ANALYSIS OF THE RELATIONSHIP BETWEEN AGRICULTURAL COMMODITY SPOT PRICES AND FINANCIAL TRADING ACTIVITIES

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Ich erkläre hiermit an Eides statt, dass ich die vorliegende Masterarbeit selbständig angefertigt habe. Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht.

Die Arbeit wurde bisher weder in gleicher noch in ähnlicher Form einer anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

Wien, Mai 2012

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Key words

Agricultural commodities; spot markets; futures markets; hedging; speculation; index funds; financialization; theory of storage; unit-root test; Granger-causality test.

Summary

There exists widespread belief that speculation in agricultural commodities has led to rising agricultural commodity spot prices in the years 2007-2008 and 2011. In order to reassess the substance of this assertion, this thesis investigates causal relationships between spot prices and futures trading activities. Theoretical considerations concerning the spot and futures markets are discussed and then spot prices for maize, wheat, rice and soybean as well as financial variables such as open interest long and volume traded are empirically tested for Granger-causality. There is a lack of a theoretical link in the literature between the change in agricultural commodity futures positions and the change in agricultural commodity spot prices. However, six rejected null-hypotheses out of 32 show little empirical evidence for causal relationships. The empirical findings raise doubts as to the belief that speculation is a major driver of rising agricultural commodity prices. Therefore, policy makers should rather support risk reducing measures on the physical demand and supply side. Moreover, political interventions in futures markets are not primarily seen as helpful in reducing agricultural commodity spot price volatility.

Zusammenfassung

Es ist die Aussage vorherrschend, dass Spekulationen am Finanzmarkt mit Futures auf agrarische Güter zu einer erheblichen Steigerung der Kassapreise von agrarischen Gütern in den Jahren 2007-2008 und 2011 geführt haben. Diese Masterarbeit untersucht die kausalen Beziehungen zwischen Kassapreisen und Finanzhandelsaktivitäten. In einem ersten Schritt sind die theoretische Grundlagen von Kassa- und Warenterminmärkte erklärt. Anschließend sind die Kassapreise von Mais, Weizen, Reis und Soja und die Finanzvariablen Open Interest Long und Volume Traded empirisch auf Granger-Kausalität getestet. Aus der Literatur konnten wenige theoretische Beziehungen zwischen den Kassapreisen und Finanzhandelsaktivitäten gefunden werden. Sechs verworfene Null-Hypothesen von insgesamt 32 empirisch getesteten zeigen weiters einen schwachen kausalen Zusammenhang auf. Die empirischen Erkenntnisse lassen Zweifel an der Aussage aufkommen, dass Spekulation mit

Lebensmitteln am Finanzmarkt einen Einfluss auf die Kassapreise von agrarischen Gütern hat. Aus diesem Grund sollten die politischen EntscheidungsträgerInnen in erster Linie risikominimierende Maßnahmen auf der physischen Nachfrage- und Angebotsseite setzen. Desweiteren werden politische Eingriffe in Futuresmärkte, um die Volatilität der Kassapreise von agrarischen Gütern zu reduzieren, als nicht sehr hilfreich angesehen.

Contents

List of abbreviations

ADF	Augmented Dickey–Fuller (test)
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
CBOT	Chicago Board Of Trade
CFTC	Commodity Futures Trading Commission
COMEX	Commodity Exchange
COT	Commitment Of Traders (of CFTC)
CME	Chicago Mercantile Exchange
DJ-UBSCI	Dow Jones-Union Bank of Switzerland Commodity Index
EMH	Efficient Market Hypothesis
FAO	Food and Agriculture Organization of the United Nations
LDC	Least Developed Country
MATIF	Le Marché à Terme des Instruments Financiers
NYMEX	New York Mercantile Exchange
OLS	Ordinary Least Squares
OTC	Over-The-Counter (market)
S&P GSCI	Standard & Poors Goldman Sachs Commodity Index
UNCTAD	United Nations Conference on Trade and Development

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1. Introduction

What has driven up food prices in the years 2007-2008 and 2011? Food prices are subject of great concern, as rising commodity prices hit the poor very hard. The price elasticity of demand for food is very high in developing countries. A change in price leads to a relatively higher decrease in demand. About 41% of the people in sub-Saharan Africa live from less than one US Dollar per day (Todaro and Smith 2009, 61). For this reason, a little change in price has tremendous impacts. Riots in some developing countries were the consequence.

This master thesis draws the attention to the relationship between agricultural commodity spot prices and futures trading activities. Commentators like Gilbert (2010) argued that agricultural commodity futures positions held by *commodity index investments* possibly led to increasing food prices in 2007-2008. In recent years, index-based investments have shown a rapid growth, hence, a strong rising demand for *long* and *short* futures positions. About “$100 billion of new investments” (Irwin and Sanders 2011, 2) flew into commodity futures markets between the years 2004-2008.

The research question has been derived following the assumptions by Gilbert (2010). He states that a rise in demand for futures contracts is likely to result in a change in agricultural commodity spot prices. Therefore, the research question of this thesis is: *Are there causal relationships between the changes in agricultural commodity spot prices and the changes in positions on agricultural commodity futures between the years 2002 and 2011?*

The theoretical part is carried out in a purely descriptive manner. Beside standard literature in agricultural economics and finance, the main journal articles used in this thesis are written by S. H. Irwin and D. R. Sanders, which provide a multitude of contributions. Also, publications composed by C. L. Gilbert, B. Cooke and M. Robles, D. Mitchell and the latest study of UNCTAD is helpful. They show latest findings and give a solid introduction into the research question whether rising demand for futures positions led to increasing agricultural commodity spot prices.

Firstly, considerations concerning price formation theory on the spot market are outlined. The price building mechanism bases on the fundamentals of *demand* and *supply*. In this context, *elasticities* are useful to gain a deeper understanding of price formation. Also, the concept of spot price *volatility* broadens the picture of spot markets.

Secondly, fundamentals concerning the futures market are given. Beside classical *hedgers* and *speculators* new market participants have entered the futures market. These *index traders* follow a long-term trading strategy and create an increasing demand for agricultural commodity futures. Hence, attention is paid to *financialization*.

Thirdly, the relationship between futures prices and spot prices is explained by *theory of storage*. According to this theory a solid theoretical link between spot prices and futures prices can be observed. The difference can be summarized with *cost of carry*. Information based hypotheses concerning the price building mechanism of futures prices are described.

The empirical part investigates causal relationships between agricultural commodity spot prices and futures trading activities. Spot price variables for *maize*, *wheat*, *rice* and *soybean* as well as financial variables such as *open interest long* (commercial long positions; non-commercial long positions; total reportable long positions) and *volume traded* were selected. The spot prices variables are the ones with highest trading volumes (in tonnes) and are storable. The financial variables capture the increasing trading activities with agricultural commodities futures (in number of contracts). Time series are tested for unit roots and Granger-causality. The hypotheses are:

- The agricultural commodity spot price was rising due to an increasing number of long positions taken by commercial traders on the particular futures contract.
- The agricultural commodity spot price was rising due to an increasing number of long positions taken by non-commercial traders on the particular futures contract.
- The agricultural commodity spot price was rising due to an increasing number of total reportable long positions on the particular futures contract.
- The agricultural commodity spot price was rising due to an increasing number of the total traded volume on the particular futures contract.

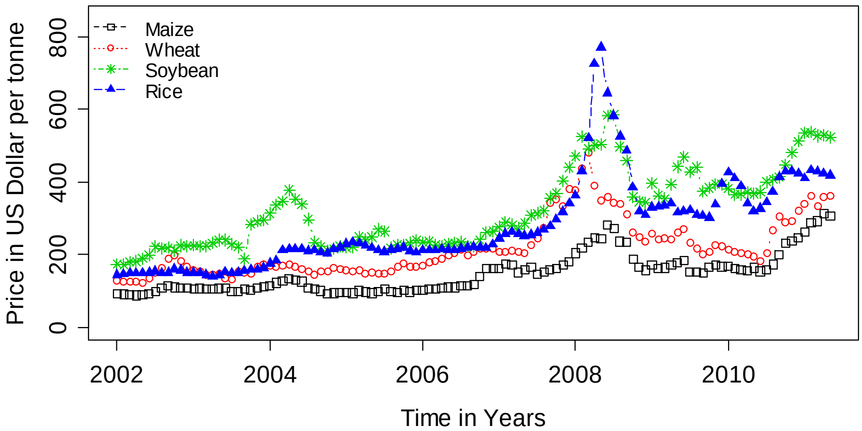
These general hypotheses are specified in accordance with the method and can be found in chapter *3. Time series analytical approach*. The Augmented Dickey-Fuller test and Granger-causality test are state of the art econometric time series analysis. Furthermore, all time series are statistically described. The empirical part is calculated with *R*.

2. Theoretical foundations of spot and futures markets and their relationship

This thesis gives some insights into price formation of agricultural commodities. Both, price formation on the spot market as well as price formation on the financial market are described. Important foundations, concepts, actors and theories are outlined as well, which are required to understand the relationship between spot and futures prices, or respectively the physical product and its financial commodity – the futures contract.

Figure 1 shows spot prices for maize, wheat, soybean and rice from January 2002 to May 2012. During this period, a constant upward trend can be observed. One can easily see that prices peaked in 2008, especially in the case of rice. In comparison with the initial value of the series the prices of maize, wheat and soybean tripled. The price of rice even increased fivefold. On a side note, the reader should be remembered that the financial crisis (beginning with the subprime crisis) started in the year 2007. In 2008, food prices decreased, but augmented again in 2010.

Figure 1: Spot prices for maize, wheat, soybean and rice, on a monthly basis



Source: FAO (2011)

2.1. The agricultural commodity spot market

A spot market is a place where individuals or institutions get into exchange. One party sells (delivers) and one party buys (pays for) a certain product in a certain quantity for a certain price. The agreed price is the *spot price*. Delivery and payment (*settlement*) have to take place immediately, which is mostly "today", the so called *spot date*. Often there is a lag between purchase and delivery. If the lag is too big (e.g. two or more days) then the trade is more likely to be a *forward* or a *futures* transaction.

Spot transactions can take place on organised markets (e.g. weekend markets) or with intermediaries. Intermediaries are helpful, as buyers and sellers hardly ever meet their desired prices, timing of delivery, etc. They buy, store and sell the goods. (Geman 2005)

2.1.1. Forms of risk

One of the most regarded elements of trading is *risk*. There are different forms of risk in a commodity spot transaction. In accordance with Geman (2005, 3ff) the most important types are price risk, transportation risk, delivery risk and credit risk:

- *Price risk* concerns the retail price for a produced commodity for instance, as there are possible price changes between sowing and harvesting. Also, operating materials are affected. There are various forms of price risk management, e.g. non-standardised contracts (forwards) or standardised contracts (futures), and are used to *hedge* the risk.[1] Volatility indicates the riskiness of a commodity.
- *Transportation risk* can be categorised in two parts: i) deterioration of goods during transportation and ii) costs of transportation risk. Both sellers and buyers hedge their risk. The former hedges against a decline in prices, the latter against increasing shipping costs.
- *Delivery risk* is crucial for buyers as they have no perfect guarantee that the quality of the delivered good absolutely meets the expectations. No financial hedge is possible. The only way is a customized contract or long-term relationship with the seller.
- *Credit risk* is given for the seller when a buyer purchases on credit. The worst case is a default, where the buyer does not pay the agreed price.

2.1.2. The market fundamentals demand and supply

Besides different forms of risk the role of prices and price formation is essential. For agricultural commodity producers and consumers the price is an important element within the decision process. For instance, a farmer maybe decides to expand his/her production, due to rising sales prices. A consumer decides to buy a good as the price is relatively low. Hence, by analysing the market fundamentals *demand* and *supply* a comprehensive understanding of agricultural commodity prices is

[1] „Hedging“ is explained in subchapter *2.2. Agricultural commodity futures markets*. A hedge describes a transaction, which is used to exposure potential shortfalls. This thesis especially describes futures contracts.

on hand. Following remarks build on the assumption of developed markets unless developing countries are especially mentioned (Tomek and Robinson 2003). For comprehensive definition of developed, emerging and developing markets please see Todaro and Smith (2009).

