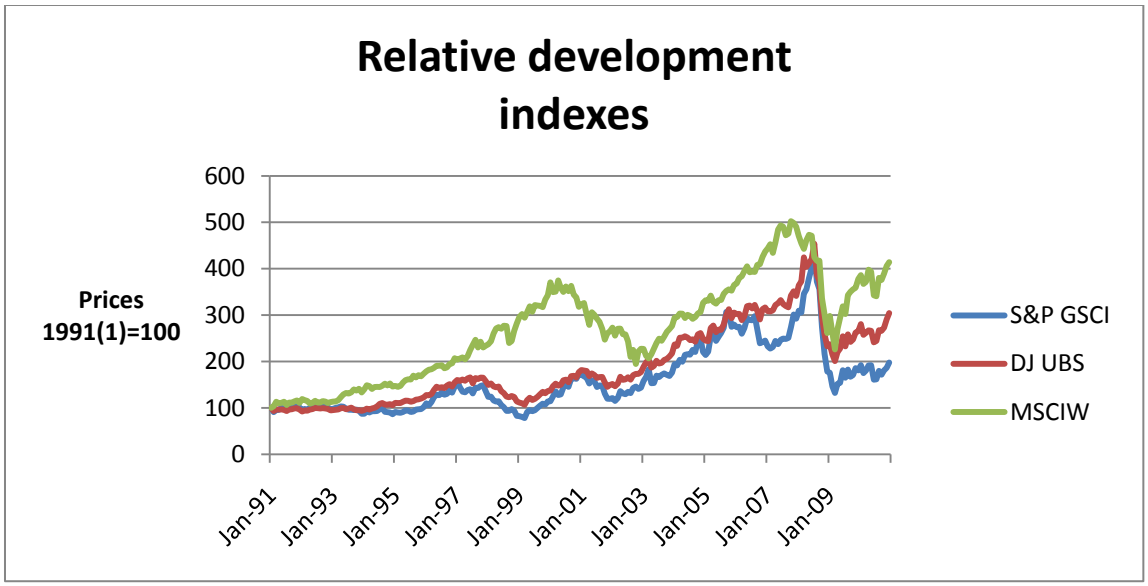


Exhibit 2.7: Relative development of three indexes, DJ-UBS CI, S&P GSCI and MSCI W. 1990-2010

3. Investment basics

The risk inherent in commodity prices is in several respects different from the risk of financial assets. The price of financial assets reflects the long term discounted value of a stream of expected future cash flows. Thus, long-term expectations and the interest rate (used to discount the cash-flows) are critical for pricing financial assets. Long term expectations and interest rates have only minimal impact on commodity prices. They may react different from financial asset prices when short-term and long-term expectations diverge. The inherent volatility in commodities is what scared many investors from investing in commodities, despite the fact that they often have low correlation with stocks and bonds, and could according to Greer (2000) provide valuable diversification in a portfolio. Most agricultural commodities are produced on a seasonal basis, and for many commodities the harvesting cycle is one year. This is a key characteristic for commodities and is therefore examined at the beginning of chapter four.

3.1 The theory of commodity pricing and risk and return factors

Unlike stock prices, commodity prices depend upon global supply and demand factors of the commodity. The supply is lead by factors like production cost, available technology and opportunity cost. Especially weather may have huge impact on agricultural commodity prices. Unfortunate weather conditions may destroy crops, and for many commodities with annual harvesting patters, it takes time to rectify the shortage. Because the production side reacts very sluggishly to market distortions, short term supply and demand shocks are compensated for by price movements. Import and export restrictions from leading producer and consumer countries also have impact on supply. In hard times with poor harvest projections, countries tend to tighten trade policies. This may be done by imposing export restrictions, which ultimately creates shortage and larger increase in price worldwide.

The demand is lead by factors like income and availability and price of substitutes. The size of a change in demand caused by a price change is determined by the elasticity. Foods often have low, negative demand elasticity, as they are an important source of nutrition and necessary for surviving unlike many other goods. However, demand elasticity for more luxurious goods is often higher than for example grains. Income elasticity is normally positive, but when the income reaches a certain

level, cheap food like grains and rice is often replaced by meat and vegetables. The supply elasticity is close to perfectly inelastic because crops have already been planted, making quantity constant.

Price determining factors are the U.S. dollar exchange rate, as many commodities are denominated in dollars. A fall in the value of the dollar tends to cause higher commodity prices. Thus, in addition to market risk, investors of commodities face exchange rate risk. A decrease in the value of the dollar reduces the returns for foreign suppliers, while raising the purchasing power and thereby the demand from foreign consumers (Akram 2008). The price of renewable resources, like agricultural commodities, also depends on estimated future production cost.

Long-term returns on commodities have not been exceptional. However, unlike stock-investments, speculators and investors in commodities may earn returns for bearing short term risk. By bearing risk for producers and consumers they receive exposure to the hedgers' short term earnings instead of its long-term cash flow. Producers of commodities want to hedge against lower future prices on their crops, while consumers want to hedge against higher future prices on the goods. Research by Morningstar (2011) has shown that for most investors, direct commodity exposure should be very limited and diversified among energy, agricultural and industrial products and precious metals. However, positions in physical commodities involve large transaction costs and because of this many investors use more liquid alternatives, such as commodity futures (Kolb & Overdahl 2010).

3.2 Market structure and investing in commodity futures

Investing in commodity futures contracts is a well known way to gain exposure to commodities without physically buying them. These contracts do not give direct exposure to the commodity, but rather represent a bet on its future spot price. Therefore returns from investments in commodity futures are not similar to the returns from investing physically. Since most ETFs *roll* futures contracts. The following section will address the structure of the futures market.

When investing in futures, it is the risk premium i.e. the difference between the *current* future price and the *expected* future spot price that benefits the futures investor. An investor will on average earn money when the futures price is set below the *expected* future spot price. That is, if the spot price at maturity turns out to be higher than expected when buying the contract. If the opposite happens, the *seller* of futures will earn money. Movements in the futures price do not provide profits to the investor because price trends, like seasonal patterns, are taken into account when set. Deviations from the expected future spot price are probable, but are also by definition

unpredictable(Gorton & Rouwenhorst 2006). Over time these should average out to zero, unless the investor has an ability to time the market correctly.

Gorton and Rouwenhorst (2006) explain Keynes' theory of normal backwardation, that it is the buyer that should receive the risk premium, because producers seek to hedge price risk for their production (the value of their output). Speculators take the opposite position, providing them insurance. For this, they demand a risk premium. This is one of the major differences between futures investments in commodities and stock investments. On the other hand, Working promoted the idea that the function of a futures market is determining returns for storage services. These two theories are considered the most important contribution to the understanding of price spreads in the futures market (Carter 2007).

Over time, as maturity closes in, the futures price approaches the spot price of the commodity, partly due to storage cost decreasing. At maturity, the two prices will be equal. If the futures price was initially set below the *expected* future spot price, the future price will gradually increase over time, rewarding the long position (see Exhibit 3.1).

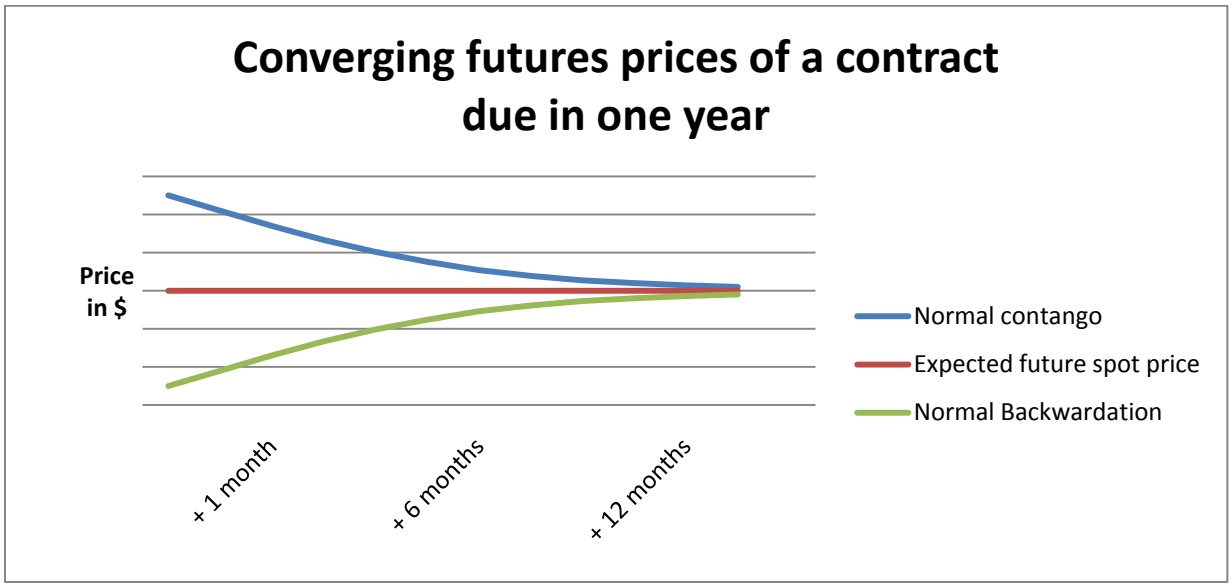


Exhibit 3.1: A graphical illustration of the futures price approaching the spot price at maturity. A market in normal backwardation rewards the buyer according to Keynes theory of normal backwardation

The term backwardation (often confused with normal backwardation) describes the position of futures prices in relation to *current* spot prices. A commodity is backwardated if the price for future delivery is below the price in the spot market. Sugar, for example, was (per 24.03.11) in a

backwardated market. Its futures curve is illustrated in Exhibit 3.2. If delivery of the commodity is undesired, investors must *roll* the contracts, meaning that the contract is replaced by a new (with longer holding period) as the old approaches maturity. This may cause a roll return, either positive or negative depending on the structure of the market. If the market is backwardated at the moment of Hence, this return is inherent in ETF values.

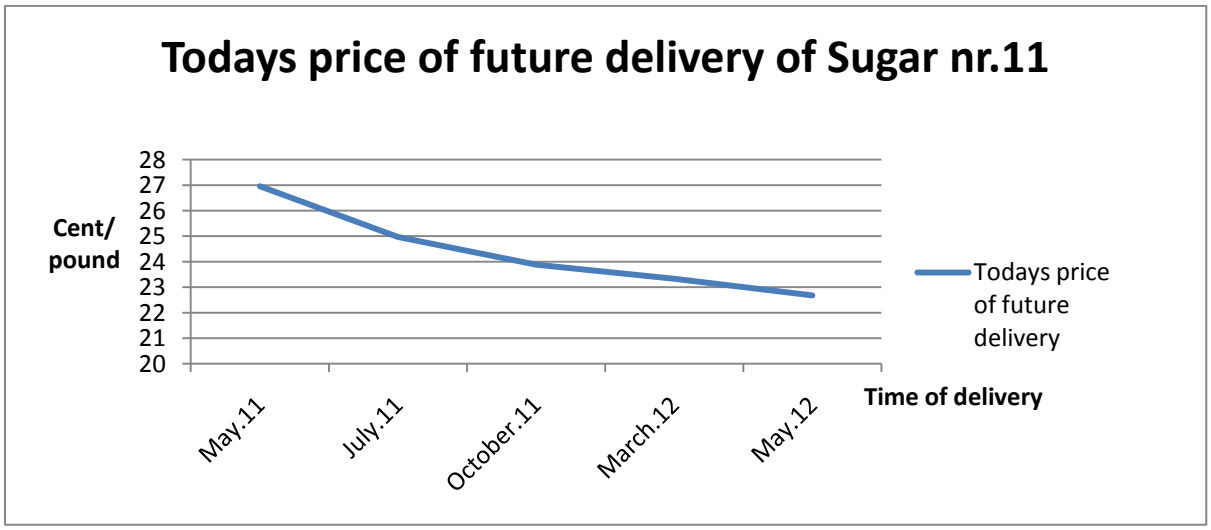


Exhibit 3.2: Sugar was per 24.03.2011 in a backwardated market. The present days price of buying a sugar futures contract is lower the further away the maturity is. The difference between the futures price and the current spot price is called basis.

The size of the backwardation is different amongst commodities. Backwardation often occurs when there has been shortage for a commodity that is expected to normalize in near future. In general, backwardation is highest for very volatile commodities where producers are sensitive to price fluctuations, and when it is costly to hold inventories (Ankrim & Hensel 1993).

The opposite of a market in (normal) backwardation is a market in (normal) contango. Research done by Gorton and Rouwenhorst (2004) conclude that there does not seem to be any systematic relationship between the two market forms, not surprisingly as it should not be possible to make profits on the basis of public information.

3.3 The pricing of commodities and commodity futures

The pricing dynamics of spot and futures prices are similar between financial and real assets. However, because an actual transaction and consumption of the goods will take place, there are factors in addition to supply and demand that cause the futures price to change. These factors are, amongst others storage cost, cost of carry, production trends and usage along with future expectations (Morningstar 2011). In addition there are benefits from owning the physical commodity that is not obtained by owning a futures contract, referred to as the convenience yield (Fabozzi et al. 2008).

An important reason for holding inventories is seasonal changes either in demand or supply. Most agricultural commodities have stable demand, while harvest is annual or in some other way seasonal. Storage makes it possible to distribute the goods throughout the year. Keeping storage is one of the major decisions producers and processors make, as it involves risk of price changes. However, the benefits of being able to keep production going might be higher than the cost of holding inventories. The convenience yield tends to be high for the commodities that are difficult to store, due to low inventories. However, the convenience yield is suggested to be a decreasing function of the level of inventory. For a producer to be willing to produce for inventories, the futures price must be higher than the spot price, and high enough to cover the cost of storage. These costs are for instance, warehouse cost, storage, insurance and spoilage. Spoilage costs are more relevant for agricultural commodities than for instance precious metals.

The theory of price of storage developed by Working (Carter 2007) focuses on the role that inventories play in the determination of futures prices. The theory splits the difference between spot and futures prices into the foregone interest of buying and storing the commodity, and the convenience yield of the inventory (Georgiev 2001). The equilibrium spot and futures price is according to Working's theory is when:

$$F_{t,T} = S_t(1+r_{t,T}) + w_{t,T} + CY_{t,T}$$

Where

$F_{t,T}$ = the price of a futures contract at time $_t$ with maturity $_T$.

S_t = the spot price at time $_t$

$r_{t,T}$ = the capital cost (opportunity cost of tying up funds in inventories.

$W_{t,T}$ = total cost of carry from time $_t$ to $_T$

$CY_{t,T}$ = the convenience yield from time $_t$ to $_T$

If $F_{t,T} > S_t(1+r_{t,T}) + w_{t,T} + CY_{t,T}$, then theory suggest that an arbitrage opportunity have occurred, for a merchant to buy and hold inventories. Conversely if $F_{t,T} < S_t(1+r_{t,T}) + w_{t,T} + CY_{t,T}$, the futures price contains an implicit convenience yield (Carter 2007). In this thesis, returns are as previously mentioned defined as the change in spot prices, and therefore the cost regarding storage is not considered. It is expected that this have affected the findings.

4. Empirical analyses of risk and return in commodity markets

In a previous study, Grilli and Yang (1988) examined relative prices of all non-fuel primary commodities in the period 1900-1986. They found that the prices fell on trend by 0.6% per annum. In addition, Cashin and McDermott (2002) found a decrease of one percent per annum in commodity prices over the period 1862-1999. In the same analysis they found that the frequency of large fluctuations increased after the early 1970's.

Chasin, McDermott and Scott (1999) presented four key findings in a working paper, analyzing monthly data for a variety of commodities from 1957 to 1999. The first finding proved that price booms are shorter than slumps for most commodities. They define a boom as the period from a through to a peak, and a slump as the opposite. Secondly, the scale of the price falls in a slump is slightly larger than increase in price in the subsequent boom. Thirdly, they found little evidence of consistency in commodity price cycle-shapes. Finally, the time spent in a slump or a boom does not affect the probability of the end. They also emphasize that these cyclical behaviors are key characteristics of commodities.

Expected commodity returns tend to be higher during periods characterized by slow growth, recession, low interest rates and low inflation, at times where stock returns are usually low (Gorton & Rouwenhorst 2006). Conversely commodity returns are low during economic expansion, when stocks have their best performance (Bjornson & Carter 1997). Developed countries are in this situation today, indicating that the commodity price increase seen the latest years might be turning.

Chasin, Liang and McDermott (2000) examined monthly prices for 60 commodities in period 1957-1998. They found that shocks in prices typically are long-lasting. For most commodities almost half the effect of the shock disappeared after five years. A wide confidence interval around the median indicates high variation in the length of price shocks. Upper movements in prices are generally shorter than downward trends.

4.1 Basic facts on the commodities

The commodity prices in this thesis are obtained from Reuters.com and New York Stock Exchange (NYSE). The weekly spot prices range from January 1990 to December 2010. This period is referred to as the total period. The 20 year period of data makes it possible to generalize the findings. However,

Elton, Gruber and Rentzler (1987) use an annual holding period as the most relevant for investments purposes. The period is for most analyzes divided into two different time periods. The first sub-period is 1990-2005, and the second sub-period is 2006-2010. The period between 2000 and 2005 was the most stabile period of the commodity prices and will also to some extent be examined. The prices of rice were slightly incomplete in between 1990-1992; this may have had a small impact on the results, but is assumed not to have an effect on the overall conclusions. MSCI World stock market index has been used to compare the results from commodities with investments in stocks, as a more traditional investment strategy. Roll (1978) states that such an investment may not represent a correct picture, as it contains a larger number of assets than a traditional portfolio. However, Dusak (1973) amongst others, used this method and it is therefore assumed to be representative.

Rice and palm oil are denoted in US$ per metric ton, sugar in US cents per pound, while corn and wheat in cents per bushel.

Returns are defined as percentage price changes. The return for a period is measured by a ratio between the price at the beginning and at the end of a period. Below is the formula for calculating discrete- and logarithmic returns.

$$Discrete\ returns = \frac{P_t - P_{t-1}}{P_{t-1}}$$

$$Logaritmic\ returns = ln\frac{\mathrm{P_t}}{\mathrm{P_{t-1}}}$$

P_t = price at time $_t$

Discrete change measures simple returns over the period while logarithmic change takes the natural logarithm of the ratio to measure the continuous interest rate on the investment. It is common to assume that logarithmic returns are normally distributed for financial assets. The same cannot be said about discrete returns. Hence, logarithmic returns will be calculated throughout this thesis. Logarithmic calculations are additive, meaning that monthly returns may be added to find annual returns. Logarithmic mean returns do, however, provide lower means than discrete returns. Additionally, since the price volatility has been high, looking at the average may give an inaccurate picture of the period since peaks and troughs are evened out. When looking at different performance measurements, discrete returns are used. Trading, amongst other expenses, in connection with the purchase of physical commodities is excluded from the analysis, and prices are not adjusted for

inflation. The results therefore offer the maximum theoretical return an investor could receive over the period.

Risk free rate

The risk free rate displays the return an investor may receive without taking any risk. US$ LIBOR, London Interbank Offered Rate (corp.bankofamerica.com 2011) is the average interest rate in American dollars that banks use on loans from each other. In this thesis weekly three months maturity US$ LIBOR was employed as the risk free alternative. An alternative could be daily rates up to twelve months maturity or different currencies. LIBOR is determined by supply and demand of the currency and is the base rate when banks are setting the level of their savings, mortgages and loan interest rates (global-rates.com 2011).

4.2 Seasonal patterns in agricultural commodity spot prices

Characteristics making commodities different from financial assets is seasonality. This is especially true for agricultural commodities with seasonal harvesting pattern. Changes caused by these regularities do not offer arbitrage possibilities, but are still important to identify due to their impact on general calculations like annual returns. Seasonal patterns in the data may create certain econometric challenges to the analyses. Contrary, many commodities are storable, which might stabilize the prices throughout the year. Also, when annually harvested commodities are grown on both the northern and the southern hemisphere seasonal patterns are weakened. Futures prices are not affected by seasonal patterns in the same manner, as predictable fluctuations are already taken into account when prices are set (Gorton & Rouwenhorst 2006).

Because of the impact on general calculations, the following sections examines whether there are any patterns in the five commodities. The price on the first Monday every month has been employed to calculate monthly returns. The following estimated model is used to detect patterns, by searching for months with significantly higher or lower returns than the average return of that year. Dummy variable represent and registers values each month (Gujarati & Porter 2009).

$$r_t - \bar{r} = \alpha r D_{Jan} + \alpha r D_{Feb} + \alpha r D_{Mar} + \alpha r D_{Apr} + \alpha r D_{May} + \alpha r D_{Jun}$$

$$+ \alpha r D_{Jul} + \alpha r D_{Aug} + \alpha r D_{Sept} + \alpha r D_{Oct} + \alpha r D_{Nov} + \alpha r D_{Dec} + \varepsilon_t$$

Where

r_t = the returns at time $_t$

D_j= dummy variable for month $_j$, where $_j$ = Jan, Feb, …, Dec. The variable takes the value of 1 in month $_j$ and 0 otherwise.

The results from the regressions are summarized in the Exhibit 4.1.

	January	February	March	April	May	June
Sugar	0.01	-0.02	0.01	-0.01	-0.02	0.02
	(0.75)	(-0.96)	(0.55)	(-0.74)	(-0.99)	(1.34)
Rice	0.01	0.03	-0.01	-0.01	0.02	0.00
	(0.49)	(1.65)	(-0.3)	(-0.67)	(0.98)	(0.05)
Corn	0.04	0.01	0.03	0.01	0.01	0.00
	(1.87)	(0.40)	(1.53)	(0.53)	(0.69)	(-0.24)
Wheat	0.00	-0.01	-0.01	-0.01	0.00	0.00
	(0.01)	(-0.68)	(-0.42)	(-0.71)	(-0.04)	(0.24)
Palm oil	0.00	-0.01	*0.04	0.00	0.01	-0.03
	(0.20)	(-0.68)	(2.24)	(0.21)	(0.74)	(-1.34)

July	August	September	October	November	December
*0.04	0.01	-0.02	-0.01	0.01	0.02
(2.18)	(0.38)	(-1.08)	(-0.30)	(0.30)	(0.84)
-0.01	0.00	0.00	0.00	-0.01	*0.04
(-0.71)	(-0.05)	(-0.11)	(0.09)	(-0.71)	(2.06)
*-0.04	*-0.04	0.01	*-0.05	*0.06	0.02
(-2.26)	(-2.22)	(0.47)	(-2.87)	(3.20)	(1.14)
*-0.06	0.01	0.03	0.02	0.03	0.02
(-3.28)	(0.47)	(1.79)	(1.10)	(1.91)	(1.20)
-0.02	0.02	0.01	-0.02	0.01	0.04
(-0.93)	(1.16)	(0.57)	(-1.23)	(0.68)	(1.93)

Exhibit 4.1: Seasonal patterns, monthly data 1990-2010. Coefficients with t-values in parentheses * indicates significant values at a 5% level.