It is necessary to understand the difference between *normal* and *inferior goods*. This is important in agricultural commodity demand and supply because foodstuff satisfies basic needs. The classification is useful when it comes to elasticities. In the elasticity section, further classifications are done for *complementary* and *substitute goods*. According to Colman and Young (1989), the *theory of consumer behaviour* states that demand for a normal good rises as income rises; demand for an inferior good decreases as income rises.

Agricultural commodity demand

Consumers – or more generally customers – have a multitude of needs, while satisfaction of these needs are subject to limitations, e.g. income. Customers buy goods which satisfy their needs best. The term *best* explains the “attempt to maximize [the customers] utility”. (Tomek and Robinson 2003, 9f)

Consumer demand reflects the relationship between prices and quantities per unit of time, other factors remain constant. Consumers are willing to buy a certain quantity of a commodity for a certain price. Various combinations of commodity A and commodity B can be shown on the indifference curve. Each of these combinations “will give the consumer equal satisfaction” and consumers have no preference for any combination (Tomek and Robinson 2003, 12).

Colman and Young (1989, 73) highlight that “demand is not the same as desire”. Consumers need to have the ability to buy a certain commodity. If they have this ability they evoke demand. In this sense, the willingness to buy a certain commodity is not enough.

Market demand depicts the aggregated demand of the individual consumers on a certain market. Consumers enter into the market when prices are low and leave the market when prices are high. Hence, price changes influence the number of consumers in the market and quantity of demand. Market demand depends on individual consumption behaviour. (Colman and Young 1989; Tomek and Robinson 2003)

Market demand has to be seen in relation to distribution of income among consumer groups. For instance, transfer of income from upper-income households to lower-income households can lead to an increase in demand from lower-income households for the quantity of food (this must not be true for inferior goods) or increasing demand for higher-quality diet. Upper-income household might decrease their demand for high-class products. (Tomek and Robinson 2003)

Colman and Young (1989, 73) and Tomek and Robinson (2003) mention following fundamental *determinants of demand*, which can lead to changes in demand:

- Demographic factors (e.g. population size: more people need more food);
- Economic factors (e.g. income: meat becomes affordable);
- Consumer preferences (e.g. life style effects: from a consume extensive society to a consume intensive society);
- Price for a commodity (e.g. prices can be too high);
- Prices for another commodity (e.g. substitution of products).

More specifically, according to the research question – *Are there causal relationships between the changes in agricultural commodity spot prices and the changes in positions on agricultural commodity futures between the years 2002 and 2011?* – Gilbert (2010) and Mitchell (2008) name following fundamental demand factors, which are assumed to be the main demand drivers of rising food prices in the years 2007-2008:[2]

- Rising demand for food commodities processed into bio-ethanol and bio-diesel in the USA and EU;
- Rising demand for animal feed, e.g. China;
- US dollar depreciation results in higher prices for US dollar-dominated commodities, because most of the internationally traded agricultural commodities are traded in terms of the US Dollar.

Agricultural commodity supply

A farmer has to take important decisions in agricultural commodity supply. On the level of *individual supply*, the farmer converts given inputs into desired outputs. Thereby, he or she coordinates and combines resources and factors in such a manner to achieve an optimal output. According to Colman and Young (1989), the main questions *production theory* analyses are:

- Which product or combination of products should be produced?
- Which quantity of these products should be produced?
- For whom should these products be produced?

[2] Gilbert (2010) and Cooke and Robles, M. (2009) for instance draw the attention to a non-fundamental explanatory approach. They state that the rising demand for agricultural commodity futures contracts very likely influenced the agricultural commodity spot price in 2007-2008.

Farms are units which produce and – sometimes – consume their own commodities. In the case of developing countries a big number of producers appear as subsistence farmers. If a subsistence farmer produces surpluses they are very likely to be sold on markets. In developed countries, predominantly farmers produce for the market. (Colman and Young 1989)

In *theory of the firm* it is assumed that maximizing profit is the main objective of a firm (generally speaking: revenues exceed costs). Ideally, a firm produces at the point where marginal costs equal to marginal revenue. Commonly it is assumed that marginal costs are rising (have an upward slope). This leads to the conclusion that returns are scaling down (yields are growing at a diminishing rate) as additional input is used. (Tomek and Robinson 2003)

It is stated that profit maximization is the main objective of a firm. However, risk plays a crucial role. For instance, price and yield risks are existing as there are lags between the production decision and sale of the commodity. Output prices may vary as they depend on a broad range of factors such as weather, pests and input costs. Most production firms are risk averse and adapt their objective of profit maximization to maximizing the expected utility. Returns have to be incorporated in the context of their riskiness (Tomek and Robinson 2003). Suitable risk management strategies could be discussed comprehensively. In the section about volatility a few strategies are described briefly. This thesis especially deals with futures trading, which can be used to hedge price risks (e.g. feeding stuff; purchase prices for commodities). Other strategies are more or less disregarded.

Opportunity costs are another important element for a farmer. These kind of costs extend the general view on costs, as merely input are concerned before. Mostly, farmers have the ability to produce alternative commodities. He or she thinks about optimal coordination, combination and allocation of scarce resources to achieve a certain output. As already mentioned before, prices are not stable and are subject to changes. Hence, a farmer has to rethink his or her commodities produced as the relative prices of two commodities change. With an economic perspective it maybe makes more sense to shift allocation of resources (partly or totally) for production used from good A to good B, but only if the value of an extra quantity of good B exceeds the value of the lost quantity of good A. In other words, the concept describes how much of good A has to be sacrificed to get an additional unit of good B. Therefore, "opportunity cost of a decision is the value of the best alternative choice which is foregone as a result of that decision." (Colman and Young 1989, 17f)

With respect to given prices, the aggregation of individual – farmer's – output is called *market supply*. The market sensitively responds to price changes on a certain commodity. On a short-run, farmers have big difficulties – or it is even impossible – to adjust their production lines. If a farmer harvests once a year he or she has to wait until the next year to change the production line according to price changes. On a long-run more time for adjustment (e.g. the business model) is given (Colman and Young 1989; Tomek and Robinson 2003).

Determinants of supply differ between short-run and long-run changes. These determinants are able to shift the supply curve. Short-run changes, which are negatively influencing the quantity produced, are due to unpredictable weather, pests and diseases for instance. Prices merely change temporarily. Long-run changes in supply, which are positively influencing the quantity produced, are due to improvement of technology and fertilizers used. (Tomek and Robinson 2003)

According to Colman and Young (1989, 35), Geman (2005, 143f) and Tomek and Robinson (2003, 68f) following factors influence agricultural commodity supply:

- Changes in input prices (hence, the price of the product);
- Changes in prices of commodities competing for the same resources;
- Changes in the prices for joint products;
- Changes in price or yield risk;
- Changes in state of technology, e.g. efficiency changes and costs of production;
- The natural environment;
- The institutional setting, e.g. support schemes;
- The inventory, so called “carry-in stocks”.

With respect to the stated research question, Gilbert (2010) draws the attention to increasing input costs for oil. Oil prices have changed and influence transport costs, production costs and nitrogen-based fertilizers. According to Baffes (2007) and Mitchell (2008), the pass-through from oil prices into agricultural commodity prices ranges from 17% to 20%. Energy costs are seen as one of the major supply drivers in rising food prices in the years 2007-2008.

Inventory is also very important supply side factor and is discussed in subchapter *2.3*. Inventories are crucial in balancing commodity demand and supply on the spot market. Demand is more regular over the whole year compared with supply, which is seasonal and requires storage to “ensure an orderly pattern of price movements within the season” (Colman and Young 1989, 148). Furthermore, taking a look at inventories is essential when analysing the relationship between spot and futures markets. Also, low stock levels are very likely to be a driver of rising food prices in 2007-2008.

2.1.3. Elasticity of demand and supply

Prices play a decisive role in consumer's demand and farmer's supply. A decrease of prices in a certain commodity is equivalent to an increase in real income. With rising income it is very likely that more money will be spend for food. Rising prices may lead to a change in commodities produced. Hence, analysing the effects of changes in price and income on demand and supply is helpful to get deeper insights in price formation. No solid general statement about the extent of the elasticity coefficient is possible for maize, wheat, rice and soybean because elasticities strongly vary according to market development, cultural preferences, time period and so on. Evidence should be investigated empirically. Elasticity of demand and supply are explained against the background of developed countries unless developing countries are especially mentioned.

<u>Price elasticity of demand</u>

Price elasticity of demand describes the relationship between price (in monetary terms) and quantity (in physical units) but does not imply anything about the responsiveness "of quantity demanded to a price change" (Tomek and Robinson 2003, 30f). The responsiveness strongly depends on the commodity. Goods can be *substitutes*, *complements* and *independent*. An explanation is given in the section about cross-price elasticity of demand.

As units and sizes differ (depending on the available dataset) it is common to use percentage relationships to become independent from units. This is described by the so called *own-price elasticity of demand*. "It is simply a ratio that expresses the percentage change in quantity demanded associated with a given percentage change in price" (Tomek and Robinson 2003, 30f). According to Jacques (2006, 285), the price elasticity ratio can be described as

$$\varepsilon_P = \%\ \Delta \text{ in quantity demanded} / \%\ \Delta \text{ in price},$$

while other factors being held constant (ceteris paribus). If a farm lowers prices for a certain product it will receive less money, but quantity of purchased products are likely to raise. It is not about absolute changes in price or quantity demanded. Again, it is about the *ratio* between price and quantity demanded. If the increase in percentage of quantity demanded exceeds (is less) the percentage decrease in price then demand is called *elastic (inelastic)*. The farmer increases (decreases) its revenues. In the inelastic-case quantity demanded will go down, but higher prices will more than compensate the fall in income. The situation when revenues remain unchanged is call *unit elastic* (Tomek and Robinson 2003).

Demand elasticity can be divided in three categories and are either smaller, bigger or equal to –1 (Jacques 2006, 285):

- elastic: $\varepsilon < -1$
- inelastic: $\varepsilon > -1$
- unit elastic: $\varepsilon = -1$

One has to consider that demand curves have negative slopes (a negative relationship). Hence, the value of elasticity is always negative as an increase of price (positive change of price) leads to less sales (negative change in quantity) and vice versa. Consequently, ε is likely to be negative. (Jacques 2006)

According to Tomek and Robinson (2003), price inelasticity is given for derived demand for almost all agricultural commodities. Derived demand describes the situation, where demand for product/service A (e.g. apples) lead to demand for product/service B (e.g. picking).

Income elasticity of demand

Analogous to price elasticity of demand, income elasticity of demand is the ratio that expresses the percentage change in quantity demanded corresponding with a certain (e.g. 1%) percentage change in income (Tomek and Robinson 2003). According to Jacques (2006, 358), the income elasticity ratio can be presented as

$$\varepsilon_Y = \%\ \Delta \text{ in quantity demanded } / \ \%\ \Delta \text{ in income,}$$

ceteris paribus. The coefficients will be mostly positive as a raise in income will lead to higher expenditures. For food commodities, such a generalization could be misleading. However, the income elasticity of upper-income households is smaller, compared with lower-income households. For superior goods (inferior goods) income elasticity is likely to be positive (negative). (Tomek and Robinson 2003; Jacques 2006)

Cross-price elasticity of demand

One can measure the responsiveness of quantity demanded for product A to changes in the price of product B. According to Jacques (2006, 357), the cross-price elasticity ratio is

$$\varepsilon_{Pa} = \% \, \Delta \text{ in quantity demanded for product A} \, / \, \% \, \Delta \text{ in price of product B},$$

ceteris paribus. The coefficient can either be positive or negative depending on the goods. Tomek and Robinson (2003) mention three categories of relationships, which base on the *substitution effect* of the price change of the alternative product B. These products might be:

- substitutes;
- complements;
- independent.

Substitute commodities have a positive substitution effect. This means, if the price of good B increases the individual tends to buy product A instead of product B. If the price of good B decreases the individual buys product B instead of product A. *Complementary* commodities have a negative substitution effect. If the price for commodity B increases (decreases), the quantity demanded for product B will go down (up). And the quantity demanded for the complementary product A will decrease (increase) as well. *Independent* commodities have a substitution effect of zero. (Tomek and Robinson 2003)

The generalization that substitute commodities have a *positive* cross-price elasticity, complementary commodities have a *negative* cross-price elasticity and independent commodities have a cross-price elasticity of *zero* has to be treated with caution, due to the potential income effect (change in the price for product B). In general, the income effect on demand for product A is negative for cross-price elasticities as a price decline will lead to higher purchases due to more income available. This must not be ignored, particularly if the income effect is bigger than the substitution effect. If the price of product B increases, the consumer's income decreases (negative effect). Neglecting the income effect consumers will buy product A instead of the relatively more expensive product B. In fact, demand for product A and B is affected as a rise in price for product B means a reduction of real income available for consumers. "Thus, the real income effect on consumption of *i* [product A] will be negative, while the substitution effect will be positive" (Tomek and Robinson 2003, 38). Subsequently, a net reduction of demand for product A is given if income effect is bigger than substitution effect for substitute commodities. For complementary commodities income effect intensifies the substitution effect. Inferior and superior food commodities have to be treated separately and should be empirically investigated. Also, there are differences between developed and developing countries according to income and proportion of expenditures for basic needs. (Tomek and Robinson 2003)

Price elasticity of supply

Own-price elasticity of supply is a measure of the responsiveness of producers to price changes. It expresses – analogous to the price elasticity of demand – the percentage change in quantity supplied as a ratio of the percentage change in price (e.g. 1%). The price elasticity ratio can be given as

$$\varepsilon_P = \%\ \Delta \text{ in quantity supplied } / \ \%\ \Delta \text{ in price},$$

ceteris paribus. The elasticity is positive as rising prices drive up quantity supplied. In the elastic-case, a 1% change in price would lead to more than a 1% change in supply. If a 1% change in price would bring less than a 1% change in supply, supply is said to be inelastic. If a change in price is equivalent to a change in commodity supply elasticity is called unit elastic. (Colman and Young 1989, 32; Jacques 2006, 291)

Cross price elasticity of supply

This kind of elasticity is not a very popular one. The cross-price elasticity of supply gives the responsiveness of quantity supplied (a certain percentage change) for good A to a percentage change (e.g. 1%) in the price of a competing (or alternative) good B. According to Colman and Young (1989, 33) the cross price elasticity of supply ratio can be shown as

$$\varepsilon_{Pa} = \%\ \Delta \text{ in quantity supplied for product A } / \ \%\ \Delta \text{ in price of product B},$$

ceteris paribus. The cross-price elasticity of supply is either positive or negative. Positive elasticity is given for complements, negative elasticity is given for substitutes.

2.1.4. Spot price volatility

The volatility of a commodity is the variability of its price over time. There are different measures to calculate volatility. Price volatility is especially important because it delivers information about the price risk of a certain commodity (Peirson 2008). In this thesis, the variance of returns over 36 months is used. In subchapter *3.4.1. Characteristics of analysed time series*, the so called rolling volatility for the spot prices of maize, wheat, soybean and rice can be found.

Volatility in context of the spot market has become increasingly important. The variability of prices in agricultural markets is higher compared with other markets (OECD 2011). Hence, price risk is higher. OECD (2011) could find little evidence that volatility in international agricultural commodity prices is given in a long-run (time period investigated: 1970-2010). However, they also state that volatility has been rising tremendously on a short-run, especially since 2006. It has to be highlighted that rising volatility on agricultural commodity markets has led to rising uncertainty for market participants in recent years. Beside farmers, processors and consumers, also traders face this kind of risk.

Other than distinguishing short and long-term variability of prices on a macroeconomic level it is helpful to differ between exporting and importing countries. It can be assumed that developing countries suffer most by food price volatility. More precisely, balances of trade from most developing countries strongly depend on agricultural commodities. Developing countries are often subject to agricultural commodity exports. International prices below domestic prices have a negative impact on export revenues. Developing countries which are dependent on food imports suffer from higher international prices compared with domestic prices. Therefore, according to the extent of integration of domestic markets in the global market, prices are likely to be transmitted from global to domestic markets. (OECD 2011)

To capture volatility it is useful to distinguish between the time dimension (short and long-run) and the macroeconomic level (importing or exporting country). On the level of individuals things are more crucial. As agricultural spot prices are subject to higher variability farmers have to apply risk management strategies. Risk management explains the circumstance which the seller or buyer attempts to minimize his or her risk. Often, hedging is undertaken in order to exposure price risk. Hedging is subject to a service fee and a broker is required. In developing countries only a minority of farmers is able to run a suitable risk management to counter price risk (OECD 2011; Geman 2005).

Besides risk management on the financial market adaptation and advancements of the business model counter volatile markets. But solely producers who have enough capital savings are able to adapt their business model according to market fundamentals. Not only the retail price of the commodity produced is important and has to be hedged, but also the operation material (like input costs, e.g. feeding stuff) is affected. In the USA and Europe governmental payments are not static and are subject to possible cutbacks. (OECD 2011)

Also, consumers are affected on the individual level by rising food prices. In developed countries effects from rising food prices on quantity demand is – in general – little. As subchapter *2.1.3. Elasticity of demand and supply* shows quantity demanded is very likely to decrease slightly, as the price elasticity of demand is negative. Rising food prices can be seen as a shortfall in income.

Income elasticity of demand is positive as a decrease in income will lead to fewer purchases. Hence, alternative products, which are relatively cheaper, are likely to experience increasing demand as cross-price elasticity for demand of substitutes is positive. Changes in price have fewer effects on quantity demanded in developed countries compared with developing countries. (Colman and Young 1989)

In developing countries elasticities can be far more responsive. Todaro and Smith (2009, 61) highlight "that the share of the population living on less than $1 per day is (...) 31.7% in South Asia, and 41.1% in sub-Saharan Africa." A change in price for foodstuff – e.g. tripling prices for maize were recognised between the years 2000-2011 – has tremendous effects on quantity demanded. OECD (2011) assumes that $^{3}/_{4}$ of total income is spend for basic foodstuff in developing countries. Direct impacts are serious. Individual diets change to less nutritious foods. Women and children are hit hardest. (OECD 2011)

2.2. Agricultural commodity futures markets

Already in the 18th century farmers have started to market their products in advance – at time of planting. Therefore, the farmer knew the price he/she was going to receive for his/her harvest per unit of weight. Hence, financing of the production was ensured. Due to harvest shortfalls or oversupply price risk is crucial for farmers. It can be useful to sell or buy commodities in advance. Standardization of quantity and quality was needed. Consequently, Chicago Board of Trade (CBOT) has been established. On this exchange futures and options contracts could be entered into.[3] (Hull 2002; Geman 2005)

Besides selling and buying in advance the farmer has to consider the time until the next harvest. Commodities have to be stored and are sold according to market requirements (Hull 2002). On the one hand, storage is not free of charge, on the other hand, farmers do not know how prices are going to develop until the next harvest as there are permanent changes in local and worldwide demand and supply structure of agricultural commodities. Selling the physical commodity in advance on the futures market comes into play. Farmers, manufacturers, venders and also speculators are participating on this market. But a very little number of contracts end in delivery of the physical commodity. (Geman 2005)

[3] Please note "options" trading is not part of this work.

2.2.1. Forward contracts and futures contracts

Futures contracts accrued from forward contracts. Still, these forerunners are used frequently. Forwards and futures do have some elements in common and some are different. *Table 1* shows a comparison of forwards and futures contracts.

Forward contracts are traded in a non-standardized manner which means quantity and quality have to be negotiated. A futures contract is standardized, hence, quantity and quality of a certain commodity are fixed. Forwards are traded over-the-counter (OTC markets) between two parties. One party sells, one party buys. Futures are traded on exchanges and are *agreements* between a seller and a buyer. But this *one* agreement becomes *two* contracts, indeed between the seller and the clearing house and the buyer and the clearing house. Hence, trading futures is anonymous as the seller and the buyer do not know each other. The seller and the buyer purely interact with the clearing house which acts as an intermediary. In the case of forward contracts, the seller and the buyer do know each other. Both contracts have in common that prices are decided today and are obligations to buy and sell. However, it is possible to “close out” (also called “reverse out”) prior to delivery (maturity date) in the case of a futures contract.

Table 1: Comparison of forward and futures contracts

	Forward	Futures
Standardized contract	no	yes
Quantity is negotiable	yes	no
Quality is negotiable	yes	no
Individual delivery date	yes	no
Place of trade	OTC markets	exchanges
Intermediary	no	clearing house
Knowledge about counterparty	yes	no
Time of price decision	today	today
Obligation to buy	yes	yes
Obligation to sell	yes	yes
“Close out” is possible	no	yes
Risk lies with	buyer and seller	clearing house

Source: Peirson 2008; Geman 2005.

If a futures contract is reversed out prior the maturity date the commodity will not be delivered. How a reverse out works is explained in a later section of this chapter. For the moment it is enough to understand that only a little number of futures contracts end in delivery. This is not possible in the case of a forward agreement.The buyer and the seller face default risk. In the case of a futures contract default risk is with the clearing house. (Peirson 2008; Geman 2005)

2.2.2. Over-the-counter markets and commodity futures exchanges

Agricultural commodities are bought and sold on spot markets. If the minimum lag between purchase and delivery is too big, a transaction is more likely to be a forward or futures transaction.[4] Besides commodity futures exchanges so called over-the-counter markets exist. Both are important markets in agricultural commodity trading.

Over-the-counter markets (OTC markets)

Forwards are traded *over-the-counter*. OTC markets are especially important as a forward allows precise risk management. A forward is not standardized in quantity and quality for a certain (e.g. agricultural or financial) commodity. Hence, these two elements are negotiated between two parties in order to satisfy the needs of both parties best. Any mutually attractive deal is possible to negotiate. Traders do not meet physically, but are linked to each other via telephone or internet. Telephone orders are recorded and replayed in cases of inconsistency. Trades are done between banking houses or between a bank and a corporate client. Today forwards are very frequently used in transactions of currency, but also in agricultural commodity trade. Compared with trades on exchanges forward transaction are usually much bigger in quantity and price. Clearly the disadvantage is the credit risk because the risk lies with the seller and the buyer. (Hull 2002)

Exchange markets

Agricultural commodity futures markets have emerged historically to huge markets. Open-outcry trading was done traditionally and is still practiced on CBOT. Today trading is carried out predominantly in electronic form (Hull 2002).

[4] E.g. Hull (2002) and Geman (2005) do not explicitly clarify the time lag. Approximately a lag of two days is mostly considered in practice as point of reference.

CBOT has been established in 1848. The idea of standardization of quantity and quality has been leading in charge of bringing buyers and sellers together trading, e.g. maize and soybean. In 1874 the Chicago Produce Exchange has been established. It was a new market for eggs, butter and poultry. Out of the Chicago Produce Exchange the Chicago Mercantile Exchange (CME) emerged (Hull 2002). In 2007 CBOT and CME merged to form the CME Group including the New York Mercantile Exchange (NYMEX) and the Commodity Exchange (COMEX). As part of the CME Group today CBOT is one of the leading grain and oilseed exchanges in the world.[5]

According to Geman (2005), the Grain Futures Act (1922) builds the basis for the regulation of futures exchanges in the USA. Furthermore, in 1974 the Commodity Futures Trading Commission (CFTC) has been established on basis of the Commodity Futures Trading Act (1974). The independent regulatory commission is of great importance as various trading data have to be reported to CFTC. Hence, CFTC is a very useful platform which provides comprehensive data in futures and options trading. CBOT is one of the most important exchanges in the world. In this thesis financial data are from CFTC.