Spot prices are according to Fama and French (1987) at their lowest during, and just after harvest, before they increase until the next. For annually harvested commodities, e.g. corn and wheat, one significant high,- and one significant low value is predicted during one year. This, however, turned out not to be the case in the analyses from the selected data set. Analyzing the monthly returns showed that corn had four significant values, one of them being positive. The same accounts for the

first sub-period. Wheat had only one significant negative value, in July. The negative values for corn and wheat were, as expected, found in the months of harvest. An investor aware of this would buy after harvest and sell just before harvest. The effects of this will be examined further in the analyses by excluding the returns from July, August and September. The results will be compared to 12 months calculations.

The monthly deviations from mean averages for the total period are illustrated in Exhibit 4.2 and 4.3, in order to emphasize the findings. The horizontal lines represent each month's average. Corn has several low values in July, but also in August and October, in addition to several positive values in November. July is the only significant (negative) value for wheat. September and November also yielded high values, which are significant at a 10% level.

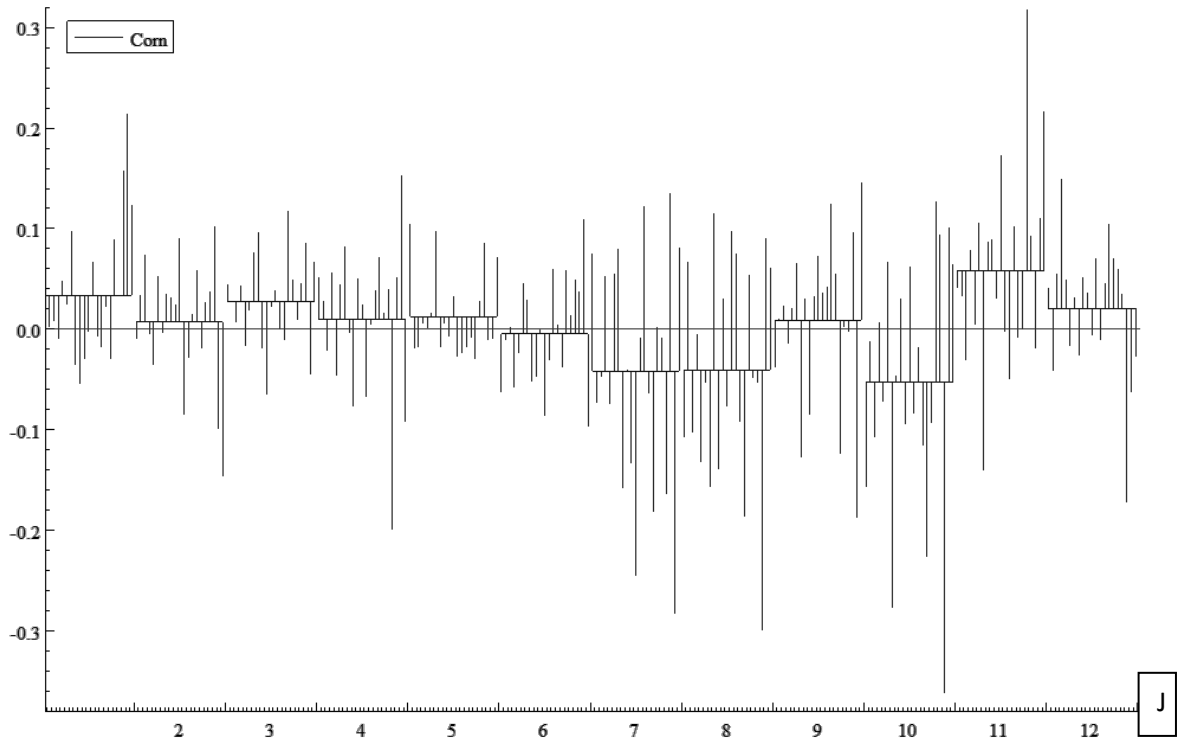


Exhibit 4.2: Monthly deviations from mean averages for corn, 1990-2010. . The horizontal lines represent each month's average. Period j shows r_j-r_{j-12} each year, and j= Jan, Feb, …, Dec

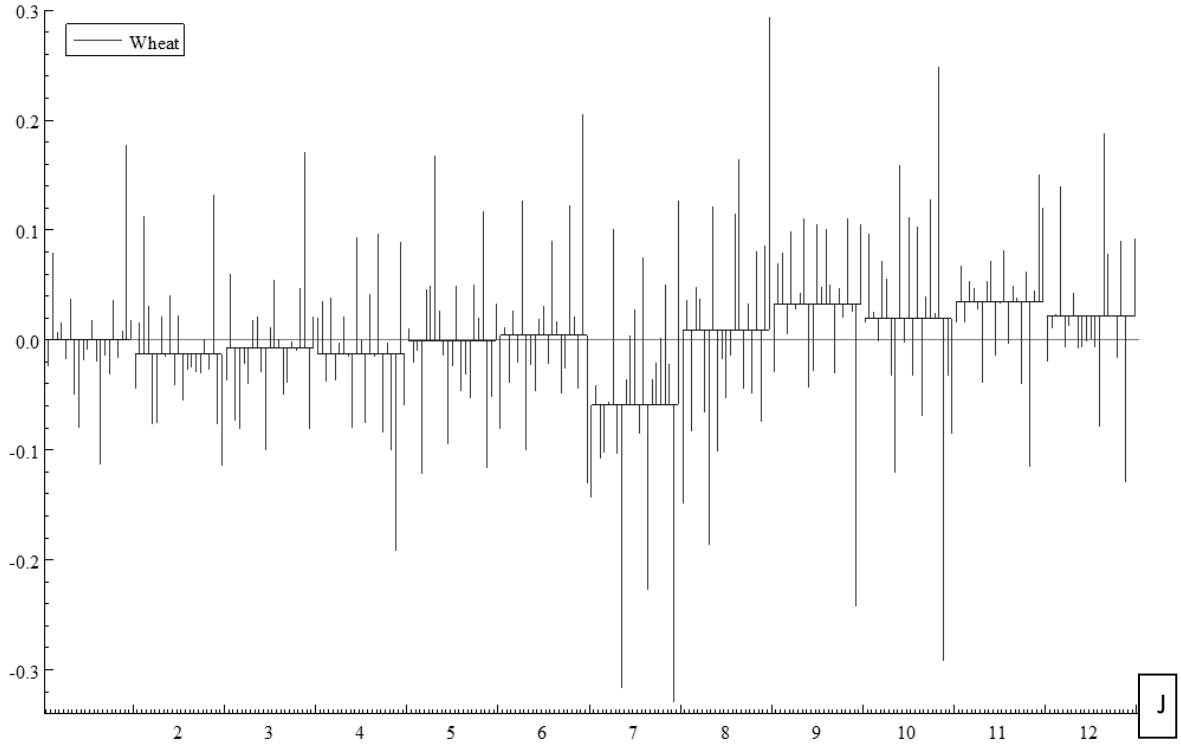


Exhibit 4.3: Monthly deviations from mean averages for wheat, 1990-2010. The horizontal lines represent each month's average. Period j shows r_j-r_{j-12} each year, and j= Jan, Feb, …, Dec

Sugar, rice and palm oil display positive significant values only. Brazil is the country producing the largest quantity of sugar worldwide. Due to production on other continents, no obvious seasonal pattern occurred. India, China and Thailand account for almost the same volume as Brazil alone. Due to spread production, 85% of harvest of sugar takes place during the period from Mai to November. Rice is produced mainly in Asia, however harvested every three to six months, therefore no annual pattern is expected. Sugar and rice are easy to store, and it is assumed that this has a depressant effect on seasonal patterns. Palm oil is mainly harvested between February and June, making significantly higher return in March, inconsistent with theory. The sub-periods show different results of seasonal patterns, however, these periods were not as predicted (see Appendix 4.1 and 4.2). Because of little consistency in the results, the data for the three commodities have not been smoothened for seasonal patterns.

4.3 Stylized facts on spot prices and price changes

The following section examines stylized facts of the commodity prices, compared to MSCI W on a total return basis. Exhibit 4.4 shows the wide range of prices during the period. The mean prices are, almost without exception, much closer to the minimum price than the maximum price. For the last sub-period (Appendix 4.4) all of the commodities seemed to have both higher mean price and higher standard deviations than the first sub-period (Appendix 4.3), in addition to the total period. These results, however, do not give a good basis of cross-comparison due to denotation differences.

The variation coefficient of the data (standard deviation / mean), allows comparing of risk and returns despite different scales. The variation coefficient is a measure of volatility per unit price. From calculations showed in Exhibit 4.4, rice is the investment alternative with the highest percentage risk of the average price. The commodities had higher coefficients during the first sub-period than the second. A decrease in the coefficient indicates that the risk has increased less than returns.

	Mean prices	Standard deviation	Variation coefficient	Minimum	Maximum
Sugar Cts/lb	11.7	4.7	0.41	5.0	39.1
Rice $/mt	310.3	136.0	0.44	168.0	1040.0
Corn Cts/bu	266.2	88.9	0.33	145.5	680.5
Wheat Cts/bu	435.4	155.5	0.36	243.0	1247.0
Palm oil $/mt	501.0	210.7	0.42	190.0	1470.0
MSCI W $	2638.1	1099.2	0.42	916.3	5133.8

Exhibit 4.4: Descriptive statistics for the commodities and MSCI W, real prices, 1990-2010.

Exhibit 4.5 presents a basic summary of annual returns and risk. Palm oil had the highest annual return with 7%, while wheat had the lowest with 3%. After excluding seasonal patterns, wheat yielded only 1% annual returns, with 5% lower risk. This may provide a more accurate picture of an investor's actual return. The annual mean return for corn was 15% after smoothing, while only 4% then accounted for the whole year. Annual risk-free rate in this period was in average 4.4%. Sugar had returns relatively close to the risk-free rate with 4%, however, the standard deviation was 31% and far from a risk-free investment. Sugar also stands out as the asset with the most years of negative returns.

MSCI W had the lowest number of years with negative returns, with only five out of total, in addition to having the lowest standard deviation. None of the returns were significantly different from zero, except for smoothed values for corn, in compliance to research by for instance Bjornson and Carter (1997).

	Annual mean returns	Annual standard dev.	Years with negative returns	Smoothed Annual mean returns	Smoothed Annual standard dev.
Sugar	*0.042 (4.45)	0.314	11	-	-
Rice	*0.049 (6.34)	0.256	6	-	-
Corn	*0.042 (4.95)	0.283	7	*0.150 (3.21)	0.213
Wheat	*0.029 (3.38)	0.279	8	0.008 (0.16)	0.234
Palm oil	*0.071 (8.07)	0.289	7	-	-
MSCI W	*0.060 (11.55)	0.172	5	-	-

Exhibit 4.5: Descriptive statistics, for the commodities and MSCI W, logarithmic changes. 1990-2010
T-values in parentheses, * indicates that annual mean returns are significantly different from zero at a 5% level
Corn and wheat are smoothed for seasonal patterns.

Means and standard deviations vary across the investment alternatives. The two sub-periods had major differences in mean returns and standard deviations (Appendix 4.5 and 4.6). During the first sub-period, the annual returns for the commodities range from 2.6% for rice to -1.2% for corn. However, after smoothing the data for seasonal patterns corn yielded an annual return of 10.6%. During the second sub-period, corn and palm oil provided the highest return amongst the commodities with 22%, followed by sugar with 17%. Again, after smoothing the corn offered 29% return. The standard deviations were also high for all commodities during the period. For instance the standard deviation of palm oil was 29% during the total period, but increased to 42% for the sub-period 2006-2010. Rice was the commodity with the lowest standard deviation in both periods.

The more stable period between 2000 and 2005 holds quite different figures of risk and returns than the periods presented above. These are presented in Exhibit 4.6. The returns range from zero from MSCI W to 15.3% for sugar, almost as high as the period 2006-2010. The risk was similar to the total period, except for rice with a slightly lower return for half the risk. After smoothing for seasonal patterns, the return for corn doubled, while wheat remained at the same level.

	Annual mean returns	Annual standard dev.	Annual mean returns smoothed	Annual standard dev. smoothed
Sugar	*0.153 (8.86)	0.305	-	-
Rice	*0.037 (4.99)	0.132	-	-
Corn	0.005 (0.33)	0.260	0.012 (0.64)	0.280
Wheat	*0.088 (6.00)	0.259	*0.090 (5.08)	0.270
Palm oil	0.023 (1.60)	0.258	-	-
MSCI W	-0.001 (-0.07)	0.157	-	-

Exhibit 4.6: Descriptive statistics for the commodities and MSCI W, logarithmic changes, 2000-2005.
T-values in parentheses, * indicates significant difference from zero at a 5% level.

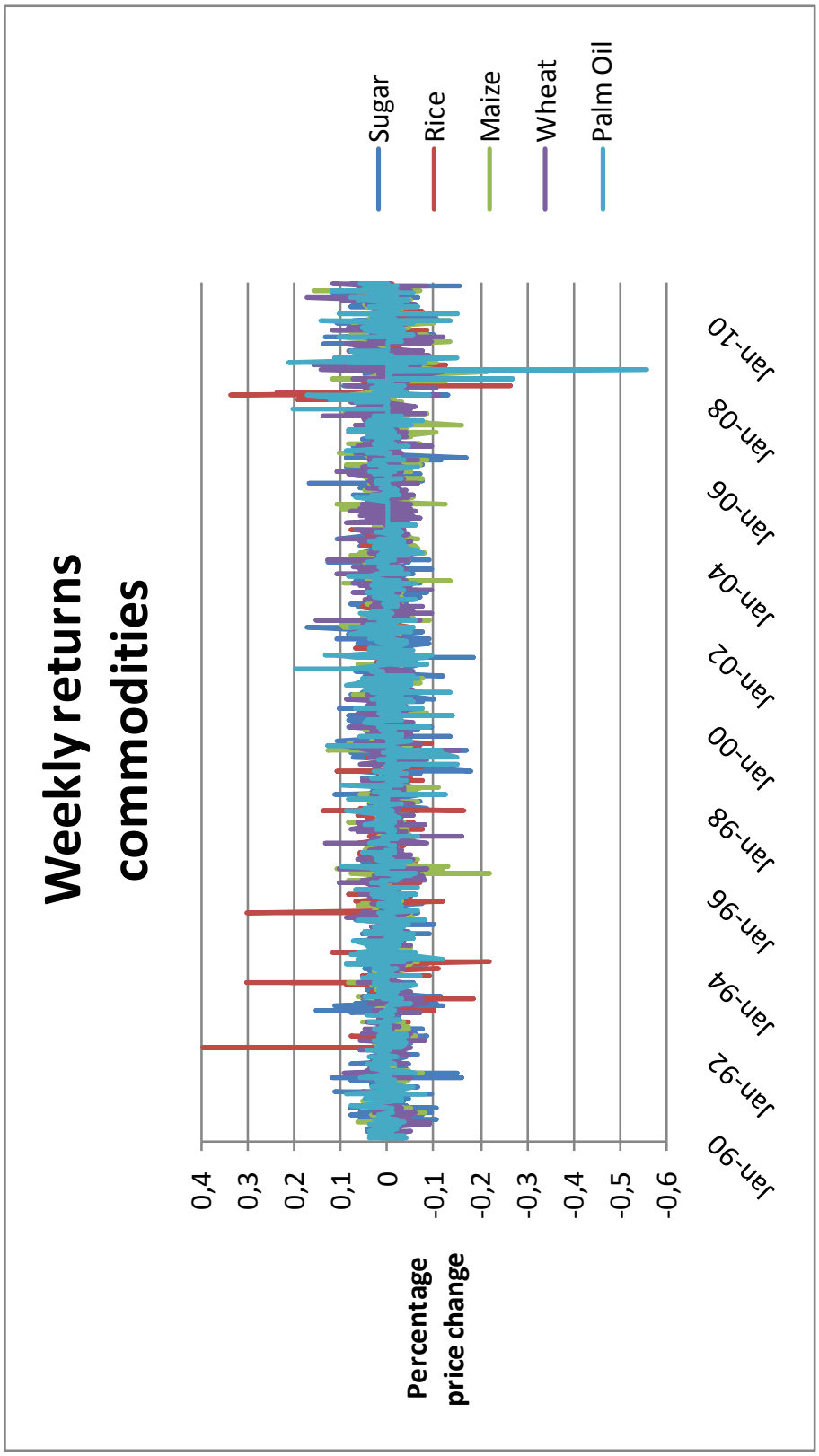
Despite the fact that the second sub-period seemed to yield higher returns than the first sub-period, only corn had significantly different returns, shown in Exhibit 4.7. Palm oil was the only commodity where the variance was significantly higher during the last sub-period than the first sub-period, as the returns increased more than risk (see Appendix 4.7 for calculations). All commodity variances were significantly different from each other and from the stock market index except for corn and wheat (see Appendix 4.8). Palm oil excels for having larger variance than all commodities except sugar. Sugar had significantly higher variance than all other investment alternatives.

	Annual mean returns			
	1990-2005	2006-2010	Smoothed 1990-2005	Smoothed 2006-2010
Sugar	0.004	0.165	-	-
		(1.47)		
Rice	0.026	0.123	-	-
		(1.03)		
Corn	-0.012	*0.218	0.106	0.309
		(2.09)		(1.02)
Wheat	0.002	0.112	-0.014	0.308
		(1.03)		(0.49)
Palm oil	0.022	0.225	-	-
		(1.72)		
MSCI W	0.070	0.028	-	-
		(-0.62)		

Exhibit 4.7: Descriptive statistics for the commodities and MSCI W, logarithmic changes.
T-values in parentheses, *indicates significant higher annual mean return the second sub-period then the first sub-period, at a 5% level.

Price fluctuations

Exhibit 4.8 visualizes the weekly return fluctuations over the period 1990-2010, to provide a more accurate picture of changes in return. For all five commodities, most observations are found within +/-1% weekly returns (53% annually). The average of the commodities overall was 0.6% returns per week. The peaks at the beginning of the period are related to rice. These three peaks affected the monthly means in the first sub-period, reducing it by 177% on average. Large fluctuations are visible towards the end of the period, especially for palm oil. Excluding the largest loss in 2008, increased the average monthly return of 38%. The weather conditions were also a factor affecting the commodity prices. Unstable weather such as heavy rain, drought or cold weather may affect the productions, and destroy yields. Fluctuations in U.S. currency affect the prices of both producers and importers.



4.8: Weekly returns, commodity data from 1990-2010

Due to the large variation in returns, moving average return of 30 months for all commodities are illustrated in Exhibit 4.9. The graph gives a better image of actual returns over the 20 year period. Extreme values are evened out, showing the more general price movements. Most observations range within +/- 26% annual returns, on average 0.5% weekly which is closer to the actual mean return. In the periods from 1998-2000 and 2007-2009 most commodities provided returns of respectively -1% weekly and +1% weekly (53% annually). The mean of real prices are affected by every price observed during the period. As demonstrated in the price graphs in chapter two, all commodities experienced ups and downs. What seems to be true for all five commodities was a rapid growth from spring 2007.

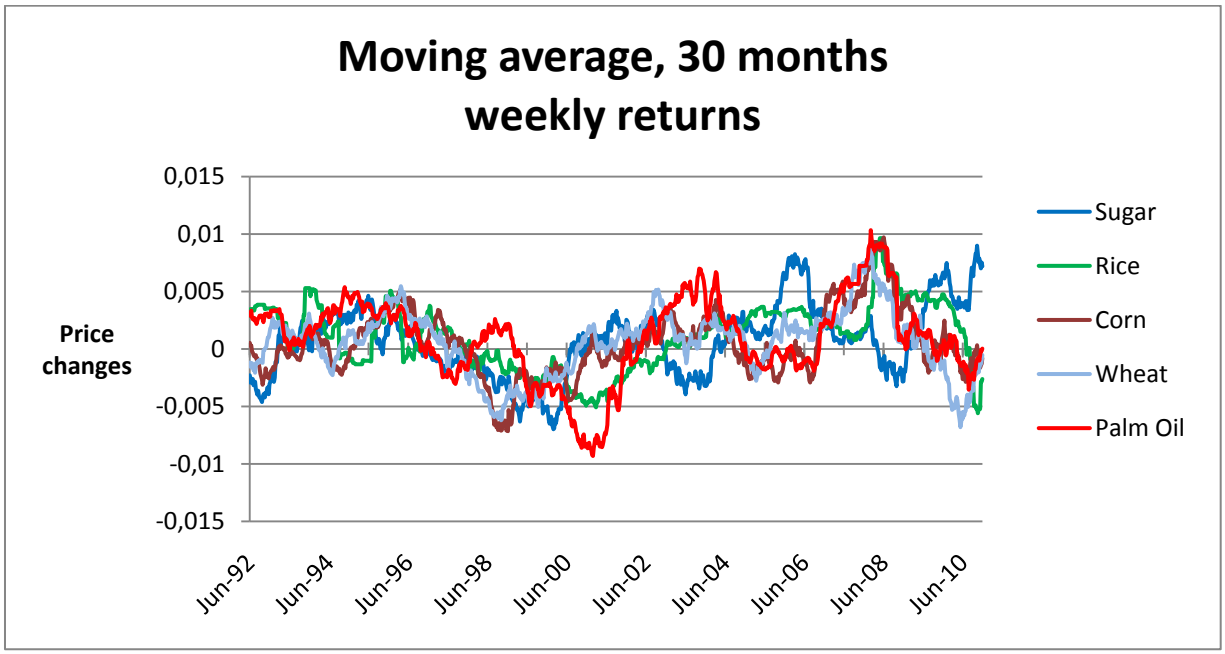


Exhibit 4.9: 30 month moving average for the five commodities, 1990-2010

4.4 Return distributions

The analyses conducted in this thesis require that data are normally distributed. Jarque-Bera, JB, is a "goodness of fit" test, measuring departure from normality. JB has an asymptotic chi^2 distribution, where H_0 represents normal distribution. The null-hypothesis is a joint hypothesis of skewness and excess kurtosis being zero (Gujarati & Porter 2009).

Calculating the JB-value resulted in rejection of all null-hypothesis, as values for Chi^2 were higher than critical (5.99). Corn and wheat were not normally distributed after smoothing of seasonal patterns.

Commodities often have skewness and "fat tails". Therefore the results were as expected and in compliance to the findings of for instance Gorton and Rowenhorst (2006).

Skewness is the ratio of the average cubed deviations from the mean and is used for measuring any asymmetry of a distribution (Bodie et al. 2009). Extreme positive values will dominate the mean and result in positive skewness. The test resulted in both positive and negative skewness, although most were small values. Positive skewness was found for sugar and rice for the total period, respectively 0.07 and 2.01. (See Appendix 4.9 and 4.10 for the two sub-periods.) A positive skewness overestimates risk due to extreme positive deviations increasing the estimate of volatility. In other words, the calculated risk of sugar and rice is overestimated. For an investor, high positive skewness is desired, meaning larger positive returns than in a normal distribution. The risk of corn, wheat and palm oil along with MSCI W is underestimated, proven by negative measures of skewness.

Kurtosis measures the extreme values at the expense of moderate values. Rice and palm oil excel with high positive values of excess kurtosis (adjusted from + three to zero in the absence of kurtosis) in all periods, meaning there have been more extreme values in the data set than in a normal distribution. Rice stands out as the commodity with the highest excess kurtosis, as mentioned, the price for rice was incorrect at the beginning of the period affecting the result of the analyses. Excluding the first years yields a JB of 80.4 and excess kurtosis of 11.7, still high. Exhibit 4.10 offers the results, and Exhibit 4.11 – 4.13 shows the distributions graphed and compared to a normal distribution.

	Skewness	Excess kurtosis	Jarque Bera
Sugar	0.07	0.72	6.57
Rice	2.01	13.46	97.61
Corn	-0.75	2.22	24.74
Wheat	-0.38	2.29	33.91
Palm oil	-0.53	7.54	179.89
MSCI W	-0.73	2.34	26.19

Exhibit 4.10: Results from testing for normality, skewness and excess kurtosis, calculations on monthly returns, 1990-2010. None of the values were significant at a 5% level.

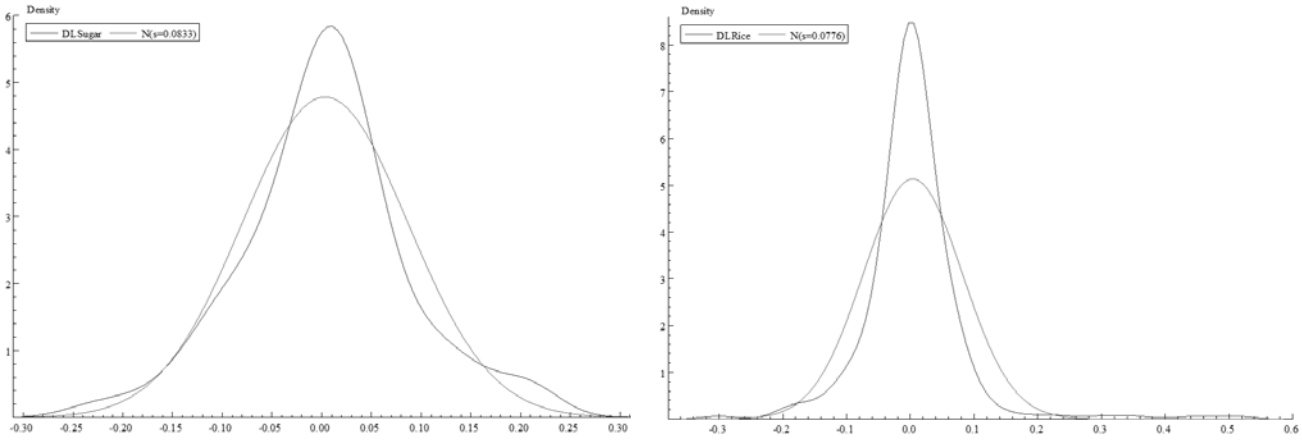


Exhibit 4.11:A: Distribution of monthly returns 1990-2010, sugar.
B: Distribution of monthly returns 1990-2010, rice.

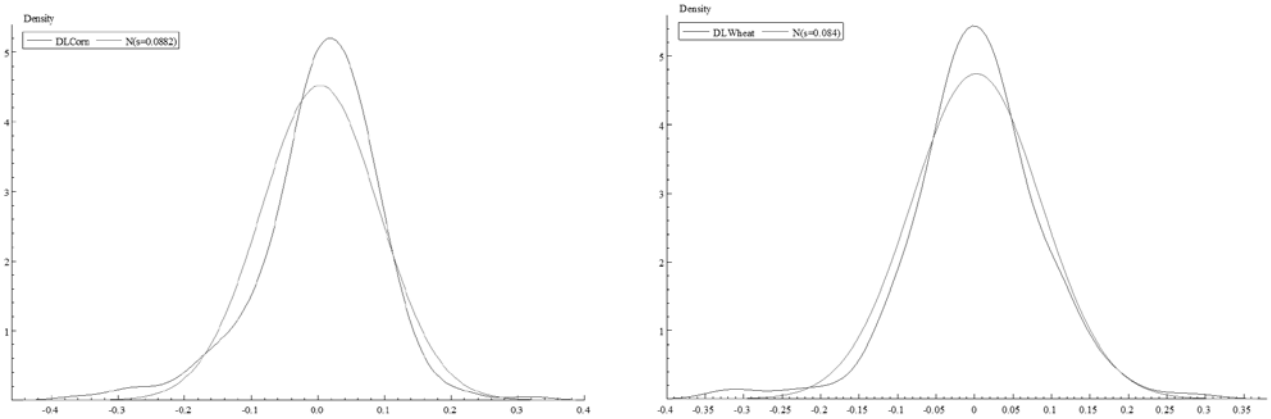


Exhibit 4.12: A: Distribution of weekly returns 1990-2010, corn.
B: Distribution of weekly returns 1990-2010, wheat.

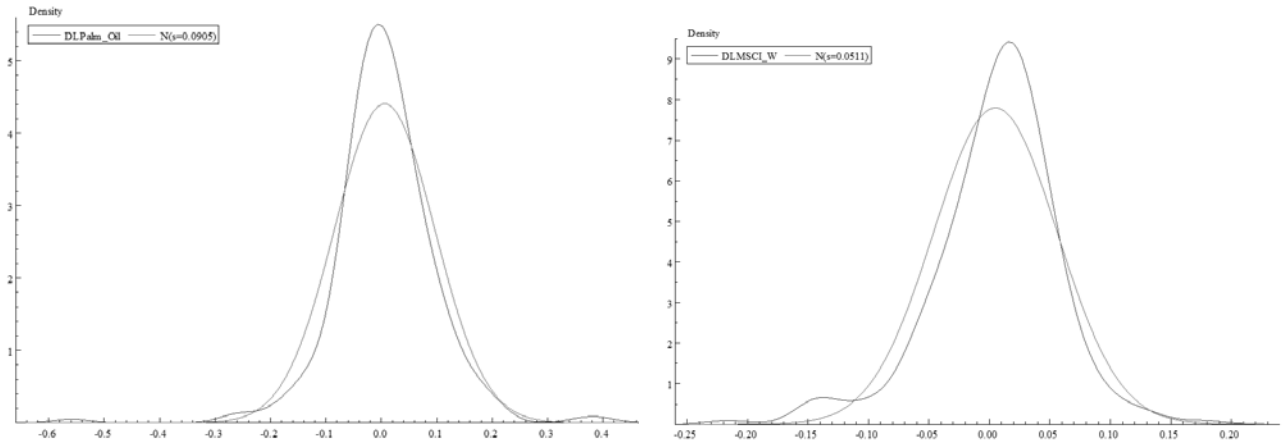


Exhibit 4.13: A: Distribution of weekly returns 1990-2010, Palm oil.
B: Distribution of weekly returns 1990-2010, MSCI.

As expected, commodities were not normally distributed, but rather had "fat tails". Another way to measure kurtosis is to count them. What is interesting is to count the observations outside a 99% confidence interval (+/- three standard deviations from the mean). The results are presented as a share of total observations and should be +/- 0.5% if the data were normally distributed. The approach may give a different view of kurtosis. Value at Risk (VaR) is a similar way of counting tales that only counts the negative values. VaR's intention is to provide information on the possible losses, in dollars, rather than the frequency of loosing. This measure is used later in this chapter.

From the JB-test, sugar was the asset closest to a normal distribution (see Exhibit 4.10). However, MSCI W when counting tales (see Exhibit 4.14) seems closer to a normal distribution than sugar because sugar does not have any observations outside the confidence interval. Rice and corn gave opposite results of each other when counting the tails, this is in accordance with the results of the JB-test. Rice had positive skewness, and thereby a large share of positive returns outside 1.6%. Corn, on the other hand, had exact opposite, 1.6% negative and 0.4% positive. Appendix 4.11 and 4.12 show the shares in the two sub-periods. Note that fewer observations have large effects on the shares.

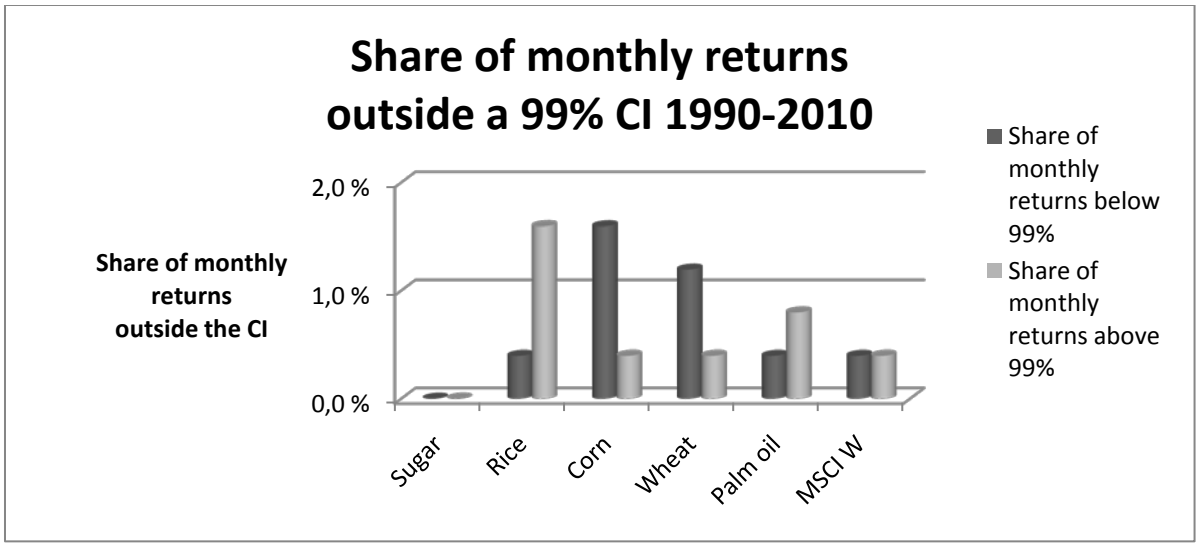


Exhibit 4.14: Shares of monthly returns outside the mean +/- three confidence intervals, 1990-2010.

To sum up; skewness is relatively close to zero for all assets, except rice, which therefore may yield higher returns than calculated. The excess values of kurtosis on the other hand, are positive for all assets. Risk averse investors generally want to avoid assets with high kurtosis because of the "fat tails", underestimatingrisk.

4.5 An examination of correlation between the assets

Commodity and commodity-related investments increased in popularity during the last decade due to substantial returns and historically low correlation to traditional asset classes (etfs.bmo.com 2011a). In this part, correlation is calculated to examine possible relationships between commodity returns and between commodity returns and stock returns. The supply and demand factors of individual commodities are, according to Greer (2000), so different that price movements of single commodities have little correlation with each other. This is consistent with the findings in this thesis (see Exhibit 4.15). The only commodities that might have a tendency of correlation are corn and wheat. As already seen, these two commodities have the same seasonal patterns, probably causing the correlation. Another reason for positive correlation may be that commodities are grown in the same geographical area or have similar areas of use.

Commodities tend to have negative correlation with stocks due to opposite influence from inflation, claimed by amongst others Fabozzi, Füzz and Kaizer (2008) and Ankrim and Hensel (1993). MSCI W proves positive correlation with corn and wheat (see Exhibit 4.15). However, Gorton and

Rouwenhorst (2004) also found positive correlation between commodities and stocks using monthly returns from 1959 to 2004. Furthermore, their analyses proved opposite results from longer holding periods. They concluded that using quarterly, annual and five-year horizons they reveal patterns in the data hidden by short-term price fluctuation. They also add that diversification benefits tend to be larger at longer holding horizons, due to negative correlation increasing over a larger holding horizon. Negative correlation with stocks indicates that commodities may be used to diversify equity and bond portfolios.

	Sugar	Rice	Corn	Wheat	Palm oil	MSCI W
Sugar	1	-	-	-	-	-
Rice	-0.08 (-1.35)	1	-	-	-	-
Corn	0.09 (1.48)	0.03 (0.50)	1	-	-	-
Wheat	0.10 (1.54)	-0.06 (-0.91)	*0.50 (9.08)	1	-	-
Palm oil	0.02 (0.25)	0.07 (1.10)	0.12 (1.94)	0.11 (1.83)	1	-
MSCI W	-0.01 (-0.23)	0.05 (0.85)	*0.23 (3.69)	*0.20 (3.23)	0.12 (1.94)	1

Exhibit 4.15: Correlation matrix of commodities and MSCI W. N= 252, t-critical = 1.98. Monthly data.

Formula for calculating significance of correlation coefficients:

$$\frac{c\sqrt{(n-2)}}{\sqrt{(1-c^2)}} \sim t_{n-2}$$

Where

c= individual correlations

n= number of observations

For the period 1990-2010 with monthly observations the correlation between returns needed to be $|0.125|$ for the coefficient to be significant at a 5% level.

The most stabile period regarding prices, 2000-2005, offered only one significant correlation coefficient (between corn and rice). This finding is closer to, but still not similar to that of for instance Ankrim and Hensel (1993) and Gorton and Rouwenhourst (2006) whose findings were negative correlation with stocks. The correlation matrix for the period is presented in Appendix 4.13. The results imply that the commodity returns have no systematic relationship.

4.6 Commodity betas

Standard deviation, defined as risk in this thesis, measure *total* risk, which can be broken down into systematic- and unsystematic components. Systematic risk is measured by beta values and indicates how much of a price change that is affected by the general development in the market. Systematic risk is affected by, for instance oil prices, interest rates and inflation. Unsystematic risk is unique risk, specific to a single company or small market sector, or as in this case, specific to a single commodity. The reason for examining beta values is that it is the part of total risk which cannot be diversified in a portfolio, while the remaining risk to some extent can. In this part, betas are presented to evaluate systematic and unsystematic risk in the commodities. MSCI W has been used as a benchmark, and the results are obtained from regressing the single index model:

$$r_{it} = \alpha + \beta_t * r_{MCSI\ W} + \varepsilon_t$$

Where

r_{it}= the return from commodity $_i$ at time $_t$

α = the average return on commodity $_i$

β_t= systematic risk (sensitivity of commodity $_i$ to the benchmark)

ε_t= an error term, and $\sigma(\varepsilon)$ measures the unsystematic risk

Monthly data has been used to mitigate noise.

The regressions showed that on a monthly basis all commodities had significant beta values different from the stock market index. This is consistent with the findings of i.e. Bjornson and Carter (1997) suggesting that commodities follow different patterns over a business cycle than stocks do. For diversification effects, low or negative beta is desired. Sugar was the only commodity that had a negative beta, however, very low value (-0.02) and not significantly different from zero. The interpretation of this would be that for a 100% increase in market returns, a 2% decrease in sugar returns may be expected, hence, decreasing the total risk in a portfolio. The four other commodities had positive beta values significantly different from the markets, however only corn and wheat significantly different from zero. The models explanatory powers, R^2, ranged from 0% to 5%, implying that the systematic risk has been a very low component of total risk. Hence, commodities bring a large share of unsystematic risk into a portfolio, and therefore a large part of the total risk may be diversified.

Exhibit 4.16 renders the beta and R^2 values for the total period. The systematic component is measured by $\beta^2\sigma^2_m$ and the unsystematic as $\sigma^2(\varepsilon)$. As R^2 was so close to zero, the value of systematic risk is also close to zero, and calculating the exact systematic risk value does not provide any further understanding of the decomposition. As example, corn had a beta of 0.39, the market variance was 0.0026, yielding a systematic risk of 0.0004 per month.

	β	R^2
Sugar	*-0.02	0.00
Rice	*0.08	0.00
Corn	*0.39	0.05
Wheat	*0.33	0.04
Palm oil	*0.22	0.01

Exhibit 4.16: Beta values with stock market index, MSCI W, used as benchmark, for monthly data 1990-2010. *indicates a beta value significantly different from 1 at a 5% level. Note that annual total risk is calculated from monthly data and therefore differ slightly

The first sub-period had even lower beta values, none significantly different from zero (see Appendix 4.14). Sugar had negative beta value, while the other commodities had positive beta values as for the total period. In addition, the explanatory power was zero, implying that all risk was unsystematic, and hence, diversifiable. During the second sub-period (see Appendix 4.14), corn and wheat had higher beta values (0.84 and 0.78) not significantly different from the market. The explanatory power was also higher, implying a larger share of systematic risk, respectively 0.0019 and 0.0016 monthly. Poorer diversification effects was brought into a portfolio for these two commodities, while the three others still had 100% unsystematic risk. In accordance with traditional asset pricing theory, it is common that beta changes over time (Bjornson & Carter 1997). In Appendix 4.14, betas for the period 2000-2005 is presented. The more stable period is characterized by a larger spread in unsystematic risk while the systematic component is zero or close to zero, as for the other periods.

As betas are changing rapidly over time, a 48 month gliding beta is for each commodity graphed in Exhibit 4.17. The betas fluctuate more or less around zero, but tend to fluctuate more the last years. The development may be caused by the large price volatility the recent years, and is not necessarily an implication of increased correlation with the market. The commodity betas, dropped in 2008, but were restored to previous stages only a few months later. The residuals of the models are graphed in Appendix 4.15-4.4.19

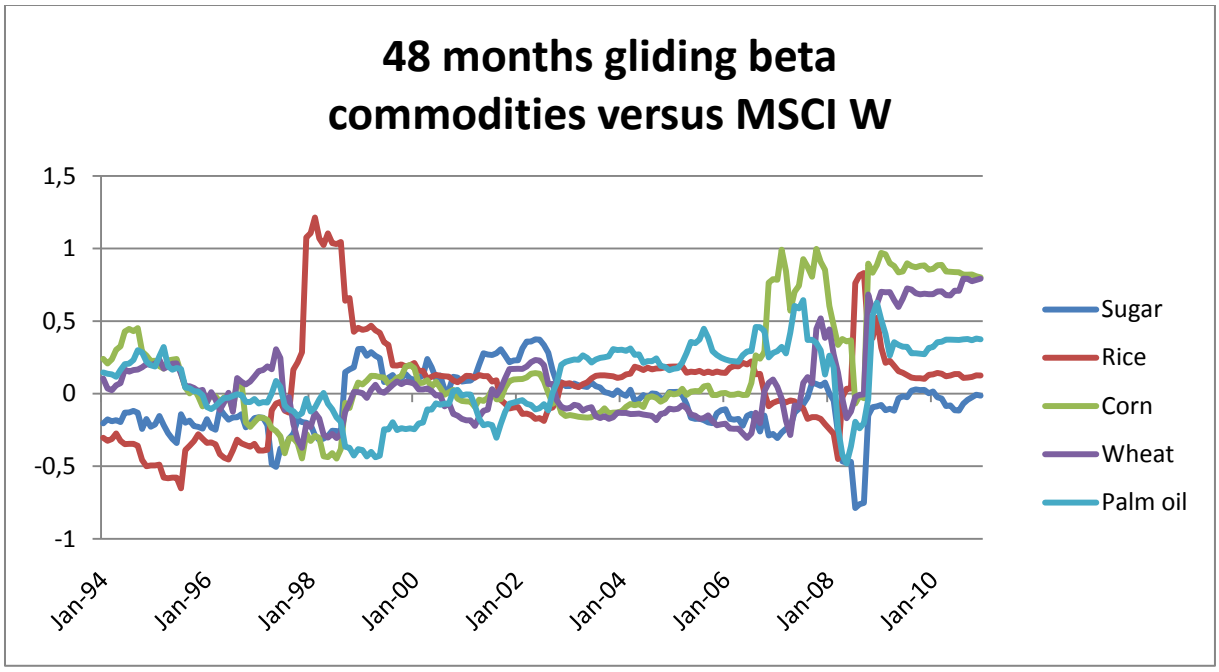


Exhibit 4.17: 48 month gliding beta for the commodities and MSCI W, 1990-2010

4.7 Commodity risk and return

This part aims to analyze and rank the different investment alternatives according to risk-adjusted performance. Four appropriate measurements have been calculated both for the total period 1990-2010, but also for the two sub-periods 1990-2005 and 2006-2010. Discrete returns are used for the following calculations, because it yields the expected value and is according to Reilly and Wright (2004) preferable when the question is what will happen later. However, they also state that there is little difference in results for a particular performance measure depending on the mean value used.

4.7.1 Sharpe ratio

Sharpe ratio, also referred to as reward-to-volatility-ratio is a measure of risk adjusted performance, developed by William Sharpe. The purpose of this tool is to find the relationship between risk and return in excess to a risk free investment. In this case it will demonstrate how investments in commodities have performed in relation to a non-risky investment and in comparison to the stock market index MSCI W.

Bodie, Kane and Marcus (2009) provides two ways of calculating the Sharpe ratio. The most common is

$$Sharpe\ ratio = \frac{\overline{r_i} - \overline{r_{rf}}}{\sigma_{(\overline{r_i} - \overline{r_{rf}})}}$$

Where

$\overline{r_i}$ = annual average return of the risky investment

$\overline{r_{rf}}$ = annual average return from risk free investment calculated by 3 months LIBOR in US$

$\overline{r_i} - \overline{r_{rf}}$ = excess returns

$\sigma_{(\overline{r_i} - \overline{r_{rf}})}$ = annual standard deviation of the excess returns

A Sharpe ratio exceeding zero indicates that the investment had higher risk-adjusted return than the risk free investment. Unfortunately, the results cannot be quantified, it is only possible to rank the commodities in order of decreasing ratios. An undiversified investment may benefit the most from this ratio as unsystematic risk is part of the formula. It is common to include the market benchmark in this analysis for comparison.

Exhibit 4.18 presents Sharpe ratios from 1990-2010 along with the two sub-periods. As mentioned, the Sharp ratio may only be used for comparison with other ratios, and the values cannot be interpreted on a standalone basis.

	Sharpe ratio		Sharpe ratio		Sharpe ratio	
	1990-2010	Smoothed	1990-2005	Smoothed	2006-2010	Smoothed
Sugar	0.17	-	0.01		0.66	
Rice	0.15	-	0.03		0.47	
Corn	0.15	0.47	-0.11	0.30	0.79	0.87
Wheat	0.09	-0.11	-0.06	-0.30	0.45	0.32
Palm oil	0.25	-	0.01		0.84	
MSCI W	0.19	-	0.23		0.11	

Exhibit 4.18. Estimates annualized Sharpe ratios. Corn and wheat smoothed for seasonal patterns in separate column. Average LIBOR US$ was 4.43% in 1990-2010, 4.82% in 1990-2005 and 2.80% in 2006-2010.