Beside CBOT there are various commodity exchanges existing which allow futures and options trading with agricultural commodities. In Europe, Le Marché à Terme des Instruments Financiers (MATIF) is noteworthy in trading agricultural commodity futures.

2.2.3. Actors on the financial market

Futures markets encompass huge amounts of liquidity and attracting various types of traders. As a trader is seeking to sell or buy a commodity “there is usually no problem in finding someone that is prepared to take the other side” (Hull 2002, 7). The citation hints at the mechanism of futures trading and is explained in a later section of this chapter.

Basically, there are two groups of participants on futures markets with different objectives. One group are commercial traders who aim to reduce price risks associated with selling or buying a physical commodity. The other group are non-commercial traders who are willing to take price risks and provide liquidity in the expectancy of profits.

In the following “arbitrageurs”, “hedgers” and “speculators” are explained. Afterwards, categories of traders used in the *Commitment of Traders*, published by the *Commodity Futures and Trading Commission*, are given. This is needed because financial data used in chapter *3* come from CFTC.

[5] For further details please visit http://www.cmegroup.com/.

Arbitrageurs

According to Peirson (2008), an arbitrageur is a participant (individual or institution) on the spot or financial market who is seeking for an immediate risk-free profit. He or she is doing so by buying and selling one commodity in two markets simultaneously. An arbitrage possibility exists between different financial markets, but also between the spot and the futures market when "the futures price of an asset gets out of line with its cash [also called spot] price" (Hull 2002, 7).

Based on Hull (2002), consider an arbitrageur is buying one metric tonne wheat for 100 monetary units in country A. If he or she simultaneously finds to sell the wheat for 101 monetary units in country B, then the arbitrageur gains an immediate risk-free profit of 1 monetary unit. This example is strongly simplified and neglects transportation costs, etc. As a big number of traders are active on the market arbitrage opportunity should be very little. Or as Peirson (2008, 559) emphasizes, an arbitrage possibility should not be given at all in "efficient markets".[6]

Hedgers

A hedger is a market participant who enters into one or more futures contracts in order to reduce the risk which comes along selling or buying a commodity (Peirson 2008) which is called "hedging". They use futures in order to offset money shortfalls occurred on the spot market. Initially futures markets were established to meet the needs of farmers who were seeking to hedge their price risk (Geman 2005). Hedgers are also known as *commercial* traders (CFTC 2012a). A hedger has a real interest in the underlying physical asset of the futures contract (Peirson 2008).

Speculators

In the case of a speculator the individual or institution wants profit from correctly anticipating in price movements by entering into futures contracts (Peirson 2008). Whereas hedgers want to dispose their risk, speculators are actively seeking for risk and betting on increasing or falling prices (Hull 2002). This is called "speculation". They take the risk (e.g. from hedgers) in order to make profits (Geman 2005, 6). The higher the risk, the higher the possible earnings or losses can be. Speculators are also known as *non-commercial* traders (CFTC 2012a). Hence, a speculator must not have any interest in the underlying physical asset of the futures contract.

[6] "Efficient markets" refer to informational efficiency. Please note that the *efficient market hypothesis* is described in a later section of this thesis.

Specified categories of traders

The *Disaggregated Commitment of Traders* (Disaggregated COT) published weekly by CFTC (2012b) improves transparency in futures markets in the USA. The report covers the most traded agricultural commodities (also energy commodities) on exchanges like CBOT, Kansas City Board of Trade, etc. The Commission separates reportable traders in "commercial" and "non-commercial". Following categories have to file daily reports with the commission:

- Producers, merchants, processors, users;
- Swap dealers;
- Money managers;
- Other reportables.

Producers, merchants, processors and *users* do have a strong interest in the underlying physical asset. They buy or sell a physical commodity and enter into futures contracts in order to hedge their risk associated with production, processing, packing and handling. (CFTC 2012b)

Swap dealers primarily trade with swaps for a commodity. The associated risk is hedged with futures contracts (CFTC 2012b). It is very likely that their counterparty is a speculator. The bulk of these traders clients are index investors (UNCTAD 2011).[7]

The category *money managers* comprises registered commodity trading advisors, registered commodity pool operators or unregistered funds identified by CFTC. For instance, hedge funds are part of this category[8]. Money managers trade in behalf of their clients (CFTC 2012b). According to UNCTAD (2011), they follow short-term supply and demand dynamics (active investment strategies). Active trading can be very profitable or costly by going "short" (bets on decreasing prices) and going "long" (bets on increasing prices).

Other reportable traders are traders who are not included in one of the other categories (CFTC 2012b). They are not obliged to report their positions and count for a little number of traders UNCTAD (2011). Their number "is derived by subtracting total long and short 'Reportable Positions' from the total open interest" (CFTC 2012b). The concept of "open interests" and "volume traded" is described in subchapter *2.2.5. Open interest and volume traded*.

Again, a trader can be a commercial trader or a non-commercial trader with the same commodity. But if the same trader holds positions in different commodities the trader can be declared different. A swap dealer, for instance, can be a commercial trader as the dealer hedges his financial risk with corn

[7] Note that index investments and swap dealing is described in a later section.

[8] Hedge funds will be explained in brief in a later section of this chapter.

futures, because he holds a derivate with an index investor as counterparty. At the same time the same swap dealer can be declared as a non-commercial trader if he or she is speculating with other commodities, e.g. financial futures.

2.2.4. Trading strategies

As we have seen in subchapter *2.2.3. Actors on the financial market,* futures markets can be divided into arbitrageurs, hedgers and speculators. In this thesis special focus is put on hedgers and speculators. According to Peirson (2008), hedging and speculating differ in the following general assumptions:

- Hedgers are interested in the underlying asset of the futures, while speculators are not;
- Hedgers are affected by the spot price *and* the futures price of the commodity, while speculators are affected by the futures price only;
- Hedgers try to dispose their risk, while speculators are actively seeking for risk.

In the following two examples are given which exemplify hedging and speculating. Afterwards, “going long” and “going short” shall be clear as well as how a “reverse out” works.

An example for hedging based on Peirson (2008, 545)

Imagine a maize farmer who aims to sell a certain quantity of maize at a certain time in future. Today one tonne of maize has a price of 100 monetary units. He or she hopes that the price for maize will increase over time (up to 110 monetary units), but it is also likely that prices decrease (down to 90 monetary units) and he or she is going to lose. The farmer faces the so called price risk.

On the spot market the farmer has a “long” position. This means that he or she is holding the commodity and hopes to sell in future for a higher maize price compared with the maize spot price today. At the same time the farmer is going to sell a maize futures contract today. He or she agrees to sell a standardized quantity of maize for 100 monetary units, delivery at a standardized time in future. He or she is now called a “short hedger”.

The farmer has no preference whether the futures price is going to increase or decrease. The farmer’s objective is making no net loss of money. The only interest he or she faces is getting rid of the price risk associated with the physical product. This is possible if the farmer takes the opposite strategy on the futures market (selling contracts; going “short”) in comparison with the spot market (holding the commodity; going “long”). A summary of the short hedge can be found in the appendix.

In the case of rising prices the farmer would have gained 10 monetary units by selling maize on the spot market. But as the farmer sold a futures contract he or she delivers maize at the nominated date on the futures contract and loses 10 monetary units. This idealized example shows the net result of approximately zero.

In the case of decreasing prices the farmer would have lost 10 monetary units by selling maize on the spot market. But as the farmer sold a futures contract he or she delivers maize at the nominated date on the futures contract and gains 10 monetary units. This leads to a net result of approximately zero. With this hedge the farmer could achieve his objective of making no loss of money. If the net result would be exactly zero it is called a "perfect hedge". But a perfect hedge is very unlikely due to imperfect convergence, specification differences and basis risk.[9]

The farmer would have possibly been better off by "reversing out" his futures position. In practice most of the futures contracts do not lead to delivery and are reversed out prior to delivery as "making or taking delivery under the terms of a futures contract is often inconvenient" and sometimes too costly (Hull 2002, 16). According to Hull (2007, 16), a close out requires "entering into an opposite trade to the original one".

As explained in a previous section, the farmer sold a contract with the clearing house, not with the buyer of the futures contract (Peirson 2008). Now, the farmer has the possibility of reversing out his futures position by buying maize futures. This is possible because futures contracts are standardized in quantity and delivery date, but have different prices. The price of the maize futures has changed over time and determines gains or losses (Hull 2007).

The next case assumes the scenario of decreasing prices. The farmer *sold* the futures contract for 100 monetary units (he or she would be obliged to deliver) but now *buys* a maize futures contract for 90 monetary units. The farmer has to tell the clearing house that he or she reversed out his position and gains 10 monetary units due to this hedge (Peirson 2008). But again, he or she loses 10 monetary units due to the sale on the spot market which leads to a net result of approximately zero.

If a futures contract would have been available for 89 monetary units, but the spot price would have been decreasing only to 90 monetary units, theoretically, the farmer would have profited by 1 monetary unit. This would be an arbitrage opportunity (buying for 89 on the futures market and selling for 90 on the spot market) but is not very likely to exist. (Peirson 2008)

[9] In subchapter *2.2.6. Basis risk* is described. This is necessary to get deeper understanding of the relationship between spot prices and futures prices. Imperfect convergence and specification differences matter marginally, hence these topics are neglected. Please read Peirson (2008, 546f) for comprehensive explanation.

Again based on Peirson (2008), we have to consider the maize buyer as well. He or she aims to buy a nominated quantity of maize at a certain point in time. Still, the spot price for maize is 100 monetary units today. The buyer hopes that the spot price is going to decrease to 90 monetary units. As it is possible for the price to rise up to 110 monetary units he or she buys a maize futures contract in order to offset the price risk. Now he or she is called a "long hedger". The buyers objective is making no loss of money. A summary of the long hedge can be found in the appendix.

In the case of rising prices the buyer would have lost 10 monetary units by buying maize on the spot market. But as the buyer bought a maize futures contract he or she buys maize on the futures market and gains 10 monetary units due to the futures contract. This idealized example shows the net result of approximately zero.

In the case of decreasing prices the buyer would have gained 10 monetary units by buying maize on the spot market. But as the buyer bought a maize futures contract for 100 monetary units he or she buys maize on the futures market and loses 10 monetary units due to the futures contract. This idealized example shows the net result of approximately zero. With this hedge the buyer could achieve his objective of making no loss of money. Reversing out the buyer's position on the futures market prior to maturity would have been possible.

Speculation

A speculator who is trading with futures does not have any interest in the physical commodity underlying the contract. Their objective is making profit due to correctly anticipating in price movements of the contract (Peirson 2008). Agricultural commodity futures are purely seen as asset class. Depending on the strategy non-commericals are holding contracts from seconds or minutes (scalping[10]) until months or even longer.

Speculators go either long or short. According to Peirson (2008), going long means that the futures contract is bought for a relatively lower price today and is reversed out (a futures contract is sold) for a relatively higher price in future. If the price is going to decrease the speculator loses money. Going short means that the futures contract is sold for a relatively higher futures price today and is reversed out (a futures contract is bought) for a relatively lower price in future. If the price is going to increase the short speculator loses money.

[10] Following types of speculation with futures are common, but are not explained explicitly in this thesis: *scalping, spreading, straddling, day trading* and *long term/overnight position taking*. Please read Peirson (2008, 545) for description.

Marking-to-market and margin call on futures exchanges

This example considers a trader is going long today (e.g. April) by entering into a e.g. July futures contract on maize for 100 monetary units. Two weeks later the price of the futures contract has increased up to 110 monetary units. The trader reverses his or her position out by selling a July futures contract on maize for 110 monetary units and makes a profit of 10 monetary units. But where does the profit come from? (Peirson 2008)

A deposit has to be paid by every trader to the clearing house in advance. The clearing house is part of the exchange (an adjunct of the exchange) and "guarantees the performance of the parties of each transaction" (Hull 2007, 23). Only members of the clearinghouse can participate in trading financial commodities like futures (Geman 2005). Every day after the closing the clearing house calculates the net position of each trader (Hull 2007). Gains are added to the account of the particular trader. If losses have been made they are subtracted from the account of the particular trader. This system is called "marking-to-market", because accounts of the traders are adjusted ("marked") in accordance with the change in the market daily. The clearing house defines the deposit and if the balance falls below a certain level due to losses, extra funds are demanded. This occasion is called "margin call". (Peirson 2008, 539)

2.2.5. Open interest and volume traded

We have seen that traders enter into futures contracts either by going long or short. An explanation of the concepts "open interest" and "volume traded" is necessary as they indicate how much trading is done. Open interest and volume traded was subject of statistical analysis, which can be found in chapter *3. Time series analytical approach*.

The total number of long positions equals to the total number of short positions. A trader's position describes the open interest held by a trader (CFTC 2012b). The concept of open interest represents all contracts outstanding given for a particular commodity (Hull 2002). "Outstanding" in this context purely refers to contracts which are "not yet offset by a transaction [reversed out], by delivery, by exercise, etc." (CFTC 2012b). As not all traders have to report their positions to the US Commodity Futures Trading Commission approximately 70-90% of the total open interest is captured by the report (CFTC 2012b). Open interests are measured at a certain point in time, e.g. at closing of each day (Geman 2005).

Besides open interest (or open positions), the volume traded gives the whole amount of contracts bought and sold over a certain period of time, e.g. traded volume per day. The volume offers information about market liquidity (the higher the volume, the higher its liquidity). It is possible for the volume traded to exceed the open interests at the end of the day (Hull 2002).

2.2.6. Basis risk with hedging

Farmers may decide in favour for hedging their risk on the futures market which is associated with their production and sales activities. Many variables like the commodity price or interest rate are hardly predictable (Hull 2007). The advantage of hedging is that unexpected surprises can be avoided for a good part. However, not every risk can be hedged perfectly and hedging is often not quite as straightforward.

Often farmers plan to sell their commodities on the spot market at some (often uncertain) future time. It is not very likely for the date of the planned spot transaction to be the same date as the maturity date of the futures contract, because an exchange offers only limited maturity dates on a particular contract (e.g. “Mini-sized Corn Futures” at CBOT in 2012: March 12, May 12, July 12, September 12, December 12).

If the planned spot transaction date and the maturity date of a futures contract do not coincide the farmer has to reverse out in advance (Peirson 2008). Furthermore, Hull (2007) points out that the hedged commodity maybe differs from the underlying commodity of the futures contract bought or sold. The risk involved is called “basis risk”. According to Hull (2007, 79), the “basis” can be described as:

Basis (B) = Spot price of asset to be hedged (S) – Futures price of the contract used (F).

The basis at the maturity date of the futures contract should be zero if the hedged asset (futures contract) equals to the asset (physical commodity) underlying the futures contract (Hull 2007). Also, Peirson (2008, 547) states that the spot price and futures price tend to move together, but “for some agricultural commodities it may not even be close to perfect”. Prior to maturity the basis is non-zero, but for “(...) many commodities, (...), the basis is positive” which is due to the fact that commodities frequently have imbalances in demand and supply and difficulties associated with storage (Hull 2007, 79).

According to Peirson (2008), considering the basis at time 0 in a hedging situation with spot price at time 0 and a futures price at time 0:

$$B(0) = S(0) - F(0).$$

The basis at time 1 is:

$$B(1) = S(1) - F(1).$$

The subtraction of the basis at time 0 from the basis at time 1 gives the change in basis between time 0 and time 1. This is called “basis risk”. The basis risk can be presented as:

$$B(1) - B(0) = [S(1) - F(1)] - [S(0) - F(0)].$$

Consider a short hedge – the farmer is storing the physical commodity costless (he is going long on the spot market) and sells futures on the exchange (he is going short on the futures market). The farmer gains money if the spot price is going to increase or the futures price is going to decrease. (Peirson 2008)

But again, the objective of a hedger is the dispersion of the risk and minimizing shortfalls. As speculators are actively seeking for risk on the financial market they are able to gain or lose big amounts of money. Associated risks and risk management strategies for speculators are not explained in this thesis.

2.2.7. Financialization and commodity index investments

Commodities as a “new asset class”

In recent years, financial industry developed a multitude of commodity investment instruments. They are provided for individuals and institutions. Financial investors in the context of “commodity index investments” most frequently take positions through long-only index funds[11], swap agreements and exchange traded funds (ETF). The goal of commodity index investors is to follow the movement of commodity prices (Irwin and Sanders 2011). UNCTAD (2011, 13) defines the increasing role of financial motives, financial markets and financial actors in the operation of commodity markets as “financialization of commodity trading”. Especially agricultural commodity markets experienced financialization. As already mentioned in the introduction chapter, a strong rising demand for long and short futures positions could be observed. Between the years 2004-2008 about “$100 billion of new investments” flew into commodity futures markets, estimated by Irwin and Sanders (2011, 2).

[11] In the same manner as Irwin and Sanders (2011) do, in this work the terms “commodity index funds” and “index funds” refer to all long-only (purchase only positions) commodity investments possibilities.

According to Irwin and Sanders (2011), "financialisation" has been termed by Domanski and Heath (2007, 66).

Before explaining how index-investments, commodity swaps and ETF's work, a brief explanation is given on the purpose of investments in agricultural commodities. Geman (2005, 333) states that many investors see commodities as "new asset class". Commodities are called to be a new asset class as "they cannot be priced by the arguments of net present value", like a bond for instance. Demand, supply and inventory are needed for commodity pricing and hence, pricing is more complex.[12]

Investments in agricultural commodities (also in energy and ore) are predominantly done for the purpose of portfolio diversification. It is expected, that the overall risk of the portfolio is reduced and possible returns are likely to increase (Geman 2005)[13]. Furthermore, they are seen to be useful to hedge against further forms of risk, like inflation risk (UNCTAD 2011). According to Geman (2005), commodity futures prices and commodity spot prices have outpaced inflation in the last 45 years. Commodities futures can be used to hedge against exchange rate risk of the US Dollar as most of the commodities are traded in US Dollar (UNCTAD 2011). An advantage is that futures markets have a relatively high liquidity (generated by both hedgers and speculators) and low transaction costs on the exchange (Geman 2005).

Possibilities of investments in the commodity business

There are various forms how one can invest in agricultural commodities. The most challenging one is probably (i) buying the physical commodity in the cash market. Depending on the product a buyer has to take care of transportation (e.g. shipping), humidity, storage and so on. Besides, it is possible (ii) to purchase stocks of companies which are running a commodity business. This kind of purchase situation is not explained in this thesis. (iii) Individuals or investors are able to buy and sell agricultural commodity futures contracts. The same is possible with (iv) options on commodity futures for instance, which can be entered into (Geman 2005), but is not part of this thesis. The remaining frequently used possibilities are investments in index funds, swap agreements and ETF's. Further exotic commodity investment vehicles exist, but are not part of this thesis.

[12] Pricing of various financial assets will be explained in-depth in Peirson (2008).

[13] Also see Irwin and Sanders (2011) and UNCTAD (2011) which refer to field surveys.

Commodity indices

The interest in commodity index investments has been steadily growing in recent years. According to Irwin and Sanders (2011, 5f), who refer to data from Barclays Capital, a strong upward movement in the value of total US and non-US assets in commodity index products could be observed. Starting in 2004 with about 50 billion US Dollars, the value of assets grew up to approximately 250 billion US Dollars in 2008. Afterwards, a sharp decline down to approximately 150 billion US Dollars followed, but the total value increased up to 300 billion US Dollars until 2010. UNCTAD (2011) shows that commodity related assets under management even reached about 410 billion US Dollars in 2011.

There are several commodity indices existing, like the most famous DJ-UBSCI (Dow Jones-Union Bank of Switzerland Commodity Index) and S&P GSCI (Standard & Poors Goldman Sachs Commodity Index). They can be seen as weighted commodity baskets (UNCTAD 2011).

Index investors follow a passive strategy. Passive in this context means that long-only positions are taken over months or even longer in contrast to active and short-time trading strategies, executed by money managers, who either go long or short (Geman 2005). Hedge funds, for instance, have an actively managed portfolio with the aim of generating high returns by application of various trading strategies in various financial markets. Hedge funds invest in commodity indices (Geman 2005), but usually follow more ambitious strategies.

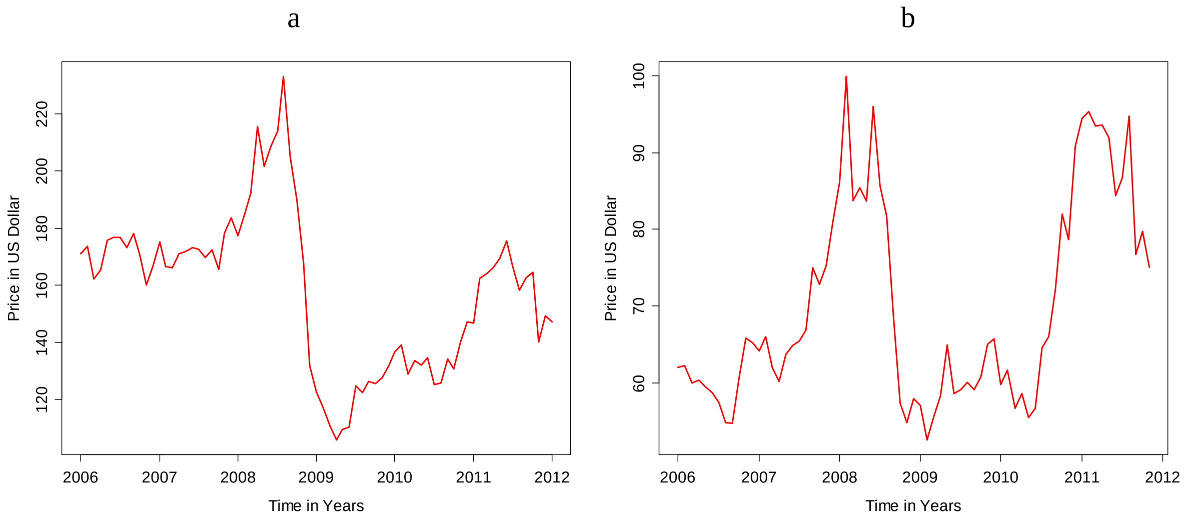
The DJ-UBSCI holds nineteen futures in seven sectors with a maximum weight of 33% in any sector. Agriculture and livestock together represents for 40% of the index weight and energy weights for 28%. Also, the DJ-UBS Agriculture Subindex is available which is computed by DJ-UBSCI [14]. In *Figure 2* both DJ-UBSCI and DJ-UBS Agriculture Subindex can found as a plot (January 2006 until November 2011). A surge is observable in 2007 which peaks in 2008. For both indices a strong decline follows, but are rising again afterwards.

The S&P GSCI comprises 24 commodity futures and is calculated by the quantity production-weighted average of these futures prices. The index is well diversified and 55% of its weight goes towards energy, 23% towards agriculture (wheat, corn, soybean, etc.) and 7% towards livestock. The rest are precious and industrial metals[15]. (Irwin and Sanders 2011)

[14] Please visit http://www.djindexes.com/commodity/ for further details (as April 9, 2012).