The results suggest that all investment alternatives have performed better than the US$ LIBOR between 1990 and 2010. However, when seasonal patterns are excluded, wheat yields a negative annual return, and hence, a negative Sharpe ratio. Palm oil is ranked higher than the market index, so is corn when excluding seasonality. The average of the commodity ratios was 0.16 and also below the

market. The average after excluding seasonal patterns, however, is 0.19 and equal to the ratio of MSCI W.

The first sub-period 1990-2005 was, as mentioned, characterized by lower values, on average negative and close to zero. On the other hand, MSCI W increased its position, leaving no doubt about its performance. Its only competitor is corn, excluded seasonality, yielding a Sharpe ratio of 0.30. The latest period turns the figures, presenting ratios as high as 0.84 for palm oil against MSCI W's 0.11. However, the risk free rate over the latest five years was average only 2.8% (compared to 4.82 for the first 15 years), making it "easier" to beat the market. Similar to the findings from the two other sub-periods, corn increased and wheat decreased their ratios by excluding the months of seasonal patterns.

Morningstar (2011) recommends Sharpe ratios based on data from the past 36 months. The Sharpe ratio development is shown in Exhibit 4.19. Even though all commodities had positive ratios over the period 1990-2010 all together, they all at some point had negative ratios at some. In the period where all commodity ratios were negative, MSCI W was positive, and quite high. When the commodity ratios increased, the ratio of MSCI W decreased, reinforcing what already mentioned about stocks and commodities having opposite behavior over the business cycle. The Exhibit also underlines the importance of not trusting the ratio as a measure for future performance. Meholm (2004) underlines that even Sharpe himself has been critical to the extensive use of the ratio. It is possible for portfolios to create losses, even if they have a high Sharpe ratio.

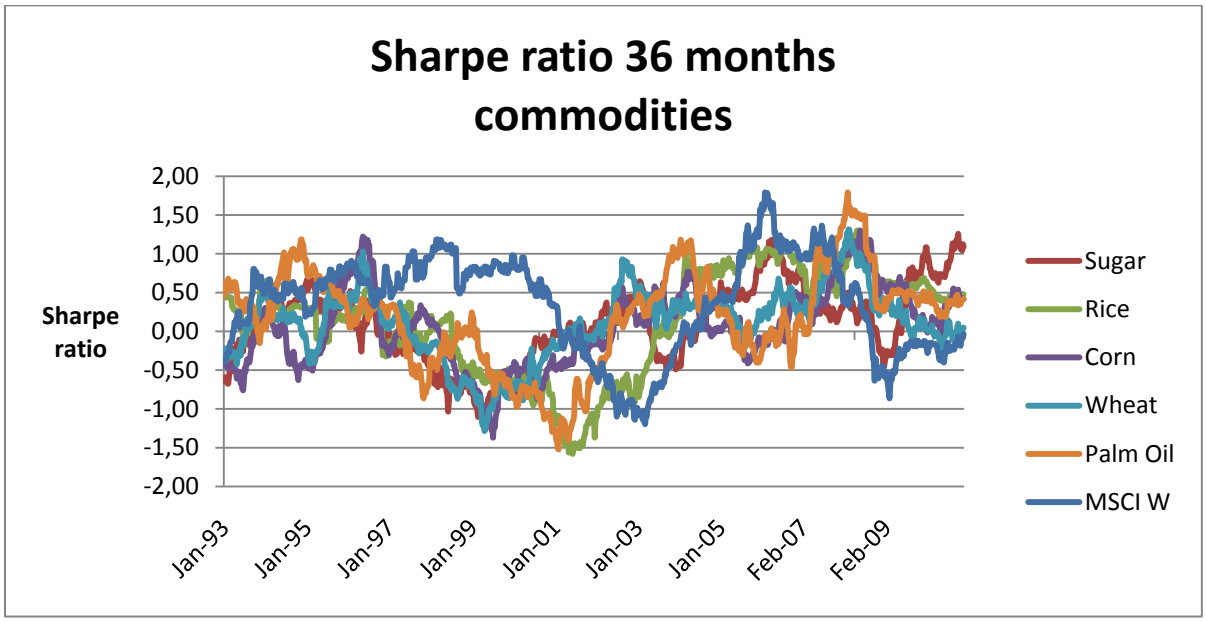


Exhibit 4.19: 36-months development of the Sharpe ratio for the commodities compared to MSCI W

4.7.2 Modigliani & Modigliani

The measure Modigliani & Modigliani (M^2) is closely related to the Sharpe ratio. It is relatively new (from 1997) and was developed by Modigliani & Modigliani. The problem with the Sharpe ratio, as mentioned, is that it can only rank the different ratios according to each other. The M^2 measurement scales up or down risk to match the market's excess risk (in excess to risk free rate). Hence, M^2 measures in percent what excess return the asset would provide, given that it had the same excess risk as the benchmark. Alternatively, M^2 quantifies the Sharpe ratio into annual percentage excess returns.

M^2 is calculated in the following manner:

$$M^2 = \left(\frac{(\overline{r_i} - \overline{r_{rf}})}{\sigma(r_i - r_{rf})}\right) \times \sigma(r_m - r_{rf})$$

Where

$\overline{r_i}$ = annual average return of the risky investment

$\overline{r_{rf}}$ = annual average return from risk free investment calculated by 3 months LIBOR in US$

$\overline{r_i} - \overline{r_{rf}}$ = risky investments excess returns

$\sigma(r_m - r_{rf})$ = annual standard deviation of the markets excess returns

$\sigma_{(\overline{r_i} - \overline{r_{rf}})}$ = annual standard deviation of the risky investments excess returns

In the period 1990-2010 the market index had excess returns of 3.2%. The results from the calculations are showed in Exhibit 4.20. Amongst the commodities, palm oil had the highest excess return (4.4%), 1.2% higher than the market's. Wheat on the other hand provides the lowest excess returns, with 1.6%, half the excess returns from the market. When excluding seasonal patterns, corn provided as much as 7.8% excess return. During the first sub-period, MSCI W had an excess return of 3.4% and all commodity excess returns were close to zero, either positive or negative. This means that an investment in this period would hardly provide any excess returns if the excess risk was the same as the market's. The exception is again corn, standing out positively after excluding seasonality. The second sub-period was characterized by high commodity excess returns, compared to MSCI W's excess return of 2.5%. An excess annual return of 10-20% provides a much better understanding of the relationship between commodities and stocks than Sharpe ratios of 0.11-0.84 does.

	M^2 1990-2010	Smoothed	M^2 1990-2005	Smoothed	M^2 **2006-2010**	**Smoothed**
Sugar	2.9 %	-	-0.4 %	-	15.4 %	-
Rice	2.5 %	-	0.4 %	-	10.9 %	-
Corn	2.5 %	7.8%	0.5 %	6.4%	18.4 %	18.8%
Wheat	1.6 %	-1.0%	-0.1 %	-2.1%	10.4 %	7.1%
Palm oil	4.4 %	-	1.4 %	-	19.5 %	-

Exhibit 4.20: M^2-values for all investment alternatives, 1990-2010 and sub-periods. Corn and wheat smoothed for seasonal patterns in own column.

4.7.3 Information ratio

When calculating the information ratio, IR, it is possible to analyze the risk-adjusted returns of an investment against the markets risk and returns, rather than the risk free rate as Sharpe ratio and M^2. The information ratio considers the excess return (in excess of the market) achieved by taking risks larger than the market's. Bodie, Kane and Marcus (2009) calculates the information ratio in the following manner:

$$Information\ ratio = \frac{\overline{r_i} - \overline{r_m}}{\sigma(r_i - r_m)}$$

Where

$\overline{r_i}$= annual average return of the risky investment

$\overline{r_m}$ = annual average market return

$\overline{r_i} - \overline{r_m}$ = excess returns, in excess of the market.

$\sigma(r_i - r_m)$ = annual standard deviation of the excess return

A positive IR-value indicates that the risk adjusted return of the investment has been higher compared to the risk adjusted return of the market. If the IR-value is negative the market had higher risk-adjusted return. IR-values are presented in Exhibit 4.21. Some are negative; however, relatively close to zero. T-values have been calculated to justify whether the IR-values are significantly different from the return of the market.

$$t - value = IR * \sqrt{N}$$

In the period between 1990 and 2010 only two commodities offered significantly positive values; sugar with 0.06 and palm oil with 0.11. Corn had a small, not significant value, turning higher than all the other values (0.25) when smoothing seasonal patterns. Wheat had a decreasing negative significant value, underlining wheat's poor performance. During the first sub-period all commodities

had significantly negative results, indicating that no commodity investment did yield a higher return than the market. The last sub-period gave opposite results and all commodities returned higher risk adjusted performance than benchmark.

	IR 1990-2010	Smoothed	IR 1990-2005	Smoothed	IR 2006-2010	Smoothed
Sugar	*0.06		*-0.09		*0.52	
	(1.99)	-	(-2.59)	-	(8.41)	-
Rice	0.02		*-0.09		*0.31	
	(0.79)	-	(-2.53)	-	(5.01)	-
Corn	0.03	*0.25	*-0.21	0.00	*0.69	*0.88
	(1.00)	(7.25)	(-6.09)	(0.00)	(11.06)	(12.28)
Wheat	-0.02	*-0.26	*-0.16	*-0.49	*0.36	*0.34
	(-0.66)	(-7.48)	(-4.64)	(-12.27)	(5.80)	(4.77)
Palm oil	*0.11		*-0.12		*0.62	
	(3.76)	-	(-3.35)	-	(9.96)	-

Exhibit 4.21: IR-values for all investment alternatives, 1990-2010 and sub-periods. T-values in parentheses, * indicates significant values at a 5% level.

4.7.4 Value-at-risk model

Value-at-risk, VaR, seeks to give an intuitive summary of risk alone, rather than risk adjusted returns as M^2. VaR measures the potential loss of the portfolio, given a specific time horizon and confidence level (α = 1-5%). Simons (1996) claims that the most common holding period, regarding VaR, is a day, a week or two weeks. However, a two-week holding period, combined with a one percent probability, makes it difficult to validate the model within a reasonable period of time.

The VaR models have been accepted by both practitioners and bank regulators as the state of art in quantitative risk measurement (Simons 1996). There is no definite answer regarding the best way of calculating VaR, and various methods may bring various results. The main approaches are known as; parametric, historical, historical simulation and Monte Carlo - a stochastic simulation. The benefit of the historical approach, compared to the others, is that it does not require the specification of normal distribution, but rather assumes that historical observations can approximate the true statistical distribution. The approach for this method is to find the lowest 1% and 5% returns. The drawback is that investors must obtain large amounts of historical data.

To quantify VaR, Exhibit 4.22 provides a table of potential losses in one week for a $1,000,000 investment with a confidence level of both 1% and 5%. The highest potential loss appears in sugar, with a 1% possibility of losing $119,800 in a week. When reducing the confidence level to 5%, there

was possibility of losing $71,300. The smallest potential loss appeared from MSCI W, with a 1% possibility of losing $76,500. At 5% level, rice had smallest loss ($32,800). For the same period, corn experienced several losses outside the 99% confidence interval (Exhibit 4.14), it is therefore expected to hold high potential losses. This turned out the other way around for the 1% case, where both sugar and palm oil held higher amounts in potential losses. For the 5% case only sugar held a higher potential loss, despite having no negative returns outside the 99% confidence interval. By this it may be concluded that the number of times of potential loss for an investor does not necessarily relate to the amounts lost. Smoothing lowers the potential loss in both the 1% and the 5% case for corn, while the potential loss for wheat increases in the 1% case and remains constant in the 5% case. These values represent the potential loss an investor had to be willing to accept.

	1% probability		5% probability	
	1990-2010	Smoothed	1990-2010	Smoothed
Sugar	-$119.800	-	-$71.300	-
Rice	-$96.800	-	-$32.800	-
Corn	-$113.400	-$94.900	-$62.400	-$54.000
Wheat	-$90.600	-$93.000	-$58.900	-$58.900
Palm oil	-$115.900	-	-$51.000	-
MSCI W	-$76.500	-	-$38.900	-

Exhibit 4.22: VaR-values, one week, 1990-2010.

A more realistic way of looking at VaR is calculating a possible weekly loss from the returns over one year. The results for 2010 are presented in Exhibit 4.23. Both the highest and the lowest potential loss at a 5% level were higher than for the 20-year period. However, corn and wheat, with seasonal patterns excluded, hold the same potential loss as with the three months included. This indicates that in the year 2010, there would have been no larger loss from holding the commodities during harvest than holding the commodity at any other time of the year.

	1% probability		5% probability	
	2010	Smoothed	2010	Smoothed
Sugar	-$142.300	-	-$99.300	-
Rice	-$72.200	-	-$49.000	-
Corn	-$125.200	-$125.200	-$66.700	-$66.700
Wheat	-$97.800	-$97.800	-$83.700	-$83.700
Palm oil	-$137.700	-	-$126.400	-
MSCI W	-$45.600	-	-$44.800	-

Exhibit 4.23: VaR-values, one week potential loss in US$, 2010.

4.8 Summing up general data description and performance evaluation

Commodity returns have changed rapidly over the period examined, with an average annual return of 4.6%. There has been a distinct difference before and after 2006. The average annual returns for the five analyzed commodities were 0.8% between 1990 and 2005 and as much as 16.9% between 2006 and 2010. For comparison, MSCI W had an annual return of 7% the first sub-period and 2.8% the second sub-period. The standard deviations have increased in the latest period.

Agricultural commodities tend to have seasonal patterns due to harvest. The results from the regression proved significant value for corn and wheat consistent with their harvesting patterns. In the 20 year period, the annual return of corn increased significantly, together with a minor decrease in risk. Furthermore, the correlation between stocks and commodities are found to be positive or close to zero. This is in compliance with Gorton and Rouwenhorst (2006), discovering positive correlation between commodities and stocks from monthly observations. However, they found negative correlation from examining quarterly or longer holding periods, in accordance with previous findings. Systematic risk have been low for all commodities, implying diversification is possible.

Looking at all four performance measurements in total may provide a more general ranking of the investments as their performance differs between the different measurements. The ranking is listed in Exhibit 4.24. VaR is included in the total rank despite the fact that Fabozzi, Füzz and Kaiser (2008) argue that the outcome may give inconsistent ranking in the risk- return framework. As Exhibit 4.24 proves, MSCI W has the best total rank in the period 1990-2010. Palm oil follows, however it would be ranked highest if VaR was excluded from the analysis. Sugar also performs relatively well for all measurements except VaR, and therefore ends up as number three. Wheat's performance was enhanced by the VaR results, but the commodity still ended up last, just after rice.

	Sharpe/M²	IR	VaR (1%)	Average	Rank
Sugar	3	2	6	3,7	3
Rice	5	4	3	4	5
Corn	4	3	4	3,7	3
Wheat	6	5	2	4,3	6
Palm oil	1	1	5	2,3	2
MSCI W	2	-	1	1,5	1

Exhibit 4.24: Total rank for the investment period 1990-2010.

To conclude, it is evident that over the last 20 year period, MSCI W stock market index proved more profitable as a standalone investment, despite the latest years reduction. It is considered valuable to diversify the portfolio with commodities. The investigation of this will be presented in part three of this thesis.

5. Exchange traded funds and tracking of underlying indexes

Buying physical goods or futures contracts are expensive and requires either rolling of contracts or storing. The easiest way to get exposure to commodity prices without having these problems is letting someone else do it. From buying an exchange traded fund (ETF), investors are exposed directly to the futures price (or in some cases the spot price) of commodities. Because of this, an ETF is an interesting investment alternative to explore. An ETF is an open-ended fund traded on stock exchanges during its opening hours. It is normally designed to track the performance of an index. They are increasingly popular all over the world. The idea is that ETFs, at least, may provide a cheap and easy way to bring diversification effects to a portfolio of stocks. The first ETF was created in Canada 1989 and the aim was to track the Standard & Poor (S&P) 500 index. ETF S&P 500 is the most sold ETF worldwide today. The market for ETFs has grown rapidly across the world. In September 2010 there was over US$ 1,181 billion invested in 2,300 ETFs (etfs.bmo.com 2011a).

5. 1 Facts and fantasies about exchange traded funds

The purpose of ETFs is to provide an easy and cheap way to invest in specific sectors, regions, bonds, futures or as in this thesis, a definite commodity group. ETFs may, like stocks, be bought on stock exchanges or through brokerage houses, but is actually more similar to open-end mutual funds. The most significant difference is that open-end mutual funds trade directly with the mutual fund company that manages the fund, while ETFs are more flexible as they trade all day during the opening hours of the stock exchange.

Another difference is that open-end mutual funds are priced once per day at their closing net asset value, NAV, for the day. NAV is the price that investors would pay or receive for redeemed shares that day. The main element of the NAV is the current market value of the underlying assets. The total value is divided by the number of outstanding shares. On the contrary, ETFs are priced continuously during the day, and it is rare to find the price of an ETF is similar to the intraday value (similar to its NAV, but calculated every 15 seconds by the exchange that trades the ETF). The estimate is guiding the investors on how much the ETF should trade for. A special process also keeps discounts and premiums from growing, by letting large investors (authorized participants) take advantage of the price difference (Ferri 2009).

ETFs come in different structures. One possibility is a product, physically holding the commodity you want to buy, which is the closest one can get to physically holding the asset (most common for precious metals). A second option is funds trading futures contracts. A third option is, ETFs tracking commodity indexes. Most of these hold futures contracts. To avoid having storage in connection with a physical purchase, the providers of the ETFs have to *roll* the futures contracts, meaning that once the maturity day closes in, the contract must be closed, and a new establishment opened. This inefficiencies may be quite costly (etfs.bmo.com 2011a) and may cause a difference in return from the underlying commodity spot-price, which could surprise investors who believed they bought the physical commodity. This is exactly what happened with investors of United States Natural gas (UNG) summer of 2007. While the spot prices of natural gas gained about 1%, UNG experienced a loss of 12%. The positive (spot) returns could not cover the cost of rolling the futures contract (Morningstar 2011). This cost is called a roll yield. Another similar concept is a positive (or negative) roll return. This is the part of the return that is gained when expiring contracts are replaced by new and cheaper (more expensive) contracts (Georgiev 2001).

5.2 ETF's benefits and drawbacks

The benefits from ETF investing are many. Compared to open-end funds ETFs have lower operating costs, in addition to flexible trading and transparency. One of the largest drawbacks is according to Ferri (2009) the learning complexities of the product. Some of the most distinct benefits and drawbacks are listed below.

Lower cost: Commission fees and trading cost tend to be lower trading with ETFs than other diversified options. Lower cost for investing gives higher expectations for return.

Portfolio transparency: ETFs can be traded during the opening hours of the stock. The investors have the trading price and the combination to a verified portfolio available at any time during a trading day. This is particularly interesting during volatile investment markets/periods.

Trading flexibility: ETFs is an easier way to trade in a particular region, market, sector or commodity. It is also possible for a trader to speculate for a price change and take a distinct market position by investing either long or short, or buying on margin.

Diversification: One ETF contains the securities that make the underlying index. Compared to other investment alternatives ETFs may have lower variability in the portfolio and get reduced volatility in price.

Liquidity: ETFs allow investors to buy or sell whenever the markets are open. In addition, the true liquidity of an ETF is represented by the liquidity of the underlying securities.

In addition to all these benefits, there are also drawbacks to consider.

Future profits: Commodities, unlike stocks and bonds, do not produce any income or have any stake in the potential future profits of a business. Morningstar research (2011) has proven long term returns from commodities not to be particularly high.

Expensive short-term investment: Short term speculation in ETFs rules out low costs and tax efficiency. Frequent trade may add up brokerage commission, and trigger tax consequences.

Interesting questions concerning ETFs are whether the risk-adjusted returns are higher from investing in ETFs than from the physical commodities, and if they actually track the indexes they state? It is considered relevant to identify how ETFs performed in relation to the stock market index followed (MSCI W). These questions will be investigated later in this section. A general description of the ETFs will be presented.

5.3 Stylized facts on ETF prices and price changes

Data for the three ETFs followed are collected from London stock exchange from origin to December 2010. ETF sugar and ETF wheat were published in September 2006, while ETF soft was published in November 2007. However, if the ETFs track the underlying indexes, data of the underlying sub-indexes may be used to backtrack the ETF data. The value of the ETFs may be estimated back in time following the same percentage as the underlying index. This provides a larger number of observations for further analysis, giving more representative results. Monthly observations are used to eliminate noise.

The returns from the ETFs have been relatively low compared to the spot-price returns. Erb and Harvey (2006) states that return on average commodity futures have been close to zero. Both sugar and wheat spot prices yields more than 6% higher annual returns than the respective ETFs in the same period. In addition, the risk from the ETFs is higher than those of the spot prices. Conversely, Gorton and Rouwenhorst (2004) found that historical returns from holding commodity futures have exceeded the returns from holding spot commodities. ETFs risk and returns are listed in Exhibit 5.1.

	Annual mean returns	Annual standard deviation
ETF soft	0.18	0.55
ETF sugar	0.10	0.41
ETF wheat	-0.03	0.50

Exhibit 5.1: Stylized facts on ETF performance from origin to 2010, hence, September 2006 and November 2007. None of the returns were significantly different from zero at a 5% level

Exhibit 5.2 identifies fluctuations of the ETF values through the period of existence. The value in November 2007 equals 100 for all three ETFs. ETF sugar was most volatile with the 2009 peak caused by poor harvest in some of the largest sugar producing countries. The abrupt fall at the end of the year was due to improved market outlook and good weather forecast. This did not hold, and the prices rose again from mid-2010. ETF soft followed the same trend from mid-May, while ETF wheat values stayed relatively low compared to the two others, and compared to the late 2007 value.