[15] Please visit the webpage of S&P for further details (as April 9, 2012).

Figure 2: DJ-UBS Commodity Index (a) and DJ-UBS Agriculture Subindex (b), on a monthly basis



Source: Yahoo finance (2012)

As mentioned above, both indices (DJ-UBSCI and S&P GSCI) base on commodity futures contracts. Since futures contracts expire they need to be “rolled forward” at the beginning of the expiration month. This means futures which are close to expiry are replaced by a futures contract with a later expiration date (Geman 2005). It is possible to” roll over” a futures into a new one at a lower price. Then investors earn a positive “roll return”. These returns “are an important explanation of why the average return on commodity futures has exceeded the average return from holding spot commodities” (Domanski and Heath 2007, 56).

Commodity index investment, swaps and exchange traded funds

In this thesis, investments in agricultural commodities through futures contracts are focused. Nevertheless, in this context swaps and exchange traded funds (ETF’s) have to be explained as well.

Only a minority of individuals and institutions invest directly in futures contracts in order to simulate a commodity index, which is rather complex. However, it is more likely for institutions to invest in funds (e.g. a hedge fund), which replicates a commodity index, like DJ-USBCI or S&P GSCI. After an order is given the fund manager either buys futures or enters an OTC swap contract with a swap dealer (e.g. bank). Swaps can be tailored in order to meet the specific needs of the instructing party (Irwin and Sanders 2011). Two parties are involved whereby a floating price (spot market price at a fixed date) is exchanged for a fixed price over a period of time. Differences paid or cash clearing is done by the counterparty (Geman 2005). The payoff of an “index swap” is indexed to a commodity index. According to Irwin and Sanders (2011, 4), “the swap dealer will in turn enter the futures market and take long positions in the corresponding futures contracts to offset the risk associated with their side of the OTC derivative."

An investor may also give an order to a swap dealer directly. Swap dealers actually hold the long positions in the futures market. Also commodity swaps are available which "enable both producers and consumers to hedge commodity prices" (Geman 2005, 363).

Exchange traded funds are developed mainly for individual investors and are offered by funds. According to UNCTAD (2011), ETF's have gained considerable importance since 2009. The company which offers the fund collects a service fee. Shares of ETF's are purchased by individuals on exchanges and its price "the share price tracks a designated commodity index". The fund manager either buys futures contracts or OTC "commodity return swaps" in order to gain commodity exposure. Again, the swap dealer is going to *buy* futures contracts in order to hedge the risk associated with the OTC derivate. Swap dealers hold approximately 85% of index-based position in agricultural futures markets. (Irwin and Sanders 2011)

2.3. The relation between spot markets and futures markets

It is important to go a step further and establish a theoretical link between spot and futures markets. This chapter gives insights in the relationship between those markets (theory of storage) and presents hypotheses about price formation on financial markets.

2.3.1. Theory of storage

It can be assumed that price discovery on spot markets bases on demand and supply factors, hence, a multitude of information is available. Furthermore, a big number of independent agents make decisions according to their own preferences. As already mentioned in brief, price formation of commodities on financial markets bases on information about demand, supply and inventory. A buyer, for instance, has the possibility either to buy grains on the spot market today and store the grains until they are needed. Besides he or she could also buy a futures contract and wait until delivery of the commodity. It is important to highlight that the buyer on the spot market faces storage costs and opportunity costs (UNCTAD 2011). According to (Peirson 2008, 542), "a futures price [F at time 0] must be less than (or equal to) the current spot price [S at time 0], plus the carrying cost [C]" and can be written as:

$$F_0 \leq S_0 + C.$$

Cost of carry (or carrying cost) comprises interest (*I*) and storage cost (*W*) and can be presented as (Peirson 2008; UNCTAD 2011):

$$F_0 \leq S_0 + I + W.$$

The price difference between a futures price and the spot price of the futures contract underlying physical commodity is called basis. According to Bailey (2005, 379), "the futures price reflects expectations about the spot price of the underlying asset at its delivery date". Hull (2002, 63) summarizes the relationship between futures prices and spot prices "in terms of the cost of carry". As long as the spot price plus carrying cost exceed (or at least equal to) the futures price no arbitrage opportunity is be given. If the futures price exceeds the spot price plus carrying cost arbitrageurs buy the commodity on the spot market today and go short on the futures market simultaneously (sell a futures contract for the higher price). A risk-free profit is obvious. Arbitrageurs follow this procedure until spot prices plus carrying costs will be at least the futures price (UNCTAD 2011). If the futures price is less than the spot price plus carrying cost an arbitrage opportunity is given as well. The commodity is sold on the spot market by arbitrageurs and immediately bought on the futures market (going long). They do so until spot prices plus carrying costs will be at least the futures price (UNCTAD 2011).

Hence, theory of storage is an attempt to explain "the differences between spot and Futures prices by analyzing the reasons why agents hold inventories" (Geman 2005, 24). This theory explains the relationship between futures prices and spot prices.

This thesis deals with storable agricultural commodities maize, wheat, rice and soybean. The purpose of storage is to balance supply and demand. Inventories have a "productive value" as rising demand and supply shortfalls can be cleared (Geman 2005.). The holders utility is the so called convenience yield. If inventories are high the utility of an additional quantity of the product is low (decreasing marginal convenience yield). And vice versa, if inventories are low the marginal convenience yield to the holder is high (UNCTAD 2011).[16]

UNCTAD (2011) takes the convenience yield (*Y*) into account. A situation in which the futures price is above the *expected future spot price* (right hand side of the below given formula) is called "contango" (Hull 2002). The futures curve is upward sloping. Typically, this situation arises when inventories are high. The storage costs plus interest rate exceed the convenience yield. One has to

[16] Convenience yield may be modelled in different ways. An overview of various approaches and results delivers Geman (2008, 25).

consider that space of storage is limited and "storage costs tend to rise with the level of inventories" (UNCTAD 2011, 4). Hence, the physical product is likely to be sold on the spot market and spot prices will decrease. This can be shown as:

$$F_0 > S_0 + I + W - Y.$$

A situation where the futures price is below the *expected future spot price* is called "backwardation" (UNCTAD 2011, 4). As the convenience yield exceeds the cost of carry the demand for inventories is high. This can be written as:

$$F_0 < S_0 + I + W - Y.$$

2.3.2. The role of information

All of the three presented hypothesis try to explain the building mechanism of futures prices. They all do have in common the role of information. Information is crucial to market participants on futures markets, as traders build their price expectations on basis of supply and demand development of the underlying physical asset.

Efficient Market Hypothesis

From a broad range of economists it is assumed that the price of a security[17] fully reflects all available information. According to Fama (1970, 383), "a market in which prices always fully reflect available information is called efficient". In the context of *informational efficiency* Malkiel (2003, 60) defines efficiency of financial markets as "markets [which] do not allow investors to earn above-average returns without accepting above-average risks" and markets are seen as helpful devices "for reflecting new information rapidly (...)".

These assumptions base on the *efficient market hypothesis* (EMH). According to the EMH, price changes follow a random walk process and "all currently available information of any relevance in evaluating the asset in question is already incorporated in the market price" (Hens and Schenk-Hoppé 2009, 165). Peirson (2008, 499f) refers to the markets "degree of efficiency" which can be tested for any commodity.

[17] In this sense, a security refers to a financial product – a futures contract for instance.

According to Fama (1970), there are three forms of efficient markets:

- Weak-form efficiency;
- Semi-strong-form efficiency;
- Strong-form efficiency.

Fama (1970) explains that prices of an asset traded on a weak-form efficient market comprise historical price data. The semi-strong-form postulates prices which incorporate historical prices and all public available news (e.g. announcements of harvest forecasts). If also privately held information is incorporated into the price of the traded asset then the market efficiency is given in its strong-form.

Other than that UNCTAD (2011, 4), for instance, highlights "existing [informational] gaps". Little or wrong information about price drivers bears a certain risk for actors on the markets. They expect a certain forward price according to their informational situation. The trading position (strategy) is taken in accordance with their individual given set of information and "tend to accentuate price movements" (UNCTAD 2011, 4). Hence, new prices must not "fully reflect" prices according to market fundamentals. The EMH fails in such a situation.

The Fundamentalist Hypothesis

This hypothesis assumes that prices are determined by market fundamentals demand and supply. Participating market agents act fully rational and the available set of information is equal to all of them. Hence, they all follow the same model. (Schulmeister 2009)

Speculation is seen to deliver important liquidity on financial markets in order to facilitate price formation of a security quickly. Furthermore, non-commercial traders do absorb the risk, which is dispensed by commercial traders. (Schulmeister 2009)

Overshooting of prices is always regarded as a consequence of exogenous shocks. Speculation is not recognized as a long-term price driver of the security. Deviations of prices from their fundamental equilibria are likely to happen, but only on a short-term. (Schulmeister 2009)

This hypothesis follows the assumptions of the efficient market hypothesis (Staritz 2012). According to the EMH available information is incorporated in the price on the commodity market immediately, depending on its degree of efficiency.

The Bull-Bear-Hypothesis

In addition to market fundamentals, this hypothesis also includes non-fundamental assumptions on price discovery. Imperfect knowledge is the general assumption. Hence, different price expectation models are applied by market participants. Social factors and emotions influence price expectations of traders. Decisions are mostly formed on a qualitative basis. Immediate reactions to news by traders are limited to time constraints and unavailable information about price expectations of other traders to the new available information. Price discovery follows a heterogeneous process. (Schulmeister 2009)

On the basis of the bull-bear-hypothesis Staritz (2012, 17) mentions the "financialization hypothesis", which assumes that prices "are driven by the expectations, behavior and interactions of heterogeneous traders, including informed traders, noise traders and uninformed traders." According to Staritz (2012), informed traders do have an interest in the physical market and appear on the financial market for hedging purposes. Noise traders, e.g. index investors, follow developments on other asset markets in order to diversify their portfolio. Uninformed traders take their decisions on the basis of statistical techniques on price trends" (Staritz 2012, 17) instead of decisions which base on fundamental information about demand and supply of the physical product. The circumstance of following short-term asset price movements is called trending. Noise trading and trending leads to overshooting of commodity prices. (Staritz 2012)

Misinterpretation of information is very likely to happen. This misleading information is incorporated in price expectations and decisions about trading strategies. It can be assumed uninformed traders do apply similar trend-following statistical analysis. Maybe this leads to herd behaviour. Consequently, due to individual identification of (wrong) trends (misinterpretation of information) from past data, new trends are generated. These new trends do not follow fundamental information. Hence, uninformed trading may leads to overshooting of asset prices, which deviate from their fundamental equilibria. In this case, acting against this trend would be irrational, even though conclusions on the basis of information about market fundamentals would signal a different trading strategy. For this reason, according to the "financialization hypothesis", market efficiency depends on the dominating group of traders (microstructure). (Staritz 2012)

3. Time series analytical approach

Econometrics requires a clear hypothesis, which is tested with proper statistical methods. The applied empirical method is time series statistics in a multivariate form. Following the assumptions of Gilbert (2010), who assumes that rising demand for agricultural commodity futures possibly led to rising agricultural commodity spot prices, variables and hypotheses are derived. In this chapter the general hypotheses (can be found in the introduction chapter) are specified in accordance with the applied Granger-causality test. All calculations are carried out with the free software *R*.[18] The belonging syntax can be found in the *Appendix* section.

3.1. Dataset and variables

All variables are on a monthly basis and are outlined in *Table 2*. Time series start in January 2002 and end in May 2011. 113 observation points are given. Gathered data describe the situation in the USA as financial data are most accessible in the US compared with European data. Furthermore, CBOT is the biggest and most influential bourse on the world.