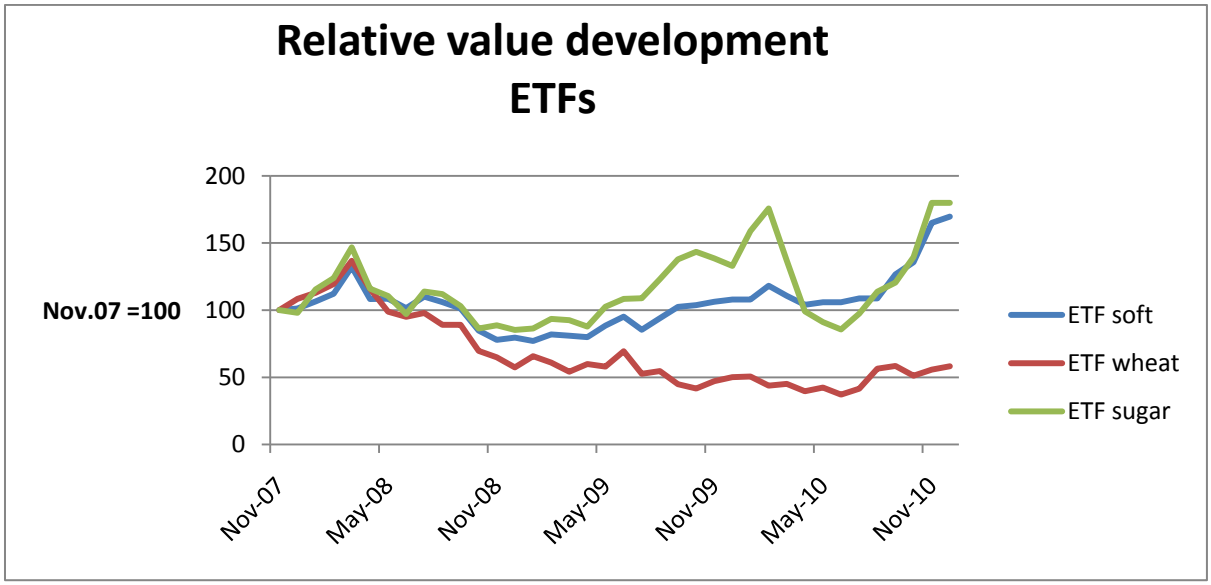


Exhibit 5.2: Relative value development of the three ETFs. Value in November 2007 equals 100.

5.4 ETFs – tracking its underlying index

The Dow Jones-UBS Commodity Index and the different sub-indexes consist of commodity futures rather than spot prices and thereby reflect the return of *rolling* investments in commodity futures. By example, the wheat contract with maturity in May is bought in January, and in February it is replaced by a July contract. In Appendix 5.1 the DJ-UBS rolling calendar is presented, listing what contracts are held in what month, and hence, when rolling of contracts occur.

The following section offers some basic facts of the investigated ETFs. ETF sugar and ETF wheat are open-ended exchange traded commodities designed to track respectively DJ-UBS Sugar Sub-Index and DJ-UBS Wheat Sub-Index on a total return basis. ETF soft (F3) is an open-ended exchange traded commodity designed to track the DJ-UBS Soft Sub-Index 3 Month Forward on a total return basis. It tracks commodity futures with maturity approximately 3 months after the DJ-UBS CI. The allocation of commodities in this ETF is 41% sugar, 31% coffee and 26% cotton. Commodities are given the same proportions as DJ-UBS CI, difference being that it only comprise of the three commodities mentioned (etfs.bmo.com 2011b). Some of the most important trading facts are presented below. The information is collected from etfsecurities.com (etfsecurities.com 2011).

ETF sugar

- A total return index designed to track Dow Jones UBS Sugar Sub-index
- The sub-index is priced off The Ice futures contracts
- Primary listing: London Stock Exchange
- Base Currency: USD
- Minimum investment: 1 security
- Management fee: 0.49% per annum
- Entry/exit fees: None when traded on exchange
- Published: 2006

Exhibit 5.3: Factsheet for ETF sugar.

ETF wheat

- A total return index designed to track Dow Jones UBS Wheat Sub-index
- The sub-index is priced off NYMEX futures contracts
- Primary listing: London Stock Exchange
- Base Currency: USD
- Minimum investment: 1 security
- Management fee: 0.49% per annum
- Entry/exit fees: None when traded on exchange
- Published: 2006

Exhibit 5.4: Factsheet for ETF wheat.

ETF soft

- A total return index designed to track Dow Jones UBS Soft Sub-index 3 month forward
- Primary listing: London Stock Exchange
- Base Currency: USD
- Minimum investment: 1 security
- Management fee: 0.49% per annum
- Entry/exit fees: None when traded on exchange
- Published: 2007

Exhibit 5.5: Factsheet for ETF soft.

This section offers an investigation of how well the ETFs track the performance of the underlying indexes. If the tracking is accurate enough, it is possible to verify backtracking of ETF values. If the return of an ETF does not track the return of the underlying index, tracking errors occurred. This phenomenon is to some extent expected and may be caused by for example timing differences when rolling futures contracts. In addition, indexes assume that dividend is reinvested on the same day the company went ex-dividend, ETF cannot, by law, reinvest the dividend, and must hold it until a dividend is paid to the shareholders (Ferri 2009). A funds trading cost is another reason for this error (etfs.bmo.com 2011a).

On the basis of the above information, the expectations are that the ETFs return track the DJ-UBS index returns to a high extent. However, some small differences will probably occur, both because of tracking error, but also because of some insufficiency in the ETF data.

In Exhibit 5.3, 5.4 and 5.5, ETF values are graphically compared (November 2007 =100) with its representative underlying index. During most of the period, it is impossible to see a difference between the two. The graph also includes relative spot prices of the commodities. This was done to visualize the difference between spot and futures value development. The spot price differed somewhat more from the two others, indicating that the spot and futures price returns are not equal. Correlations in returns are calculated and presented later on. ETF soft is graphed up against its underlying index and a constructed portfolio of cotton, coffee and sugar spot prices. This constructed portfolio may differ from the index and the ETF than the spot-prices of wheat and sugar, due to changes in weights of the portfolio over the years which have not been replicated.

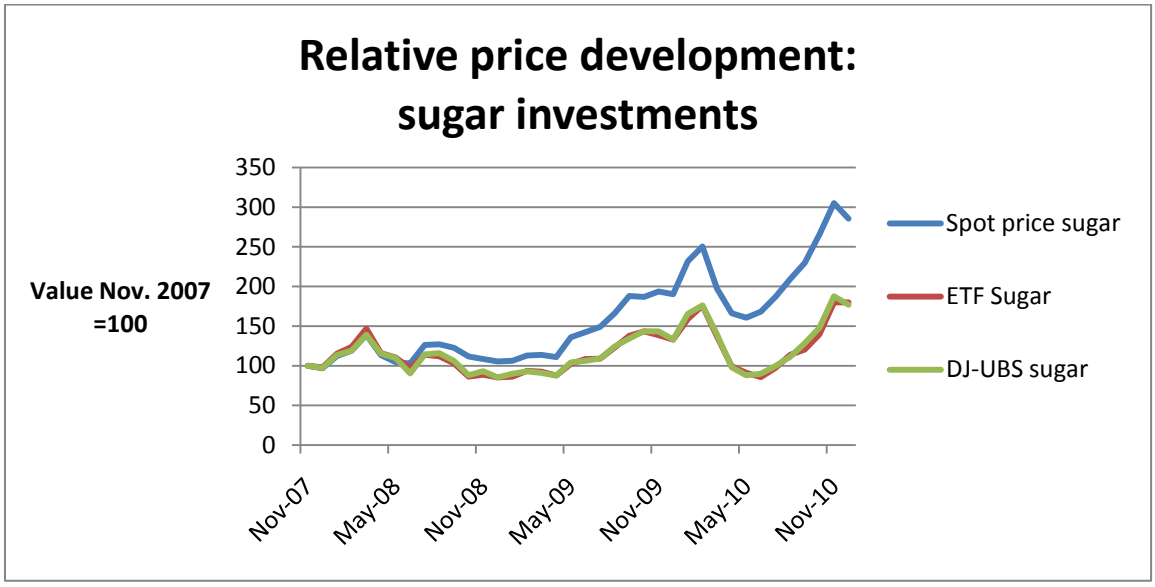


Exhibit 5.6: Relative value development for ETF sugar versus DJ-UBS sugar and the spot prices of sugar, November 2007-December 2010. November 2007=100 for all assets.

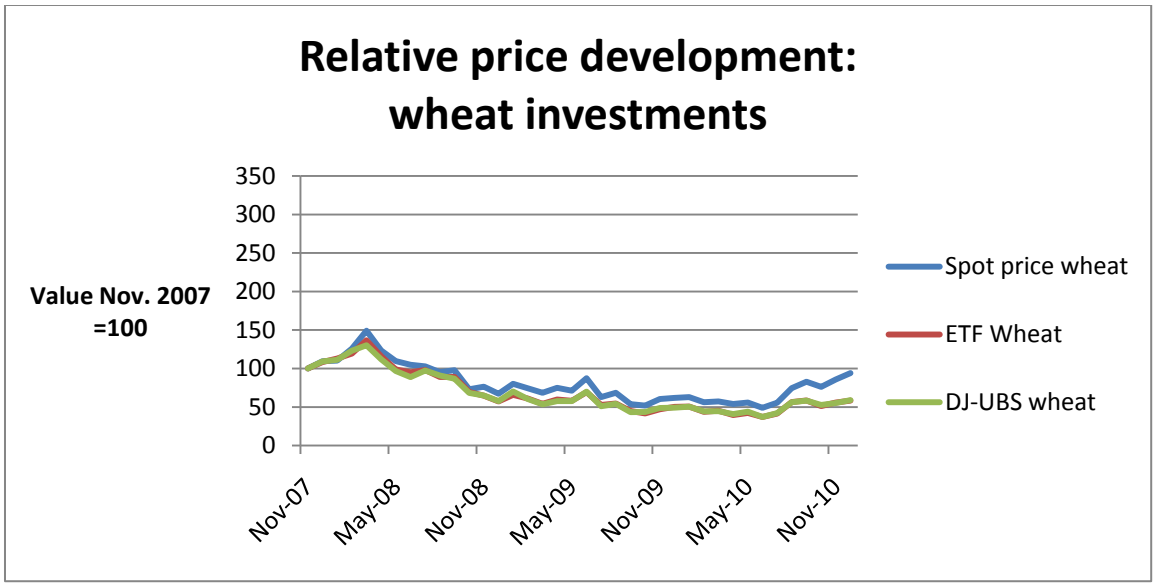


Exhibit 5.7: Relative value development for ETF wheat versus DJ-UBS wheat and the spot prices of wheat, November 2007- December 2010. November 2007=100 for all assets.

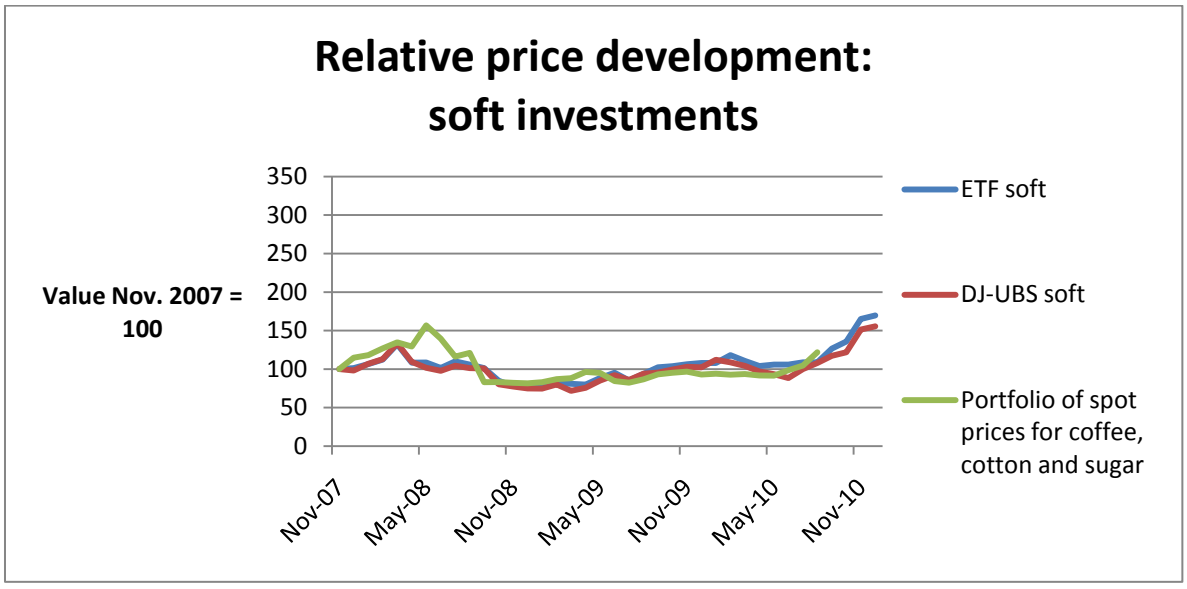


Exhibit 5.8: Fluctuations in monthly return for ETF soft, DJ-UBS Soft and a portfolio with the same relationship as the index: sugar (41%)C, coffee (31%) and cotton (26%). November 2007- December 2010. November 2007=100 for all assets.

Exhibit 5.6 shows a graph of DJ-UBS soft against the relative spot prices of cotton, coffee and sugar alone. This is to visualize how the different commodities have pulled the index in different directions. Gaps in different directions, and as seen from the descriptive statistics in Exhibit 5.1, has caused a smaller standard deviation for the soft index that for the single commodity sub-indexes. This implies

that a commodity index may be a more appropriate investment than a single commodity for risk averse investors.

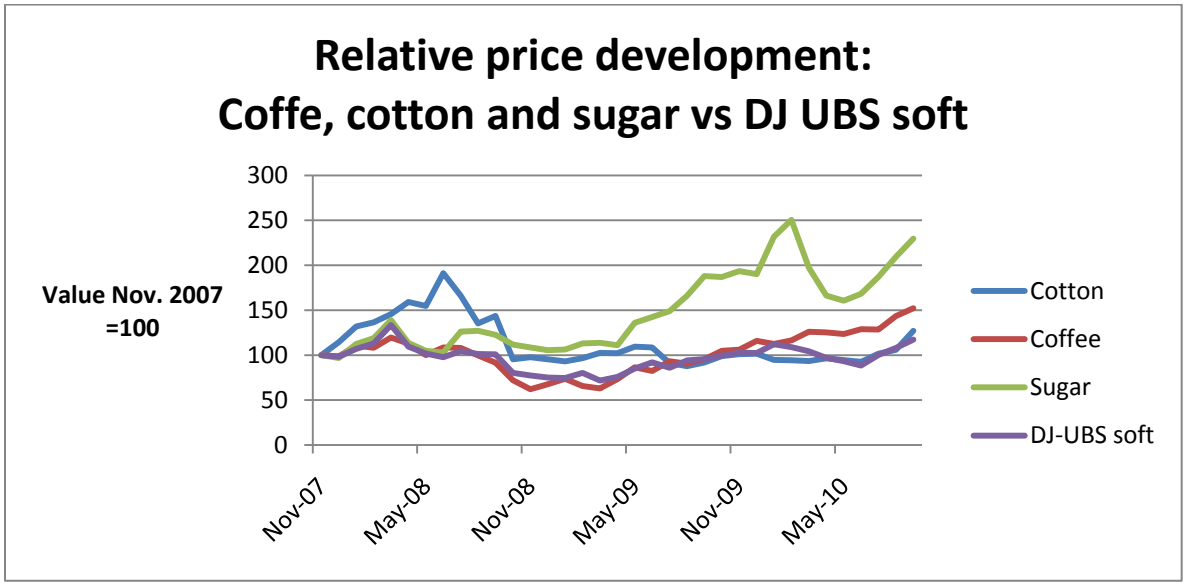


Exhibit 5.9: Relative price development for DJ-UBS Soft and spot prices of cotton, coffee and sugar. November 2007-December 2010. November 2007=100 for all assets.

Exhibit 5.7 presents the average tracking error and the standard deviation of them, from the three ETFs against their underlying indexes. ETF sugar and wheat had average errors close to zero. ETF soft experienced the highest tracking error, caused by insufficient data, in addition to timing differences when rolling the futures contracts. The standard deviation of the tracking error was also higher for ETF soft than the two other.

	Average monthly tracking error	Average monthly Standard deviation of tracking error
ETF soft	0.0016	0.050
ETF sugar	0.0002	0.039
ETF wheat	-0.0001	0.037

Exhibit 5.10: Average monthly tracking error, and the standard deviation of the tracking error. 2006/2007 -2010

5.4.1 Correlation between ETFs and their underlying indexes

The average tracking error of ETF sugar and wheat are close to zero. Correlation between the commodities and their underlying indexes and assets was calculated to decide if the data of the

underlying asset could be used to backtrack data on the ETFs. The results are presented in Exhibit 5.8. As mentioned, the data for the ETFs were somewhat incomplete, especially at the beginning of the period which may have had some effect on the results. In addition, differences in returns between futures and spot price investments were examined for significant difference. Calculations of correlation were in compliance with the graphs of ETFs and underlying assets (Exhibit 5.3-5.5).

	Sugar	Wheat	DJ-UBS sugar	DJ-UBS wheat	DJ-UBS soft	ETF sugar	ETF wheat	ETF soft
Sugar	1	-	-	-	-	-	-	-
Wheat	0.18 (1.32)	1	-	-	-	-	-	-
DJ-UBS sugar	*0.90 (15.54)	*0.28 (2.17)	1	-	-	-	-	-
DJ-UBS wheat	0.21 (1.55)	*0.93 (18.65)	*0.30 (2.28)	1	-	-	-	-
DJ-UBS soft	*0.71 (7.45)	*0.60 (5.47)	*0.73 (7.83)	*0.54 (4.71)	1	-	-	-
ETF sugar	*0.91 (15.71)	*0.30 (2.21)	*0.95 (20.78)	*0.30 (2.18)	*0.78 (5.83)	1	-	-
ETF wheat	0.21 (1.47)	*0.95 (21.26)	*0.28 (2.01)	*0.96 (24.36)	*0.58 (5.04)	*0.30 (2.19)	1	-
ETF soft	*0.71 (5.89)	*0.43 (2.85)	*0.69 (5.63)	*0.37 (2.34)	*0.83 (8.96)	*0.75 (6.65)	*0.41 (2.63)	1

Exhibit 5.11: Correlation between returns, monthly observations from 2006-2010, ETF soft: 2007-2010. * indicates a significant correlation on a 5% level. n=37. T-critical 2.02

ETF sugar correlated 0.95 with DJ-UBS sugar, ETF wheat 0.96 with DJ-UBS wheat, and ETF soft 0.83 with DJ-UBS soft (with the most incomplete data). This implies that backtracked data of for instance ETF sugar will give at least 95% representative results. Also, the returns from the spot prices tend to correlate with the underlying index. Spot prices of sugar and wheat are correlated with the sub-indexes (hence, the futures price) respectively 0.90 and 0.93, which was the general finding for commodities, according to Bailin (Morningstar 2011). As mentioned, the correlation between futures and spot prices were not as similar as some might believe. First and foremost, futures price returns are not expected to suffer from clear seasonal patterns like spot prices do. Fama and French (1987) argue that as harvest-time is well known public information, an investor will roll futures contracts in order to avoid the price decrease.

A t-test for difference in mean returns showed that the returns from rolling of futures contracts (price changes in DJ-UBS sub-indexes) were significantly different (at a 5% level) from the returns of

the respective spot-prices. DJ-UBS sugar also has a significantly lower variance than spot price sugar, while there was no significant difference in wheat's variance (see Appendix 5.2 and 5.3).

The conclusion from these investigations is that ETFs virtually track their underlying indexes. Practically this means that the historical values of the DJ-UBS sub indexes can be used to backtrack values for the ETFs, which are only available from 2006 and 2007. This may make the calculations of ETF performance more valid.

5.5 Descriptive statistics on backtracked ETF data

Based on previous results, it is assumed that the development of the index-values may be used to replicate the development of ETF values. This was done by estimating the historical value of the ETF, by the same percentage the index changed. ETF-values were backtracked to 1991, and are from this point on named ETFs. Exhibit 5.9 presents the annual mean returns and standard deviation of the backtracked ETF data.

	Annual mean returns	Annual standard deviation
ETF soft	0.028 (0.46)	0.273
ETF sugar	0.078 (1.08)	0.322
ETF wheat	-0.038 (-0.55)	0.30.9
Sugar	0.046 (4.45)	0.314
Wheat	0.029 (3.38)	0.279

Exhibit 5.12: Stylized facts on backtracked ETF data, 1991-2010. T-values in parentheses. None of the mean returns are significantly different from zero at a 5% level.

In the period 1991-2010, the annual mean returns from the ETFs were somewhat different from the spot price returns (see Exhibit 4.5). ETF sugar had higher return for the same risk as from spot return, while ETF wheat had lower return, for approximately the same risk. ETF soft had lower return and standard deviation than both spot price sugar and ETF sugar, due to lower returns in cotton and coffee. None of the mean returns were statistically different from zero at a 5% level.

Exhibit 5.10 presents number of years where the underlying futures contracts were in normal backwardation and normal contango. The first contract each year during the period 1990-2010 was examined. Some years failed to prove a clear pattern and were not considered. The return from ETF wheat was lower than spot price return, this may be caused by many years of negative roll return from rolling contracts when the market was in normal contango, the same accounts for coffee. ETF sugar had balance in number of years of normal backwardation and normal contango, in addition to higher return than spot price sugar.

	Number of years in normal backwardation	Number of years in normal contango
Sugar	6	5
Wheat	5	9
Cotton	6	6
Coffee	2	6

Exhibit 5.13: Number of years in normal backwardation and normal contango for the ETF futures contracts analyzed. Data collected from wikiposit.org. First month contract each year from 1990-2010.

5.6 ETFs risk and returns

Four performance measures are used to analyze the performance of the ETFs, as for the single commodities. This made it possible to compare spot-price performance and futures-price performance (through ETFs). Some difference between the two is expected to occur due to the costs of storage not being subtracted from the spot price returns. Results for sugar, wheat and MSCI W are taken from calculations in chapter four.

5.6.1 Sharpe ratio

In the period of 1990-2010 MSCI W was, again, ranked highest of the investment alternatives, meaning that an investment in the stock market provided the highest excess returns (in excess of the risk free alternative) given the risk associated, see Exhibit 5.11. ETF soft and wheat had negative values, due to negative excess returns over the period. None of the single commodities had negative Sharpe ratios the same period (Exhibit 4.18). The average Sharpe of the ETFs was -0.06, much lower than MSCI W's 0.19, and spot sugar and wheat averaged at 0.13. The difference between spot price returns and ETF returns might be a result of both rolling yield and a negative roll return, in addition to storage costs not being subtracted from spot prices.

The first sub-period was characterized by even lower Sharpe ratios, with the exception of ETF sugar. Three ratios were negative, with MSCI W has the highest valued. The ETFs average was -0.12, pulled down by ETF wheat (-0.40). It is important to notice that ETF sugar had a much higher ratio than physical sugar, perhaps due to a positive roll return.

The last sub-period, 2006-2010, had as expected much higher values. Spot price sugar had a Sharpe ratio almost 30 times higher than ETF sugar. MSCI W ranked lower than three of the investment alternatives but still higher than ETF sugar and wheat. The average of the ETFs was 0.002 -almost zero, while spot sugar and wheat had an average as high as 0.55. However, Sharpe is only a measurement for ranking, and other measurements will be examined to have a closer look at the scale of the differences.

	Sharpe ratio 1990-2010	Sharpe ratio 1990-2005	Sharpe ratio 2006-2010
Sugar	0.17	0.01	0.66
Wheat	0.09	-0.06	0.45
ETF soft	-0.03	-0.13	0.10
ETF sugar	0.11	0.18	-0.02
ETF wheat	-0.25	-0.39	-0.07
MSCI W	0.19	0.23	0.11

Exhibit 5.14: Sharpe ratio, 1990-2010, 1990-2005 and 2006-2010. Return on risk free investment was respectively 4.34%, 4.83% and 2.8%.

Exhibit 5.12 identifies a graph of a gliding 36-month Sharpe ratio for the ETFs. The trend was quite similar to that of the single commodities. However, the interval appears to be somewhat lower, ranging from +1 to -2, while single commodities had many values above 1 and almost none below -1.5. ETF sugar excels in the period 2000-2003, both spot price sugar, corn and wheat followed the same trend, while palm oil and rice appeared more similar the two other ETFs. MSCI W excels from the others, especially in the period 1997-2003. Despite having the highest value in total, it fluctuated intensely over the 20 year period.

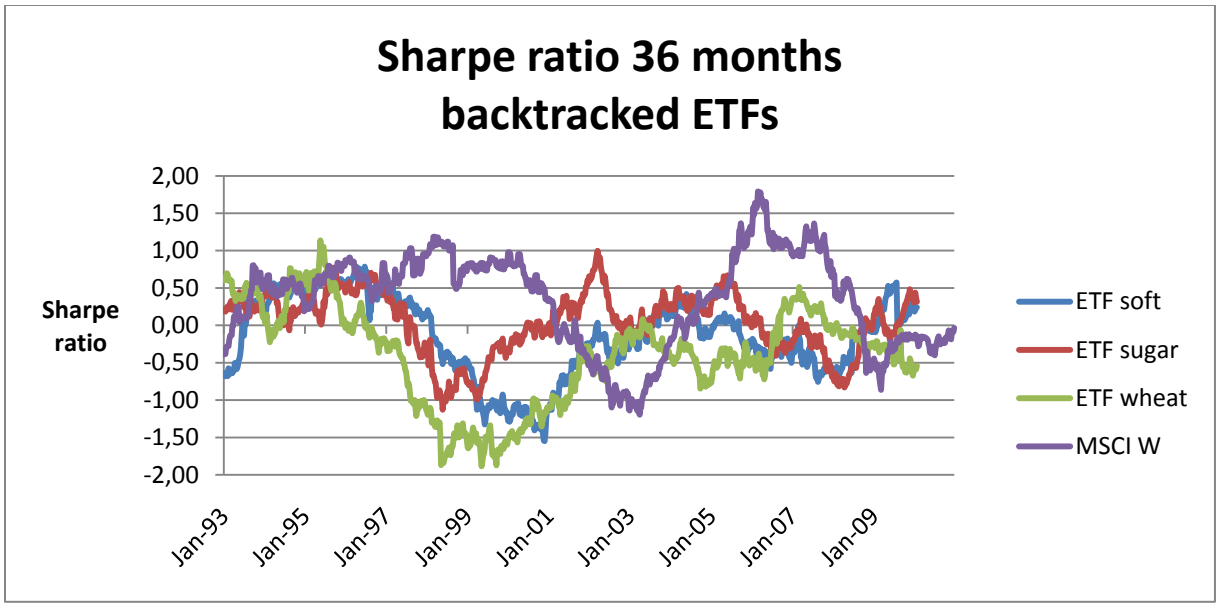


Exhibit 5.15: 36 month Sharpe ratio for the three backtracked ETFs and MSCI W. 1990-2010.

5.6.2 Modigliani & Modigliani

In the period 1990-2010, all investment alternatives performed poorer than the market, with ETF soft and wheat performing even poorer than the risk free rate. They provided negative returns of respectively 0.5% and 4.2% with the same excess risk as the market (see Exhibit 5.13). Sugar and wheat spot prices would have positive excess returns of respectively 2.9% and 1.6%, while the market had 3.2% excess returns. As mentioned earlier, commodity figures are much lower in the first sub-period than the second sub-period, however, it is important to remember that costs were not subtracted from the spot price returns when interpreting the results. Markets excess return in the first and second sub-period was respectively 3.4% and 2.5%.

	M^2 1990-2010	M^2 1990-2005	M^2 2006-2010
Sugar	2.9 %	-0.4 %	15.4 %
Wheat	1.6 %	-0.1 %	10.4 %
ETF soft	-0.5 %	-2.7 %	2.3 %
ETF sugar	1.9 %	1.1 %	-0.6 %
ETF wheat	-4.2 %	-5.0 %	-1.5 %

Exhibit 5.16: M^2 values, measuring excess returns above the market's, for the same level of risk.

5.6.3 Information Ratio

As mentioned in the analyses of the physical commodities, a significant positive IR value indicates that the risk-adjusted return of the investment is higher than the markets (positive excess returns). Exhibit 5.14 provides the IR-values of the ETFs and spot prices. Spot price sugar had a low, significant positive value in the period 1990-2010. ETF soft and ETF wheat had both significant negative IR-values in the period from 1990-2010, meaning that the market had higher risk-adjusted return than the ETFs. The fact that none of them had positive, significant IR-values is consistent with the findings by Sharpe calculations where MSCI W had the highest ratio. Spot price sugar had a positive, significant value of 0.06, still higher than the markets, which may be argued to be a low value for a 20 year period.

In the first sub-period, as expected, all five commodities had negative, significant value. In the second sub-period it was evident that spot sugar and spot wheat had significant values, both of which were quite high. Again, the more important thing to notice is the large gap between commodities and the ETFs.

	IR 1990-2010	IR 1990-2005	IR 2006-2010
Sugar	*0.06 (1.99)	*-0.09 (-2.59)	*0.52 (8.41)
Wheat	-0.02 (-0.66)	*-0.16 (-4.64)	*0.36 (5.80)
ETF soft	*-0.17 (-5.25)	*-0.32 (-10.27)	0.04 (0.58)
ETF sugar	-0.026 (-0.81)	-0.003 (-0.08)	-0.07 (-1.18)
ETF wheat	*-0.34 (-10.73)	*-0.50 (-15.87)	-0.11 (-1.77)

Exhibit 5.17: IR-values 1990-2010, 1990-2005 and 2006-2010, * indicating a significant IR-value at a 5% level, calculated by the t-value: IR*√n

5.6.4 Value at Risk

Value at risk was calculated to give a clearer insight into the risk of the assets. Exhibit 5.15 lists potential weekly losses for an investment of $1,000,000, with confidence levels of both 1% and 5%. The highest potential loss was found in ETF sugar, with a 1% probability of losing more than $121,400 in one week. There was a 5% probability of losing more than $69,100 from the same investment, which is almost double the potential 5% loss from MSCI W ($38,900). DJ-UBS Soft excels along with MSCI W with lower potential losses than the other investments, probably because of diversification effects from being a portfolio rather than a single commodity.

	1% prob 1990-2010	5% prob 1990-2010
Sugar	-$119.800	-$71.300
Wheat	-$90.600	-$58.900
ETF soft	-$70.800	-$42.000
ETF sugar	-$121.400	-$69.100
ETF wheat	-$9.000	-$58.100
MSCI W	-$76.500	-$38.900

Exhibit 5.18: 1% and 5% potential loss over one week for an investment of $1,000,000 for 1990-2010.

The year 2010 was more volatile than 1990-2010 in total, and in this year, ETF sugar holds a potential weekly loss of more than $229,900 at a 1% level (see Exhibit 5.16). This is almost double the amount from 1990 to 2010. All the other investment alternatives had higher potential losses in 2010 as well, but with MSCI W and ETF soft still much lower, making them more suitable for risk averse investors. These calculations may provide more descriptive information concerning the risk of loss, and of the profit. Regardless of how much return an investment provides, an investor has to be willing to take the risk of losing these amounts. If not, other investments with lower risk are advised.

	1% prob 2010	5% prob 2010
Sugar	-$142.300	-$99.300
Wheat	-$125.200	-$83.700
ETF soft	-$71.600	-$65.000
ETF sugar	-$229.900	-$123.000
ETF wheat	-$136.200	-$68.100
MSCI W	-$45.600	-$44.800

Exhibit 5.19: 1% and 5% potential loss in one week in 2010 for an investment of an investment on $1,000,000

5.7 Concluding points on investments in ETFs, tracking and analysis of performance

Informed investors conclude that the benefits from investing is ETFs are larger than the drawbacks (Ferri 2009). Nilsen (2011) quotes Thore Johnsen, professor at the Norwegian school of economic and business administration (NHH) stating that there is nothing daunting about investing in ETFs, *if* the investment has long term horizon. Historical analyses of the performance of these investments are however, somewhat insufficient due to the short history of most ETFs, and the fact that the latest

years were characterized by large fluctuations and abnormal market structure. However, due to close tracking of the underlying assets, the data could be backtracked, making it possible to indentify at performance in a historical perspective. A correlation of more than 95% between an ETF and the underlying index should give a result from backtracked data that is at least 95% correct.

It may be difficult to obtain a sufficient insight in which investments that performed most profitable during the period examined. Some of the investments stand out positively several times, however, some are ranked very different using different measurements. To obtain clear overall picture, all measures are summed up in Exhibit 5.17, and ranked by an average of the different results. It is worth noticing that in total, spot sugar performs better than ETF sugar, and spot wheat performers better than ETF wheat. Again pointing out; this might be due to cost of rolling commodity futures contracts and because storage cost from buying at spot price is not subtracted.

1990-2010	Sharpe/M²	IR	VaR (1%)	Average	Rank
Sugar	2	1	5	2.7	2
Wheat	4	3	4	3.7	4
ETF soft	5	4	1	3.3	3
ETF sugar	3	2	6	3.7	4
ETF wheat	6	5	3	4.7	6
MSCI W	1	-	2	1.5	1

Exhibit 5.20: A total rank made by the average of the different performance measure rankings, investment period 1990-2010.

Exhibit 5.17 also identifies that the stock market index, MSCI W, clearly performed the best, above both physical commodities and financial commodities, meaning that even though cost are not subtracted from spot price return, they still would not be capable of outperforming the stock market index. Once again it may be alleged that *"there is no such thing as a free lunch".*

6. Can commodities or exchange traded funds bring positive diversification effects to a portfolio of stocks?

The analysis so far has indicated that neither physical commodities, nor commodity ETFs are profitable as standalone investments compared to the stock market index MSCI W. Their overall returns have been rather low, with exception of the latest years rapid price increase. Poole, P., chief strategist for HSBCs capital management (DN.no 2011) predict this trend to continue for several years. Both Bodie and Rosansky (1980) and Erb and Harvey (2006) agree that including commodities in a portfolio may provide valuable diversification effects by lowering the risk, but still providing the same returns. The next step in this commodity investment analysis will therefore be to identify the diversification benefits commodities may bring to a portfolio of traditional stocks. Before building a portfolio, it is important to identify some objectives; time horizon, risk tolerance, level of financial knowledge and personal preferences. Some previous research, with different outcomes, will be reviewed before the portfolio construction.

The discussions concerning this topic have been ongoing for years. Historically, according to Georgiev (2001) direct investments in commodities have been a small part of traders portfolio. A more common way of exposure was indirectly invest through commodity based companies. In his analysis during 1990-2001 for a sample of stocks, bonds, hedge funds and commodity indexes he concluded that significant portfolio diversification benefits may occur in direct commodity investments such as S&P GSCI. He concluded that the benefits of commodity investments are the unique exposure to for instance inflation and positive roll-returns (Georgiev 2001). The investors will, according to Georgiev, achieve an improved risk-adjusted performance in the portfolio.

Morningstar's advice is to limit the position of commodities in the portfolio to a small portion of the total assets. They specify that the investor must know what he is buying and be aware of the downsides with the investment (Morningstar 2011). Another important point is made by Anson (1999): the actual level of investment in commodity futures will depend on the investor's individual level of risk tolerance, utility function and initial portfolio composition. The more risk an investor is willing to take, the more benefits he will obtain by including commodities in the portfolio. The reason behind this is the great long-term diversification potential of commodity futures.

After studying the performance of managed commodity funds, during the period 1982-1996, Edwards and Liew (1999) concluded that commodities were profitable as a standalone investments

and as an asset in a diversified portfolio of stock and bonds. The analysis was based on Sharpe ratios, among others. They also pointed out that investing in a passively managed commodity index does not replace an investment in managed commodity fund.

Elton, Gruber and Rentzler (1987) analyzed publicly traded commodity funds in the period from July 1979 to June 1985 with the opposite result. They compared monthly returns in this period to returns from indexes consisting stocks and bonds, and found two to three times higher standard deviation in commodities than in other investment alternatives. Based on this analysis they do not recommend any investor to invest in commodity funds, neither as a standalone investment nor in a portfolio consisting stocks and bonds.

6.1 Computing portfolios

The following part seeks to analyze potential benefits of including commodities in a portfolio. The five commodities discussed earlier will be considered, along with backtracked data for the ETFs and two commodity indexes. This thesis looks at a long investment time horizon, thus following a buy-and-hold strategy. Different risk levels will be investigated to see if the results are in compliance with Anson (1999), arguing that larger diversification benefits are obtainable for larger risk.

A portfolio optimization model was used to estimate optimal share per asset for different rate of returns based on historic prices. The period under investigation is mainly July 1993 to December 2010, but also January 2006 to December 2010. Whether historic prices are relevant for this investigation is a discussion outside this thesis, however, Bjornson and Carter (1997), investigating commodities in the period 1969-1994, and Fabozzi, Füss and Kaiser (2008) in 1970-2006 found similar return figures. Thus, even though the relevance might not be present, it is assumed to be a decent estimate.

The portfolio optimization model is based on Markowitz mean/variance portfolio model. The essence behind this theory is that diversification may reduce risk without reducing returns. Markowitz showed that the return from a portfolio is equal to the weighted average of the returns from the individual assets. The risk, on the other hand, may be smaller than the weighted average (Bodie & Rosansky 1980). By using the efficient set, it is possible to identify the tradeoff between risk and return, and thereby find the portfolio matching the objectives (etfs.bmo.com 2011a).

As the market index ranked highest in different performance measures, its risk and return has been taken as a basis when looking for diversification benefits. It is expected that an investor would demand a return at least as high as the markets, but seek to reduce the risk.

6.1.1 A portfolio consisting of commodities and MSCI World

Firstly, by using the Markowitz based model, a portfolio with the five commodities and MSCI W was optimized. The weights are presented in Exhibit 6.1. MSCI W as a standalone investment had an expected annual return of 6.6% with a standard deviation of 18% for the period July 1993- December 2010. Including the five commodities in a portfolio, minimizing the risk, could provide an expected annual return of 6.6% for a risk of 14.2%, which is lower than the risk for MSCI W alone. The weights for this portfolio would be 58% in MSCI W, 25% in sugar, 15% in palm oil and 2% in rice. In comparison, only palm oil had an equally high expected return as MSCI W for the same period, however, with a 33.6% risk. The risk free rate in this period was 4.1%, calculated by 3 months US$ LIBOR (dnbnor.no 2011). Bailin (Morningstar 2011) suggest a commodity allocation of four to ten percent in an investor's portfolio based on a historical view.

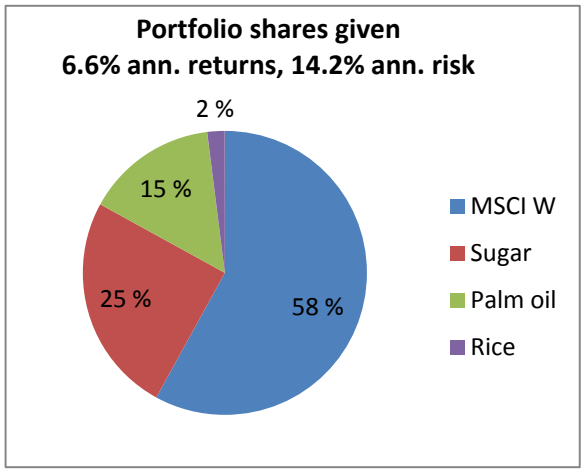


Exhibit 6.1: Portfolio shares for a portfolio of single commodities and the stock market index MSCI W. Annual return of 6.6% and annual risk of 14.2%. Historic data from the period 1990-2010.

For the period 2006-2010, all commodities had a much higher returns than earlier years. Annual returns ranged from 11% for wheat to 22% for corn and palm oil, whilst MSCI W, as most other stocks dropped, had an annual return of only 2.8% (see Exhibit 4.X). This period might not be representative for commodities in general. However, if Chris Newlands (2010) in Financial Times was right and a super cycle has started, features like this *could* be seen also in the years to come.

Palm oil provided the highest return amongst the commodities, and is therefore also the last asset standing when the return requirement reaches 22%. However, the standard deviation at this level is also high (annually 41.6%), confirming Anson's (1999) findings that, the more risk one is willing to take, the higher returns are obtainable. Minimizing risk for different rate of returns gave optimal shares per investment as seen in Exhibit 6.2.

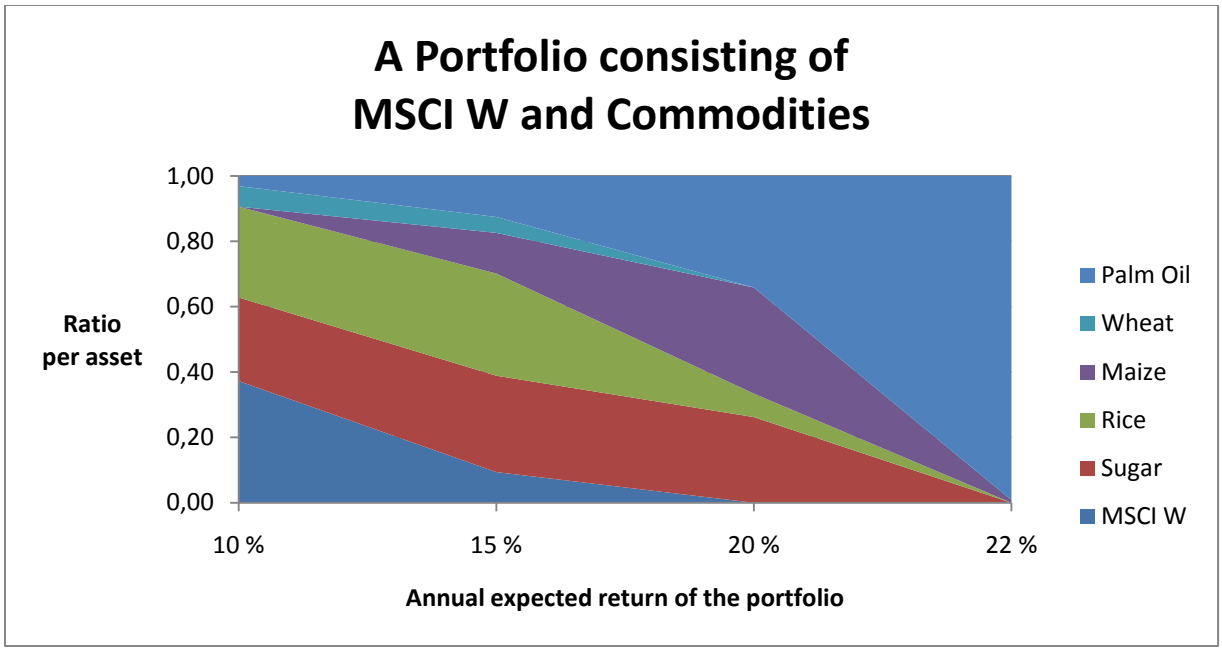


Exhibit 6.2: Shares for a portfolio consisting of commodities and MSCI W. 16.5% standard deviation for 10% annual return, 18.6% risk for 15% return, 25.5% risk for 20% return, 53.2% risk for 22% representing the efficient set of the portfolio return in the period 2006-2010. (See Appendix 6.1 for exact ratio numbers)

MSCI W had an annual standard deviation of 23.3% in this period however by including commodities in the portfolio it was possible to obtain almost 20% annual return at the same level of risk. Alternatively it was possible to obtain 2.8% return for 16.5% risk, much lower than 23.3%. Ankrim and Hensel (1993) supports that by including commodity indexes in a portfolio, an investor may achieve positive effects on risk and return. However, they pointed out the importance of the index being diversified across different commodities, and that the effect does not depend on the index construction or the index supplier. These five commodities are agricultural commodities only. If including a more diversified commodity index will provide an even better risk-return tradeoff will therefore displayed later.

In comparison of the period 2006-2010, MSCI W had an annual mean return of zero in the period 2000 to 2005. The markets return was in this case therefore not desirable. The period was, however, a period of stable growth for the commodities, and a diversified portfolio for this period would mostly contain commodities. The shares of a portfolio with 10% annual return may be seen in Exhibit 6.3 and contains 47% sugar, 16 % rice, 27% wheat, 2% palm oil and 8% MSCI W, for a 15.3% risk. Shares for portfolios holding different returns may be seen in Appendix 6.2.

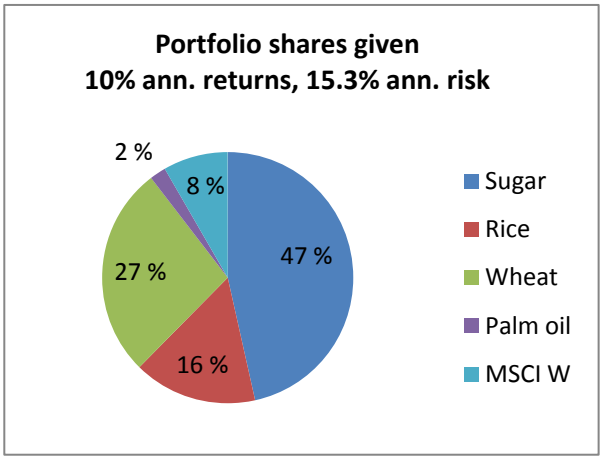


Exhibit 6.3: Portfolio shares for a portfolio of single commodities and the stock market index MSCI W. Annual return of 10% and annual risk of 15.3% Historic data from the period 2000-2005

The feasibility of including spot prices of commodities into a portfolio may not be realistic. The futures price approaches the spot price at delivery, but hardly any commodities trade at its spot price due to the costs and implications accompanying physical delivery. Seasonal patterns are not excluded from the computing of portfolios with spot price commodities. Analyzes of the effects of seasonal patterns show that there are significant differences in risk and returns after smoothing the data. Therefore, in reality an investor may not hold the commodities throughout a whole year. It is still assumed that analyzing their behavior in a portfolio may provide information of commodities in general. Including ETFs in a portfolio is emphasized as a more feasible solution for the average investor.