Price developments of three different storable grains and one oilseed are investigated. In *Table 2* one can find details and sources. Spot prices for maize, wheat, rice and soybean are used. These variables show highest trading volumes (in tonnes) and are storable. Hence, they represent a sound profile of storable agricultural commodities. Their prices increased sharply in 2007-2008 and 2010-2011.

Additionally, financial variables can be found in *Table 2*. The selected variables are commercial long positions, non-commercial long positions, total reportable long positions and total volume traded. These variables capture the rising demand for commodity futures contracts. It is assumed that index investments play the key role in rising demand for futures contracts. Index investments take long-only positions. Hence, exclusively "long" positions are investigated.

[18] http://www.r-project.org/

Table 2: Overview of variables used in statistical analysis

Variables	Name of variable	Description and units	Source
Maize	*Maize*	US No.2, Yellow, U.S. Gulf (Friday) in US$/ton, monthly averages	FAO (2011)
Wheat	*Wheat*	US No.2, Hard Red Winter ord. Prot, US f.o.b Gulf (Tuesday) in US$/ton, monthly averages	FAO (2011)
Rice	*Rice*	White Broken Rice, Thai A1 Super, f.o.b Bangkok (Wednesday) in US$/ton, monthly averages	FAO (2011)
Soybean	*Soybean*	US No.1, Yellow, U.S. Gulf (Friday) in US$/ton, monthly averages	FAO (2011)
Open interests	*CommLo* *NonCommLo* *TotRepPosLo*	Long positions taken by commercials Long positions taken by non-commercials Total reportable positions long. Contracts per piece.	CFTC (2011b)
Volume	*VolCorn* *VolWheat* *VolRice* *VolSoy*	Total volume traded on maize, wheat, rice and soybean. Contracts per piece.	IFPRI (2011)[19]; CFTC (2011a)

3.2. Specified hypotheses

The general hypotheses are adapted in accordance with applied statistical methods and variables. The specified hypotheses can be found below. Time series are tested for *Granger-causality*. According to Lütkepohl and Krätzig (2004), the null-hypothesis of the Granger-causality test is:

$$H_0\text{: } X \text{ do not Granger-cause } Y.$$

The null-hypothesis is tested against the alternative hypothesis (H_1) and can be described as

$$H_1\text{: Not } H_0.$$

[19] It is worth noting that help by Miguel Robles (IFPRI) and Cristina Chiarella (IFPRI) for gathering data was highly appreciated.

Spot prices are tested bi-directionally for Granger-causality. Hence, the vice versa null-hypothesis is

$$H_0\text{'}: Y \text{ do not Granger-cause } X.$$

The vice versa null-hypothesis is tested against the vice versa alternative hypothesis (H_1') and can be presented as

$$H_1\text{'}: \text{Not } H_0\text{'}.$$

For each spot price – maize, wheat, soybean and rice – eight hypotheses are drawn up. These spot price variables (X) are tested whether they do not Granger-cause the financial variable (Y) *and* vice versa (according to bi-directionality), whether the financial variables (Y) do not Granger-cause the spot price (X). The null-hypotheses are:

- Spot prices do not Granger-cause long positions taken by commercial traders on the particular commodity futures. And vice versa, long positions taken by commercial traders on the particular commodity futures do not Granger-cause the particular spot prices.
- Spot prices do not Granger-cause long positions taken by non-commercial traders on the particular commodity futures. And vice versa, long positions taken by non-commercial traders on the particular commodity futures do not Granger-cause the particular spot prices.
- Spot prices do not Granger-cause total reportable long positions traded on the particular commodity futures. And vice versa, total reportable long positions traded on the particular commodity futures do not Granger-cause the particular spot prices.
- Spot prices do not Granger-cause total volume traded on the particular commodity futures. And vice versa, total volume traded on the particular commodity futures do not Granger-cause the particular spot prices.

3.3. Description of applied statistical methods

All variables are time series. Time series analysis is a helpful tool to investigate hypotheses over various variables. "A time series is a set of observations, each being recorded at a specific time" (Brockwell and Davis 2002, 1). The observations in a given time series *y* may be described as

$$y_1,...,y_T$$

and "is generated by a stochastic process $\{y_t\}_{t \in T,}$ where T is an index set containing the subset {1,...,T}. The subscript t are usually thought of as representing time (...)" (Lütkepohl and Krätzig 2004, 10).

A time series is supposed to be generated by a *random* process, a so called *stochastic* process, which is "a collection of random variables" (Lütkepohl and Krätzig 2004, 10). Burke and Hunter (2005, 8) state that "the fundamental building block is the autocorrelation structure of a time series", which may be described as "the relationship between neighbouring values" or as "correlation between the two random variables".

Characteristics of a time series

One of the most important properties of time series is *stationarity*. Properties – like mean and variance – of a stationary time series are the same over time. As (Lütkepohl and Krätzig 2004, 10) explain a stochastic process y_t is stationary if

1. $E(y_t) = \mu_y$ for all $t \in T$ and
2. $E[(y_t - \mu_y)(y_{t-h} - \mu_y)] = \gamma_h$ for all $t \in T$ and all integers h such that $t - h \in T$.

The first statement (or first moment) shows that the expected values (also called mean) E for any observation y_t of a stationary process have the same constant mean μ_y. The second moment shows that the variances are time invariant because for h = 0 the variance

$$\sigma_y^2 = E[(y_t - \mu_y)^2] = \gamma_0$$

does not depend on t. The covariances

$$E[(y_t - \mu_y)(y_{t-h} - \mu_y)] = \gamma_h$$

do not depend on the point in time t but just on the gap in time h of the two members of the process. (Lütkepohl and Krätzig 2004, 11)

In order to investigate a variable with proper statistical tests time series has to be stationary, which means properties remain the same. Mostly, economical time series are not stationary at all and a first important step is to check properties of the variables. In order to find out whether stationarity is given, time series are characterised by plots and descriptive statistics. But this is not sufficient and suitable statistical tests have to be applied. Suitable plots (spot prices, volatility, etc.) and a summary table of descriptive statistics can be found in subchapter *3.4.1. Characteristics of analysed time series*.

Transformation of a time series

Investigation of economical variables requires time series to be stationary. Mostly, characteristics of an economical time series are far away from stationarity. Therefore, data have to be transformed accordingly. The logarithmic transformation (natural log) from a time series y_t, e.g. log(*Maize*), is important. Sometimes this helps to stabilize the variance, if the variance of the original time series rises with the level of the series. (Lütkepohl and Krätzig 2004)

Moreover, by building first differences of the log-variables, e.g. diff(log(*Maize*)), trends of the time series are eliminated. The diff-log transformation roughly gives the rates of change, or also called return (in this thesis monthly returns). The rates of change may be given as

$$\Delta\log(y_t) = \log(y_t) - \log(y_{t-1}).$$

One has to consider sometimes a diff-log transformation makes a time series look like a stationary series, but the series may still be non-stationary. Hence, applying proper statistical tests is essential. (Wooldridge 2009; Lütkepohl and Krätzig 2004)

Integrated process and unit root process

Transforming a non-stationary stochastic process into a stationary by considering first differences is said to be *integrated of order one* I(1). If differences have to be applied *d* times to make the process stationary the series is said to be *integrated of order d* I(*d*) (Lütkepohl and Krätzig 2004, 21). A process

$$\mathrm{I}(d) \text{ with } d \geq 1$$

is said to have a *unit root*. A unit root is given if 1 is a null (or root) of the equation. Therefore, a stochastic process with a unit root is a non-stationary process. The order of integration can be calculated by application of a unit root test (Lütkepohl and Krätzig 2004, 21). Wooldridge (2009, 609) states “that the augmented Dickey-Fuller test is probably the most popular [unit root test] (...).”

Augmented Dickey-Fuller (ADF) tests

The order of integration is important for further statistical analysis. In a first step, all log-variables are tested for unit roots with the ADF-test. The according null-hypothesis checks existence of unit roots

$$H_0: \phi = 0,$$

which equals to a non-stationary process of the series. The alternative hypothesis is stationarity

$$H_1 : \phi < 0$$

of the time series (Lütkepohl and Krätzig 2004). The ADF test may be described in form of a regression as

$$\Delta y_t = \phi y_{t-1} + \Sigma\, \alpha_j^* \Delta y_{t-j} + u_t\,,$$

where α

$$\phi = -\alpha(1) \text{ and}$$

$$\alpha_j^* = -(\alpha_{j-1} + ... + \alpha_p).$$

The process is integrated when

$$\alpha(1) = 1 - \alpha(1) - \ldots - \alpha_p = 0.$$

The ADF test "is based on the t-statistic of the coefficient ϕ from an OLS [ordinary least square] estimation (…) [and] has a non-standard limiting distribution. (...) In these tests a decision on (…) the number of lagged differences of y_t has to be made" (Lütkepohl and Krätzig 2004, 54).

In this thesis the function *VARselect* is used to determine the lag order *p*. *VARselect* draws on the Akaike information criterion (AIC). Lag order *p* is determined by minimizing the AIC and is important for the ADF test. They are summarized in the appendix section.

If the order of integration of the investigated log-variable is not clear, log-variables have to be tested for unit roots by applying ADF test. If the test fails to reject H_0 time series is still non-stationary. Therefore, log-variables are differenced and ADF test is applied again. According to Lütkepohl and

Krätzig (2004), this procedure will repeated until unit roots are rejected and time series are stationary. Counting the number of repetitions of differencing gives the order of integration.

In the same manner as Lütkepohl and Krätzig (2004, 55) did, a 5% critical value is considered as 10% may delivers too weak evidence. H_0 is rejected when p-value of ADF test is smaller than 0.05. Afterwards, the *maximum* order of integration of the group of time series (two time series are used as a group; variables X and Y) is saved into the variable *m*. Additional lags *m* are required for Granger-causality test. Maximum order of integration values are summarized in the appendix section.

Vector autoregressive models (VAR)

Now, as maximum order of integration is known a VAR model has to be set up. This VAR process is "a suitable model class for describing the data generation process of a small or moderate set of time series variables" (Lütkepohl and Krätzig 2004, 87). According to them, neglecting deterministic terms and exogenous variables the VAR model captures the dynamic interactions of a set of time series variables *K*, which is

$$y_t = (y_{1t}, \dots, y_{Kt})'.$$

The model is

$$y_t = A_1 y_{t-1} + \dots + A_p y_{t-p} + u_t,$$

where the A_i's are (K x K) coefficient matrices and u_t is an unobservable error term. An appropriate lag length for the variables is determined, based on function *VARselect*. Again, lags are determined by minimizing the AIC of the log-variables.

Granger-causality analysis

According to determined lags and maximum order of integration, Granger-causality test is applied. Granger defined a variable X_2 (Granger-)causal for a variable X_1 if time series X_2 helps to improve the forecasts of time series X_1 (Lütkepohl and Krätzig 2004). X_2 is not Granger-causal for X_1 if the bivariate VAR(*p*) of the form

$$\begin{bmatrix} X_{1,t} \\ X_{2,t} \end{bmatrix} = \sum_{i=1}^{p} \begin{bmatrix} \gamma_{11,i} & \gamma_{12,i} \\ \gamma_{12,i} & \gamma_{22,i} \end{bmatrix} \begin{bmatrix} X_{1,t-i} \\ X_{2,t-i} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix}$$

has $\gamma_{12,i} = 0$, i = 1,2, … , p. X_2 is not granger-causal for X_1 if its lags do not appear in the equation. An exogenous variable m in the model is incorporated in the VAR process and $m > 0$. According to Toda and Yamamoto (1995), a VAR process is fitted whose order exceeds the true order. A lag augmented model with m additional lags is used in the test. Afterwards, Granger-causality is tested for which the null-hypothesis is *X do not Granger-cause Y* and the alternative null-hypothesis is *Not* H_0. As Granger-causality tests bi-directionally the vice versa null-hypothesis (H_0') is *Y do not Granger-cause X* and the vice versa alternative hypothesis is *Not* H_0'.