6.1.2 A portfolio consisting of commodity based exchange traded funds and MSCI World

As many investors already noticed, ETFs allows for an efficient way to expose themselves to commodities in various ways. They are ideal for building portfolios because of their flexibility, low costs and wide range of investment options (etfs.bmo.com 2011a). Trading with ETFs makes it possible to *short* the investment. The analysis in the previous part of this thesis concluded that the ETFs literally track their underlying indexes, therefore, ETF data are backtracked to July 1993 by using historical data for the underlying assets.

In the period 1993-2010 the three ETFs provided an annual return lower than MSCI W in addition to having higher standard deviations. The optimal result was therefore a portfolio of 100% MSCI W as

long as the aim was to keep market return. In other words, the ETFs could not provide diversification effects to the portfolio.

The ETFs would have to perform at least as good as the market index (6.6%) to be included in a portfolio. ETF sugar had an annual return of 6.3% in the period 1993-2010. If the return requirement is lowered to 6.3%, the portfolio yields a risk of 15.3% which is less than the risk of the stock index. This portfolio shares would be 72% MSCI W, 18% ETF sugar and 10% ETF soft, as sees from Exhibit 6.4.

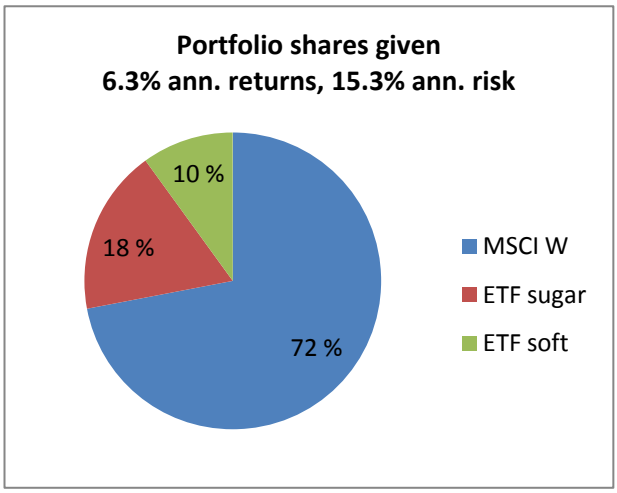


Exhibit 6.4: Portfolio shares for a portfolio of ETFs and the stock market index MSCI W. Annual return of 6.3% and annual risk of 15.3%. Historic data from the period 2000-2005

Conversely, by rising the returns of all ETFs 5% annually, ETF soft, sugar and wheat would return respectively 4.8%, 6.65% and -5%. An increase like this would be large enough to make ETF sugar and soft valuable as part of a portfolio. The optimal weights would be 76.4% MSCI W, 23% ETF sugar and 0.6% ETF soft. The risk would be 16%, which is 2% lower than MSCI W alone. The question then arises whether it is likely that the ETFs yield 5% higher returns? Appendix 6.3 lists the average annual return for each year from 1993 through 2010 for ETF soft and sugar. Out of the last 18 years, ETF soft had a higher return than 4.8% 7 times, and ETF sugar had higher than 6.65% 10 times. This indicates that it is possible to obtain these values; however, it is not likely to happen every year and furthermore it is impossible to say whether they will provide these returns again the next years.

Furthermore, allowing for short sale of ETFs opens up to additional possibilities; the markets return (6.6%) could be kept, for a lower standard deviation. The expected return may be endless when shorting; however the standard deviation will be endless to. Exhibit 6.5 lists possible investment shares for obtaining different risk and return values. A return of 6.6% (MSCI W alone) may be obtained by taking a small short position in ETF wheat (which had a negative return over the period), and a long position in the three others. An expected return of 15% may be obtained by mainly taking a larger short-position in ETF soft and a larger long-position in the others.

Expected return	MSCI W	ETF soft	ETF sugar	ETF wheat	Ann.st.dev of portfolio
5 %	0.55	0.29	0.08	0.08	0.145
6.6 %	0.64	0.30	0.11	-0.05	0.151
10 %	0.85	0.32	0.18	-0.35	0.191
15 %	1.15	0.35	0.29	-0.78	0.283

Exhibit 6.5: Efficient set for a portfolio consisting MSCI W and ETFs where shorting is allowed for. Historical data for the period 1993-2010.

Between 2006 and 2010 all ETFs had higher returns than MSCI W (2.8%), however, still much lower than spot-price commodity returns. With MSCI W returns as the requirement for the portfolio, risk could be reduced (from 23.3% to 20.6%) by constructing a portfolio of 62% MSCI W, 31% ETF soft and 7% ETF sugar. Higher returns are obtainable, but to provide a higher return than 6.1% (ETF soft), it is necessary to allow for shorting. Exhibit 6.6 shows the shares for the discussed portfolios and the efficient set for portfolios with shorting.

Expected return	MSCI W	ETF soft	ETF sugar	ETF wheat	Annual st. dev of portfolio
2.8%	0.62	0.31	0.07	0.0	0.20
5 %	0.43	0.33	0.18	0.06	0.17
10 %	-0.28	1.23	-0.15	0.21	0.39
15 %	-0.99	2.13	-0.48	0.35	0.67
20 %	-1.71	3.04	-0.82	0.49	0.97

Exhibit 6.6: Portfolio shares for portfolio with return equal to the markets and the efficient set for a portfolio consisting MSCI W and ETFs where shorting is possible. Historical data from 2006-2010.

The returns from the ETFs were higher for sugar and lower for the two others in 2000-2005 than in 1993-2010. This implies that a well diversified portfolio in this period should consist of MSCI W and ETF sugar. The optimization model suggests a portfolio of 51% MSCI W, 44% ETF sugar and 5% ETF soft, for a return of 10% and a risk of 16.8%. For other portfolio shares, see Appendix 6.4 or Appendix 6.5 for portfolios with shorting.

6.1.3 A portfolio consisting commodity indexes and MSCI World

A portfolio optimization model was run for MSCI W along with two commodity indexes to see whether a broad diversified index may provide better diversification than the five single agricultural commodities addressed in this thesis. The two are: DJ-UBS Commodity Index (DJ-UBS CI) consisting of 23 commodities including agricultural, metals, livestock and energy and S&P Goldman Sachs Commodity Index (S&P GSCI) consisting 24 commodities including energy products, metals and agricultural products).

To obtain an expected return of 6.6%, the portfolio gave a risk of 14.6% and a portfolio consisting of 57% DJ-UBS CI and 43% MSCI W (Exhibit 6.7). 14.2% risk was found in the portfolio of MSCI W and single commodities, in fact, lower than with the indexes. This indicates that there is no further diversification effect from including several additional commodities.

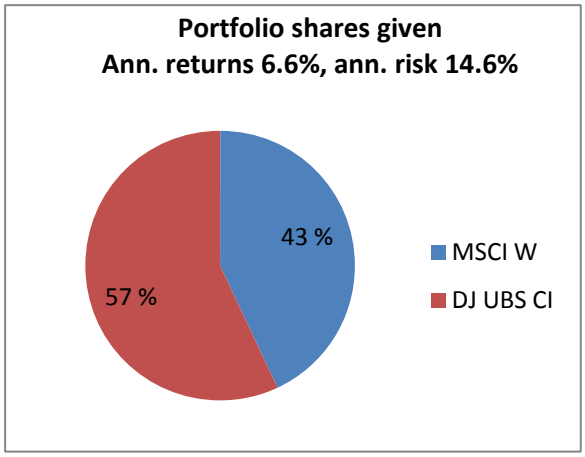


Exhibit 6.7: Portfolio shares for a portfolio of ETFs and the stock market index MSCI W. Annual return of 6.3% and annual risk of 15.3%. Historic data from the period 2000-2005

In 2007, S&P GSCI experienced its best year since 2001 (Flood 2008). However, in early 2008 a rapid price decrease destroyed the positive trend resulting in a negative average annual return of almost 7% for the commodity index (see Appendix 6.6). DJ-UBS, consisting of many of the same assets ended up with an annual return close to zero. Hence, there would have been no diversification effects from including an index diversified across different commodities rather than the five agricultural commodities. However, the two commodity indexes are highly correlated with each other (0.9), and they are correlated to MSCI W by 0.23 and 0.30, (Appendix 6.7) which is higher than the correlation between MSCI W and any of the single commodities.

6.2 Concluding points on portfolio compositions

MSCI W had an annual return of 6.6% throughout the period 1993-2010. The spot price commodity returns was equally high for some commodities (costs not excluded). However, higher standard deviations make them unsuitable as standalone investments. The ETFs had lower performance than

the physical commodities, due to costs of rolling contracts and the exposure to negative roll return (if the market is in contango).

The aim of running a portfolio optimization model on the investigated assets was to find out whether they could bring any positive diversification effects to a portfolio of stocks. The results are all pointing in the same direction; including commodities in a portfolio may help to spread the risk and thereby lowering it, while still providing the same expected return as the market.

By including spot price commodities to the portfolio, the risk was reduced from 18% to 14.6% for a 6.6% return. However, this raised the question of whether it is feasible to invest in spot prices of these commodities. If not, buying and rolling futures contracts would be the closest alternative. This on the other hand brings a number of costs and disadvantages, as discussed earlier, leaving ETFs the most feasible alternative. ETFs, however, had lower returns than MSCI W, and thereby, the optimal portfolio for keeping the market return was 100% MSCI W. If the returns from the ETFs were only 5% higher over the period, two of the three could provide benefits by being included in a portfolio, reducing the risk from 18% to 16%.

Many ETFs are possible to sell short. This opens up for the possibility of increased returns, however, also increasing the risk. As an example, ETF wheat had negative average return over the period of investigation and could provide benefits if shorted. However, it is impossible to say whether this trend will continue. Erb and Harvey (2006) state that thinking of past performance as a forecast for future performance is dangerous. They follow with pointing out that future price expectations should be based on an understanding of fundamental drivers, and that past returns may only be a guide if the future return drivers are the same as in the past.

The period 2006-2010 was characterized by high commodity-, and low stock returns. This is explained by Gorton and Rouwenhorst (2006), arguing that commodities perform well in early stages of recession , at a time where stocks tend to disappoint. Holding commodities in a portfolio with stocks could provide valuable diversification effects. Whether the increased prices in this period are due to the behavior of the commodities in the business cycle or due to the start of a commodity super cycle is beyond the scope of this thesis. Nevertheless, the overall conclusion from computing several portfolios implies that there are potential diversification effects from holding commodities in a portfolio with stocks. The share of commodities depends on the stage of the business cycle.

7. Conclusions

This thesis presents analyses of the relationship between risk and return for five agricultural commodities traded at spot prices, and three commodity based exchange traded funds. The examined assets are: sugar, rice, corn, wheat and pail oil, ETF sugar, ETF wheat and ETF soft. They are compared to each other and to the stock market index, MSCI World. The analyses were considered in the total period 1990-2010 in addition to two sub-periods, 1990-2005 and 2006-2010. The last period was characterized by two global crises; the financial crisis and the food crisis.

Several analyses have proven that physical commodities were not profitable as standalone investments. This is argued to be due to lower risk-adjusted returns than stocks, caused by high volatility in prices. In addition, the drawbacks of buying the physical good, e.g. storage costs, insurance and cost of carry, are not considered in this analysis. Commodities tend to have low correlation with stocks, implying low systematic risk. Hence, commodities may provide valuable diversification effects when included in a portfolio of stocks. This confirms the findings of Bodie and Rosansky (1980).

The first sub-period examined was characterized by more stable prices and lower commodity risk adjusted returns than the 20 year period. The 2007-2008 recession and food crisis affected the latest sub-periods outcome from the analyses. The returns of the five commodities from this period were up to 55 times higher than during the first sub-period. In comparison the stock market index decreased by 60% on average. Naturally, the standard deviation also increased in the latest period. Performance measurements imply that with these figures, commodities might be profitable even as standalone investments. Investors should especially consider exposure to commodities in times of recession and low inflation, when stocks tend to have a low performance. The two sub-periods analyzed in this thesis follow these trends and thereby confirms previous research.

Creating a portfolio of stocks and broad diversified commodity indexes does not provide any diversification effects beyond including single commodities in the portfolio. This is in contrast to research by Ankrim and Hensel (1993), expressing the importance of diversifying the index across different commodities when investing.

Exchange traded funds represent a relatively new investment possibility meaning there is a shortage in available data. Exchange traded funds are passively track their underlying indexes to a high extent. Naturally, the correlation between an exchange traded fund and spot prices of the underlying

commodity is high. Analyses of exchange traded funds generally identify a poorer performance than its respective spot prices, partly due to unconsidered costs. Nevertheless, they too provide diversification effects in portfolios. Most exchange traded funds may be sold short, allowing for more flexibility from investing.

The above conclusions are based on historical prices, and are not considered a good prediction of the future. Nevertheless, the overall conclusions are that commodities bring valuable diversification effects to a portfolio of shares. Exchange traded funds are, despite their rather poor historical performance, assumed to be the most feasible way for the average investor to expose himself to commodities. Thereby avoiding the inconveniences of storing the physical good, due to exchange traded funds characteristics, reducing the costs of rolling future contracts.

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Appendix chapter 4: Empirical analysis of risk and return in commodity markets

Appendix 4.1: Seasonal patterns 1990-2005:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Sugar	-0.01	*-0.04	0.02	0.01	-0.03	0.03	0.02	0.00	-0.02	-0.01	-0.01	0.03
Rice	0.02	0.03	-0.01	*-0.04	0.02	-0.01	-0.01	0.00	0.00	0.00	-0.01	*0.04
Corn	0.01	0.01	0.03	0.02	0.01	-0.01	*-0.04	*-0.04	0.01	-*0.07	0.03	*0.04
Wheat	-0.01	-0.01	-0.02	0.00	0.00	-0.01	*-0.07	-0.01	*0.04	*0.03	0.03	0.02
Palm oil	0.00	-0.02	0.02	0.00	0.01	-0.03	-0.02	0.01	0.03	-0.03	*0.04	0.02

Appendix 4.1: Seasonal patterns, 1990-2005.

Appendix 4.2: Seasonal patterns 2006-2010:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Sugar	*0.10	0.06	-0.03	-0.09	0.01	-0.01	*0.09	0.03	-0.01	0.00	0.04	-0.02
Rice	-0.01	0.03	0.02	0.08	0.01	0.02	-0.03	-0.01	-0.02	0.01	-0.02	0.02
Corn	*0.12	-0.02	0.03	-0.01	0.03	0.02	-0.05	-0.05	0.01	0.01	*0.14	-0.03
Wheat	0.04	-0.02	0.03	-0.05	0.00	0.03	-0.03	0.07	0.00	-0.03	0.05	0.01
Palm oil	0.01	0.01	*0.13	0.03	0.03	0.00	-0.01	0.05	-0.04	-0.01	-0.07	0.10

Appendix 4.2: Seasonal patterns, 2006-2010.

Appendix 4.3: Stylized facts real prices 1990-2005 :

	Mean prises	Std.devn	Var.coeff.	Min	Max
Sugar	9.97	2.32	0.23	4.98	15.87
Rice	257.42	61.53	0.24	168.00	410.00
Corn	235.44	55.46	0.24	145.50	512.50
Wheat	374.31	77.35	0.21	243.00	727.50
Palm oil	425.58	123.45	0.29	190.00	770.00
MSCI W	2218.10	843.26	0.38	916.25	3772.50

Appendix 4.3: Descriptive statistic for the five commodities and MSCI World. Real prices 1990-2005

Appendix 4.4: Stylized facts real prices 2006-2010 :

	Mean prices	Std.devn	Var.coeff.	Min	Max
Sugar	17.12	6.19	0.36	10.53	39.14
Rice	479.31	167.61	0.35	297.00	1040.00
Corn	364.49	103.18	0.28	193.50	680.50
Wheat	630.66	179.80	0.29	409.00	1247.00
Palm oil	742.39	247.30	0.33	380.00	1470.00
MSCI W	3982.10	654.20	0.16	2196.90	5133.80

Appendix 4.4: Descriptive statistic for the five commodities and MSCI W. Real prices 2006-2010

Appendix 4.5: Stylized facts 1990-2005 :

	Annual mean returns	An.standard deviation	Ann.mean returns smoothed	Ann.st.dev Smoothed
Sugar	0.004 (0.35)	0.30	-	-
Rice	*0.026 (3.14)	0.24	-	-
Corn	-0.012 (-1.46)	0.25	0.173	*0.106 (2.45)
Wheat	0.002 (0.28)	0.25	0.205	-0.014 (-0.30)
Palm oil	*0.022 (2.74)	0.24	-	-
MSCI W	*0.070 (13.66)	0.15	-	-

Appendix 4.5: Descriptive statistics for the five commodities and MSCI W, logarithmic changes, 1990-2005.
T-values in parentheses. *indicates significance at a 5% level.

Appendix 4.6: Stylized facts 2006-2010 :

	Annual mean returns	Ann.standard deviation	Ann. Mean returns Smoothed	Ann.st.dev Smoothed
Sugar	*0.17 (7.80)	0.34		
Rice	*0.12 (6.55)	0.30		
Corn	*0.22 (9.40)	0.37	0.309	*0.290 (2.10)
Wheat	*0.11 (5.04)	0.36	0.308	0.078 (0.57)
Palm oil	*0.22 (8.73)	0.42		
MSCI W	*0.28 (19.47)	0.23		

Appendix 4.6: Descriptive statistics for the five commodities and MSCI W, logarithmic changes, 2006-2010.
T-values in parentheses. *indicates significance at a 5% level.

Appendix 4.7: F-test for difference in variance between the periods, 2006-2010:

	Annual variance 1990-2005	Annual variance 2006-2010	F-value
Sugar	0.021	0.027	1.26
Rice	0.013	0.021	1.61
Corn	0.014	0.032	2.28
Wheat	0.014	0.030	2.07
Palm oil	0.013	0.040	*3.11
MSCI W	0.005	0.013	2.47

Appendix 4.7: F-test for significant differences between 1990-2005 and 2006-2010. * indicates significant value at a 5% level.

Appendix 4.8 F-test for difference in variance between commodities and MSCI W. 1990-2010:

	Sugar	Rice	Corn	Wheat	Palm oil
Sugar	-	-	-	-	-
Rice	*0.66	-	-	-	-
Corn	*0.81	*1.22	-	-	-
Wheat	*0.79	*1.19	0.97	-	-
Palm oil	*0.85	*1.28	*1.04	*1.07	-
MSCI W	*0.55	*0.83	*0.68	*0.70	*0.65

Appendix 4.8: F-test of variance, weekly data 1990-2010.
*** indicates significant values at a 5% level. For the total period the upper F-critical for the commodities are 1.03 and the lower F-critical is 0.97 Upper F-critical is found in the F-table for α=0.05, lower value found by the inverse of F: 1/F-critical.**

Appendix 4.9: Test for normality 1990-2005

	Chi^2	Skewness	Excess kurtosis
Sugar	72.30	-0.33	1.88
Rice	768.20	3.44	46.49
Corn	128.07	-0.41	2.83
Wheat	80.15	0.02	1.84
Palm oil	303.35	-0.01	4.47
MSCI W	601.48	-0.34	7.79

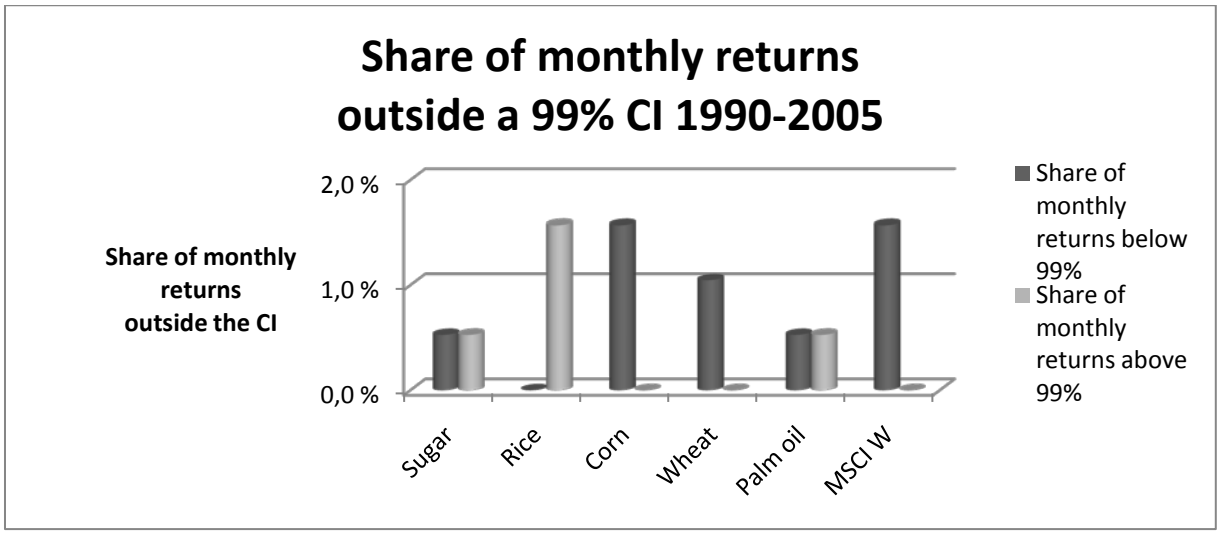
Appendix 4.9: Results for testing for normality, skewness and excess kurtosis, 1990-2005.

Appendix 4.10: Test for normality 2006-2010.

	Chi²	Skewness	Ex. Kurtosis
Sugar	20.08	-0.11	1.45
Rice	687.15	1.43	27.83
Corn	16.55	-0.53	1.44
Wheat	7.08	0.36	0.63
Palm oil	156.53	-3.57	36.75
S&P GSCI	12.12	-0.50	1.02
MSCI W	88.27	-0.44	4.34

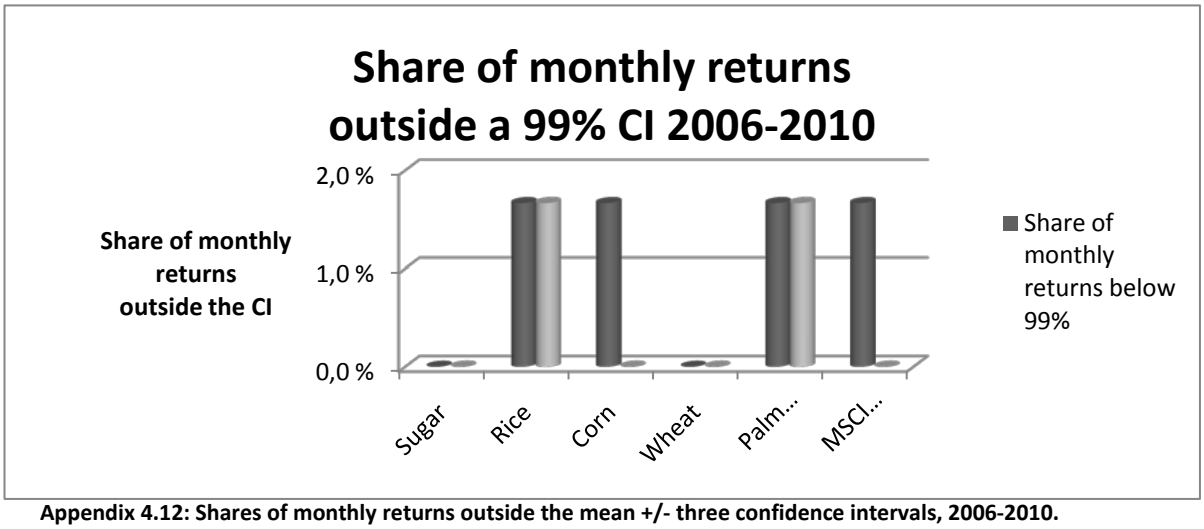
Appendix 4.10: Results for testing for normality, skewness and excess kurtosis, 2006-2010.

Appendix 4.11. Degree of fat tails 1990-2005:



Appendix 4.11: Share of monthly values outside a 99% confidence interval

Appendix 4.12: Degree of fat tails 2006-2010:



Appendix 4.12: Shares of monthly returns outside the mean +/- three confidence intervals, 2006-2010.

Appendix 4.13, correlation matrix 2000-2005:

	Sugar	Rice	Corn	Wheat	Palm oil	MSCI W
Sugar	1					
Rice	-0.13 (-1.12)	1				
Corn	-0.13 (-1.11)	*0.24 (2.07)	1			
Wheat	0.15 (1.28)	-0.06 (-0.53)	0.23 (1.96)	1		
Palm oil	-0.15 (-1.24)	0.00 (0.04)	0.20 (1.72)	-0.07 (-0.62)	1	
MSCI W	0.01 (0.07)	0.21 (1.80)	0.06 (0.50)	-0.02 (-0.20)	0.10 (0.82)	1

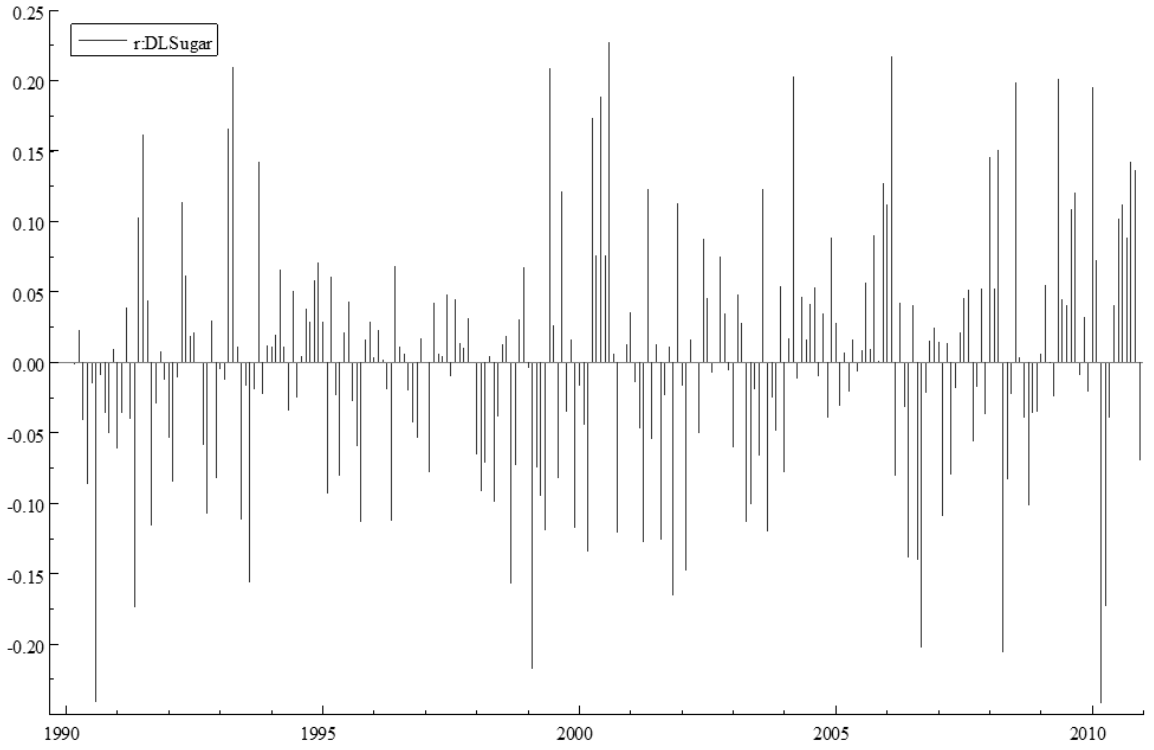
Appendix 4.13: Correlation matrix, monthly data, 2000 to 2005.
Coefficient significant at 0.233 or higher. N=71 t-critical=1.99

Appendix 4.14: Beta-values and share of systematic risk

	1990-2005		2006-2010		2000-2005	
	β	R^2	β	R^2	β	R^2
Sugar	-0,03	0,00	0,00	0,00	0,09	0,00
Rice	0,06	0,00	0,09	0,00	0,14	0,04
Corn	0,07	0,00	0,84	0,22	0,08	0,00
Wheat	0,00	0,00	0,78	0,21	-0,03	0,00
Palm oil	0,09	0,00	0,39	0,05	0,15	0,01

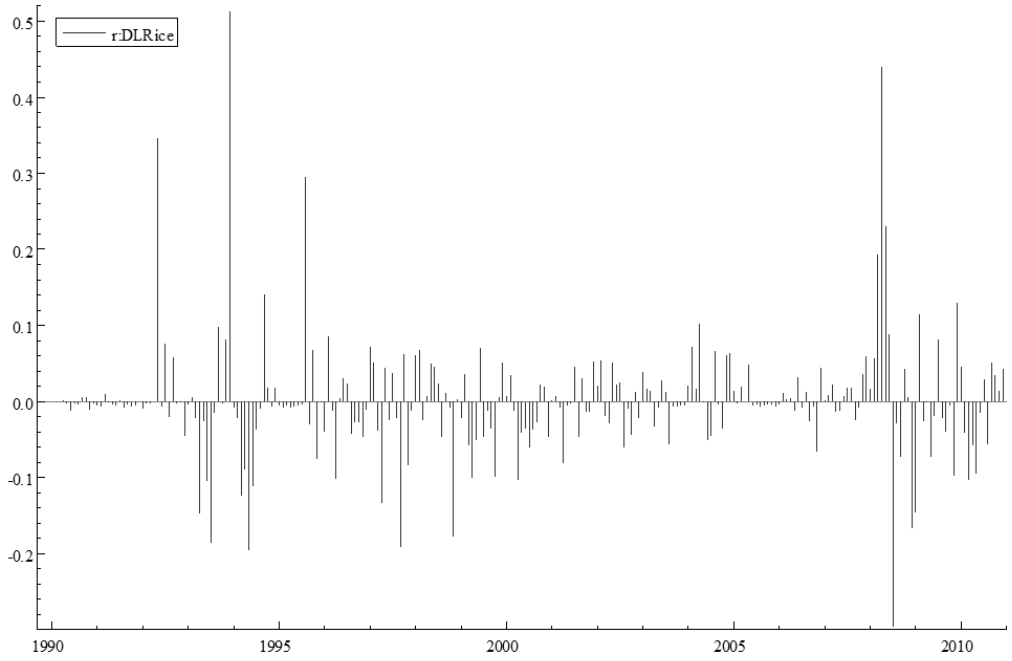
Appendix 4.14: Beta-values for the three periods, MSCI W as benchmark.
T-value in parentheses. *indikerer signifikante verdier.

Appendix 4.15: Plot of residuals sugar



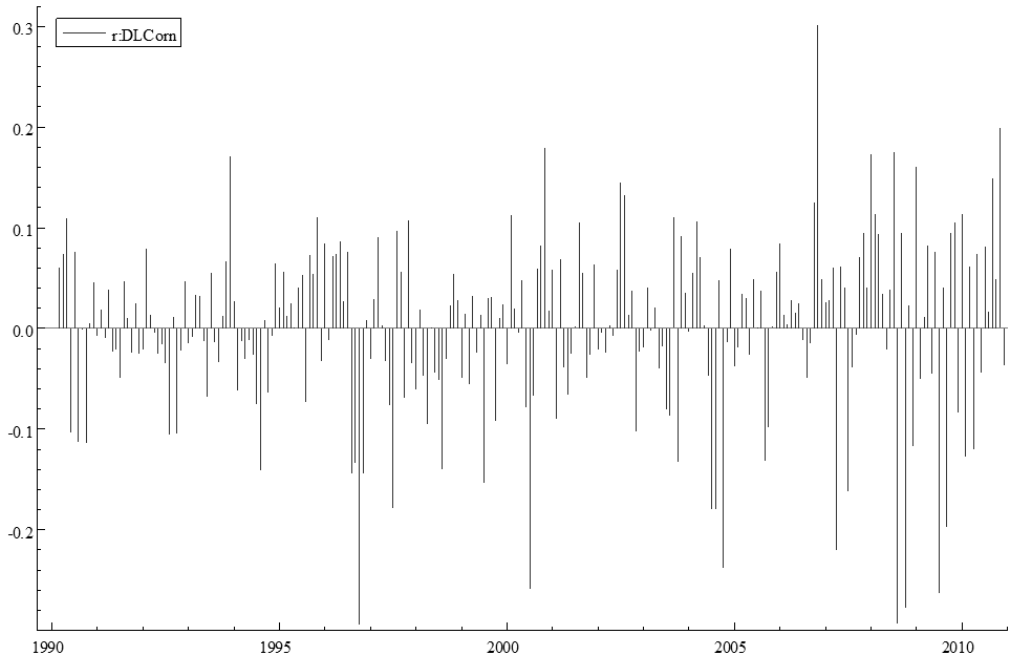
Appendix 4.15: Plot of residuals sugar against MSCI W 1990-2010

Appendix 4.16: Plot of residuals rice



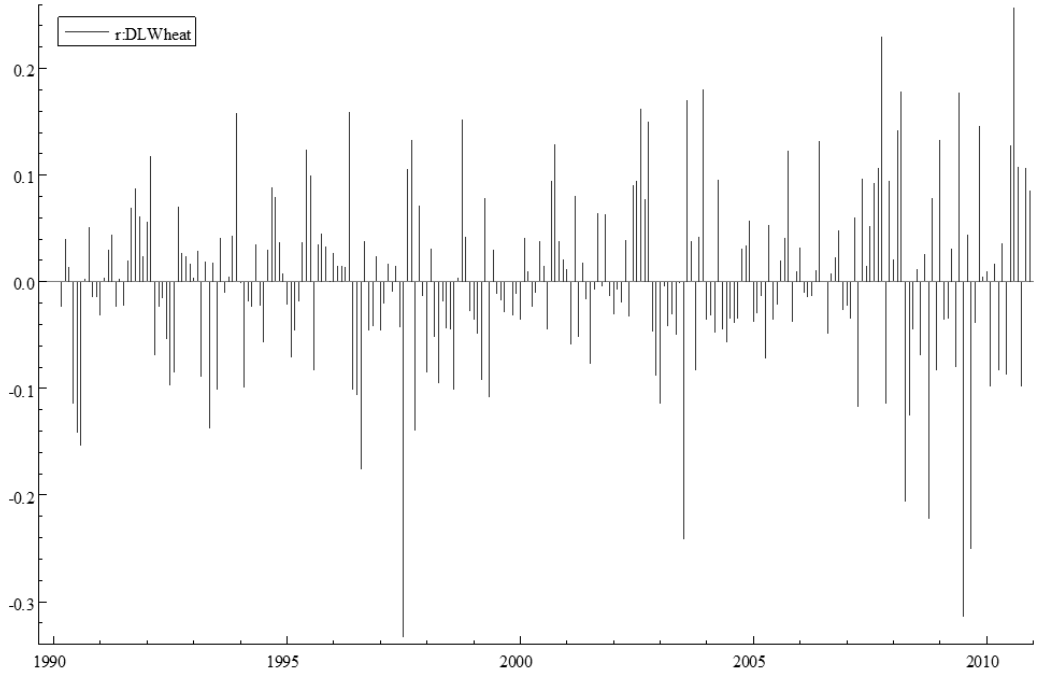
Appendix 4.16: Plot of residuals rice against MSCI W 1990-2010

Appendix 4.17: Plot of residuals corn



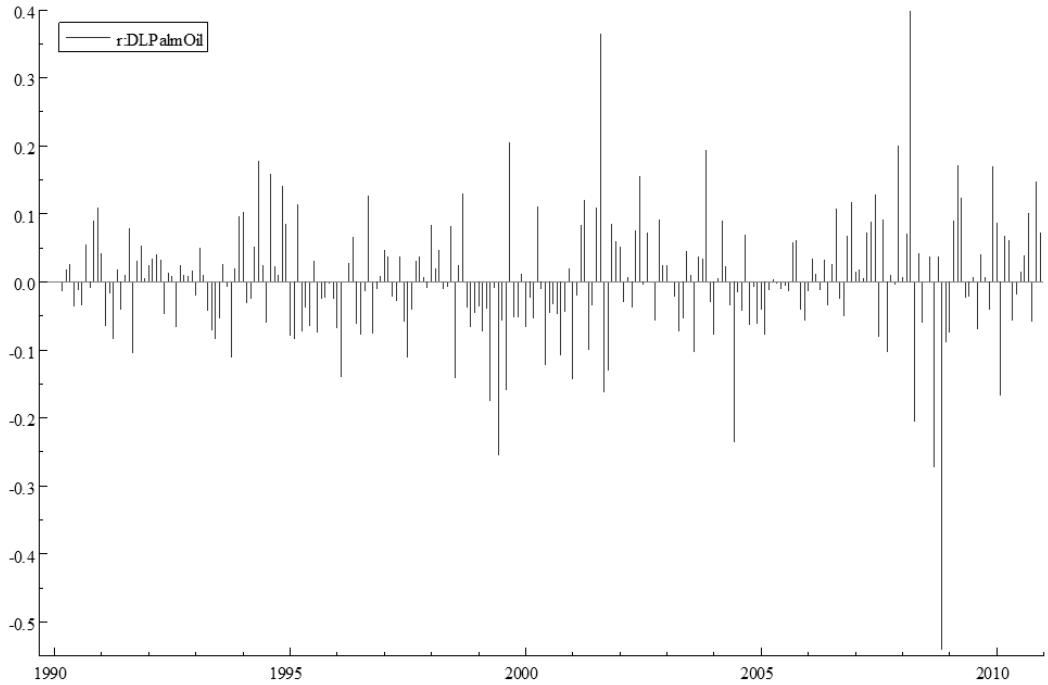
Appendix 4.17: Plot of residuals corn against MSCI W 1990-2010

Appendix 4.18 Plot of residuals wheat:



Appendix 4.18: Plot of residuals wheat against MSCI W 1990-2010

Appendix 4.19: Plot of residuals palm oil



Appendix 4.19: Plot of residuals palm oil against MSCI W 1990-2010

Appendix chapter 5: Exchange traded funds and tracking of underlying indexes.

Appendix 5.1 DJ-UBS commodity index contract schedule:

Commodity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	F	G	H	J	K	M	N	Q	U	V	X	Z
Natural Gas	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Crude Oil	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Unleaded Gas	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Heating Oil	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Live Cattle	JUN	JUN	AUG	AUG	OCT	OCT	DEC	DEC	FEB	FEB	APR	APR
Lean Hogs	JUN	JUN	JUL	AUG	OCT	OCT	DEC	DEC	FEB	FEB	APR	APR
Wheat	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Corn	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Soybeans	MAY	JUL	JUL	NOV	NOV	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Soybean Oil	MAY	JUL	JUL	DEC	DEC	DEC	DEC	JAN	JAN	MAR	MAR	MAY
Aluminum	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Copper	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Zinc	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Nickel	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Lead	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Tin	MAY	JUL	JUL	SEP	SEP	NOV	NOV	JAN	JAN	MAR	MAR	MAY
Gold	JUN	JUN	AUG	AUG	DEC	DEC	DEC	DEC	FEB	FEB	APR	APR
Silver	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Platinum	JUL	JUL	JUL	OCT	OCT	OCT	JAN	JAN	JAN	APR	APR	APR
Sugar	MAY	JUL	JUL	OCT	OCT	OCT	MAR	MAR	MAR	MAR	MAR	MAY
Cotton	MAY	JUL	JUL	DEC	DEC	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Coffee	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY
Cocoa	MAY	JUL	JUL	SEP	SEP	DEC	DEC	DEC	MAR	MAR	MAR	MAY

[1]This contract schedule and roll methodology reflect the rules of the Dow Jones-UBS Commodity Index℠ and its subindexes as of June 2010. This schedule and other index rules are subject to change over time.

Appendix 5.1: Contract schedule G-F3, (etfsecurities 2011)

Appendix 5.2: T-test for difference in returns:

	T-values 1990-2010			T-values 1990-2005			T-values 2006-2010		
	Mean	Sugar	Wheat	Mean	Sugar	Wheat	Mean	Sugar	Wheat
DJ UBS soft	0.00	*-13.20	-	0.00	*-3.93	-	0.01	*-7.25	-
DJ UBS sugar	0.01	*5.22	-	0.01	*11.62	-	0.00	*-5.50	-
DJ UBS wheat	0.00	-	*-21.61	0.00	-	*-20.92	0.00	-	*-3.50

Appendix 5.2: T-values for difference between monthly mean returns spot versus futures. * indicates significance values at a 5% level.

Appendix 5.3: F-test for difference in variance:

	F-test 1990-2010	
	Sugar	Wheat
DJ UBS sugar	*0.48	-
DJ UBS wheat	-	1.20
DJ UBS soft	0.91	-

Appendix 5.3: F-values for difference in variance from 1991-2010 based on monthly data.*indicates significance values at a 5% level.

Appendix chapter 6: Can commodities or exchange traded funds bring positive diversification effects to a portfolio of stocks?

Appendix 6.1. Portfolio shares of commodities and MSCI World 2006-2010:

Return	MSCI W	Sugar	Rice	Maize	Wheat	Palm Oil	Ann.st.dev of portfolio
10 %	0.37	0.26	0.28	0.00	0.06	0.03	0.165
15 %	0.09	0.29	0.31	0.12	0.05	0.13	0.186
20 %	0.00	0.26	0.07	0.32	0.00	0.34	0.255
22 %	0.00	0.00	0.00	0.01	0.00	0.99	0.432

Appendix 6.1: Ratios of the assets in a portfolio consisting of commodities and MSCI W. Period 2006-2010

Appendix 6.2. Portfolio shares of commodities and MSCI World 2000-2005:

Return	MSCI W	Sugar	Rice	Corn	Wheat	Palm oil	Ann. st. dev. of portfolio
5,8 %	0.13	0.13	0.48	0.01	0.15	0.10	0.09
10 %	0.08	0.47	0.16	0.00	0.27	0.02	0.15
14 %	0.00	1.00	0.00	0.00	0.00	0.00	0.28

Appendix 6.2: Portfolio shars for different returns. Hisorical data from 2000-2005

Appendix 6.3. Annual returns each year, ETF soft and sugar:

Year	DJ-UBS Soft	DJ-UBS Sugar
1993	0.016	**0.112**
1994	**0.365**	**0.288**
1995	**0.085**	**0.086**
1996	**0.099**	**0.138**
1997	**0.321**	**0.230**
1998	-0.187	-0.429
1999	-0.219	-0.279
2000	-0.021	**0.508**
2001	-0.215	-0.072
2002	**0.192**	**0.283**
2003	-0.052	-0.129
2004	0.005	0.060
2005	0.036	**0.323**
2006	-0.069	-0.179
2007	-0.083	-0.219
2008	-0.270	-0.131
2009	**0.310**	**0.445**
2010	**0.419**	**0.285**

Appendix 6.3: Years of returns above 4.8% for ETF soft and 6.65% for ETF sugar between 1993 and 2010

Appendix 6.4. Portfolio shares ETFs and MSCI W 2000-2005:

Return	MSCI W	ETF soft	ETF sugar	ETF wheat	Ann.st. dev. of portfolio
5 %	0.41	0.26	0.24	0.09	0.14
10 %	0.51	0.05	0.44	0.00	0.17
15 %	0.18	0.00	0.82	0.00	0.24
17 %	0.00	0.00	1.00	0.00	0.29

Appendix 6.4: Portfolio shares, historical data 2000-2005.

Appendix 6.5. Portfolio shares ETFs and MSCI W 2000-2005, shorting:

Return	MSCI W	ETF soft	ETF sugar	ETF wheat	Ann.st.dev. of portfolio
5 %	0.41	0.26	0.24	0.09	0.14
10 %	0.52	0.15	0.39	-0.07	0.17
15 %	0.64	0.03	0.55	-0.22	0.21
20 %	0.76	-0.08	0.71	-0.38	0.25
25 %	0.87	-0.20	0.86	-0.53	0.30
30 %	0.99	-0.32	1.02	-0.69	0.34

Appendix 6.5: Portfolio shares of ETFs and MSCI W, shorting possible, historical data from the period 2000-2005

Appendix 6.6 Descriptive statistics for DJ-UBSCI and S&P GSCI:

	1990-2010		1990-2005		2006-2010	
	Ann. mean returns	Ann. St. dev.	Ann. mean returns	Ann. St.dev	Ann. mean returns	Ann. St. dev
S&P GSCI	0.044	0.013	0.080	0.197	-0.069	0.312
DJ UBS CI	0.056	0.016	0.075	0.125	-0.001	0.234

Appendix 6.6: Descriptive statistics for the commodity indexes DJ_UBSCI and S&P GSCI for the total period and the two sub-periods.

Appendix 6.7: Correlation matrix of commodities, commodity indexes and MSCI W.

	Sugar	Rice	Corn	Wheat	Palm	S&P GSCI	MSCI W	DJ UBS
Sugar	1	-	-	-	-	-	-	-
Rice	-0.02	1	-	-	-	-	-	-
Corn	0.15	-0.03	1	-	-	-	-	-
Wheat	0.18	-0.05	0.47	1	-	-	-	-
Palm	-0.01	0.03	0.03	-0.02	1	-	-	-
S&P GSCI	-0.02	0.03	-0.01	-0.02	0.01	1	-	-
MSCI W	-0.06	0.01	0.00	-0.02	0.07	0.23	1	-
DJ UBS	-0.02	0.04	0.01	0.00	0.02	0.90	0.31	1

Appendix 6.7Correlation between commodities, commodity indexes and MSCI W