3.4. Characteristics and results

3.4.1. Characteristics of analysed time series

In this section, a statistical summary is given for the spot price variables *maize*, *wheat*, *soybean* and *rice*. Furthermore, plots of spot prices and according financial variables can be found as well. Hence, it is possible to study the properties of each time series and gives a good idea about data used. Lütkepohl and Krätzig (2004) encourage doing so.

In *Table 3* one can find a descriptive key summary statistics for all spot prices. The lengths of the analysed time series are approximately eleven years. *Min.* gives the eleven year low (minimum) and *Max.* the eleven year high (maximum) of the particular spot price in US Dollar per tonne. Therewith, margin of fluctuation is apparent.

Table 3: Descriptive summary for all spot price variables in US Dollar / tonne, on a monthly basis

Key statistics	Maize	Wheat	Soybean	Rice
Min.	87.6	122.8	172.2	140.3
1st Qu.	104.5	158.0	226.9	206.8
Median	132.5	200.2	291.4	228.0
Mean	147.9	217.9	322.3	278.0
3rd Qu.	169.9	247.2	393.8	338.5
Max.	314.0	481.5	586.2	772.0
Stand. Dev.	55.2	77.43	108.1	124.3

Source: FAO (2011)

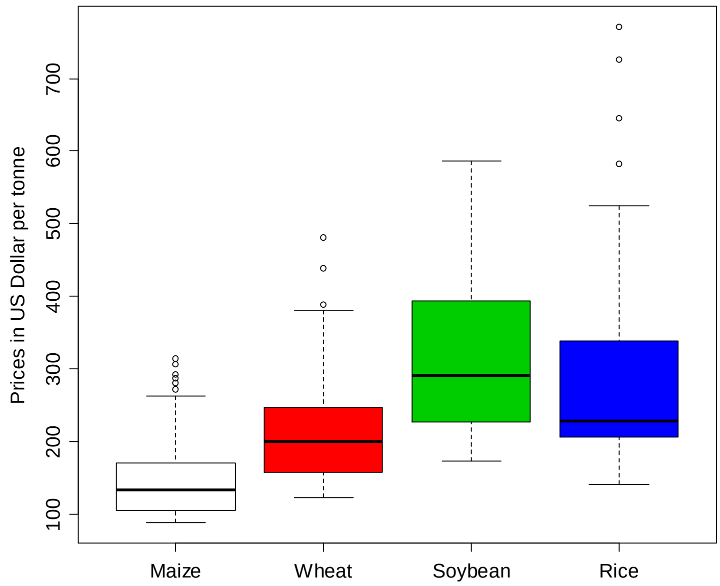
1st Qu. and *3rd Qu.* represents lower and upper quartile. 25% of all observations are below the given value of the first quartile. 50% of all observations are between the first and third quartiles. 25% of all observations are above the given value of the third quartile.

The *Median* is the second quartile and halves observations – 50% of the observations are below, 50% are above the given value of the median. Quartiles allow conclusions about distribution and measure of location. See also *Figure 3* for graphical illustration.

The arithmetic *Mean* or average is the expected value of the series. *Stand. Dev.* (standard deviation) is a measure of variability and indicates dispersal from the mean. (Groß 2010)

In *Figure 3* one can find boxplot diagrams for all tested grain variables in US Dollar per tonne. As mentioned above, the median (bold black line in the coloured boxes; Q2) halves the observations. Furthermore, it is easy to compare minimum and maximum observations (Q1 is the bottom line of the box and Q3 is the upper line of the box). Outliers become apparent as well, which are observed in the year 2008. Obviously, the price range of rice is highest and the one of maize smallest. The mean (expected value of the series) of soybean is highest compared with the other series.

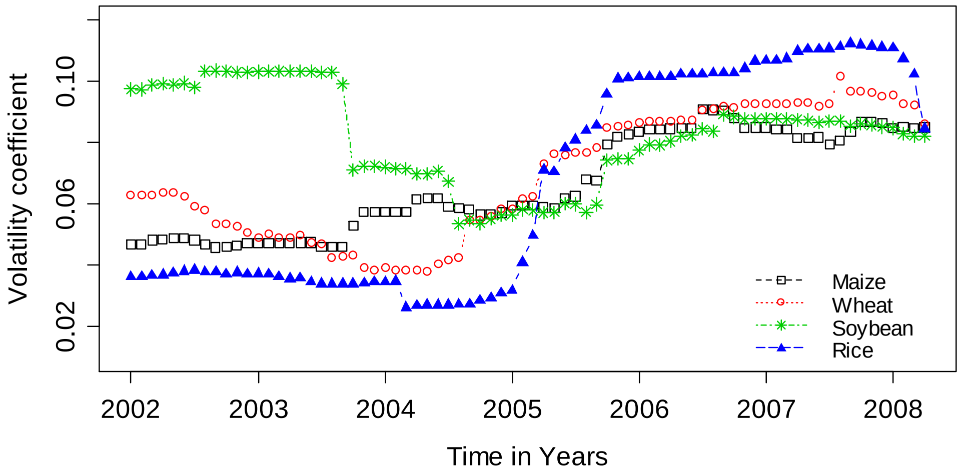
Figure 3: Boxplot diagram for all spot price variables, on a monthly basis



Source: FAO (2011)

In *Figure 4* the volatility of each time series is given. It measures the variance of returns over 36 months. This is a so called 36 months rolling volatility (the last 36 data points get lost). One can see rising volatility for maize, wheat and soybean, starting approximately in the year 2005. In the years 2002 and 2003, volatility of soybean is already high compared with the grains. After a brief decline in 2004 volatility rises again in 2005, hand in hand with the other commodities. However, the highest level of volatility for soybean remains during the years 2002-2004.

Figure 4: Rolling Volatility over 36 Months between 2002 and 2011, on a monthly basis



Source: FAO (2011)

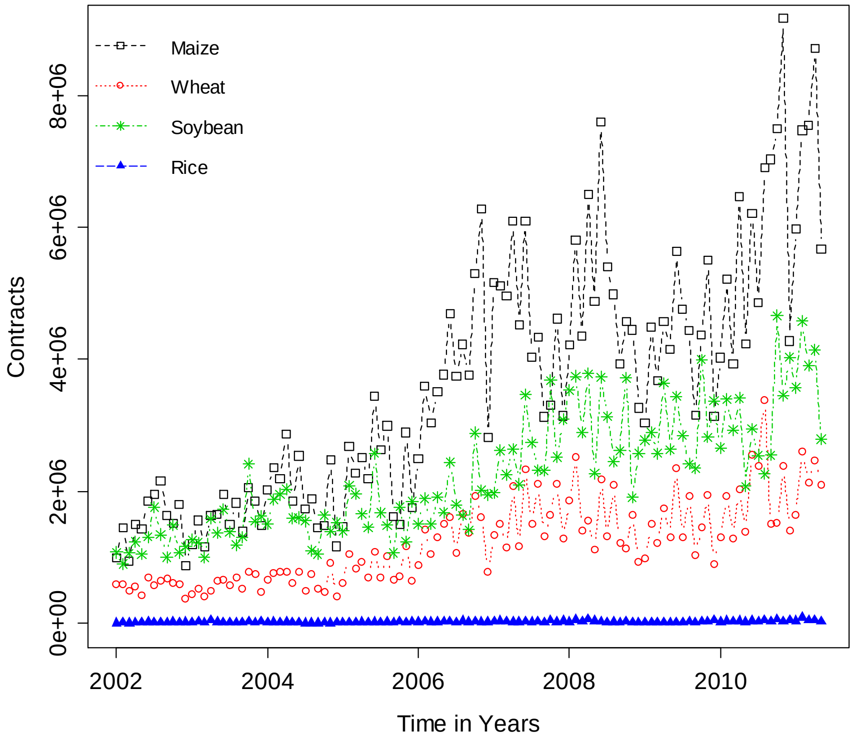
On the next graphs (*Figure 5*) development of open interests is given. Each commodity shows the open interests for commercial traders, non-commercial traders and total reportable positions, which always has to exceed the other series. Strong rising open interests in the years 2005/2006 and in the year 2009 can observed for each futures. This upward movement confirms open interest has been rising since 2002. Non-commercial traders positions (speculative positions) are below commercial traders positions, but not in the case of rice.

Figure 5: Open Interests long for maize (a), wheat (b), rice (c) and soybean (d), on a monthly basis

Source: CFTC (2011b)

Figure 6 shows the volume traded on maize, wheat, soybean and rice. In the starting period of the time series there was less trading then in 2008 or 2010, except for rice, which is traded on a very small scale level on CBOT over the whole period. But the volume traded on maize rose in 2008 and 2010. The same is given for wheat and soybean, but on a far smaller level. It is also worth to mention that the volatility (fluctuation around the mean) is rather unsteady, especially for maize.

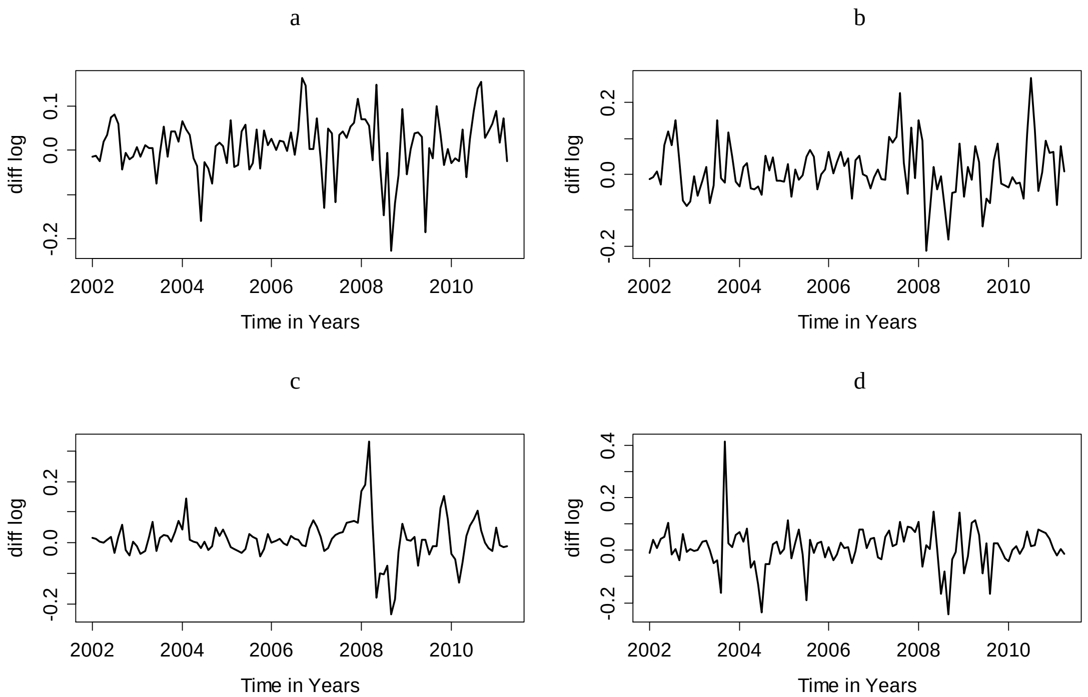
Figure 6: Volume traded for all spot variables, on a monthly basis



Source: IFPRI (2011) and CFTC (2011a)

Further graphs (*Figure 7*) show the monthly rate of change (so called return). The illustrated time series look like stationary series as they fluctuate around a constant mean. Variances seem to be stable. But to be sure time series are tested for stationarity.

Figure 7: Returns for maize (a), wheat (b), rice (c) and soybean, on a monthly basis



Source: FAO (2011)

Furthermore, values (*Table 4*) and graphs (*Figure 8)* from the autocorrelation function (ACF) for spot prices are presented. Lütkepohl and Krätzig (2004) recommend to follow this standard procedure (plotting and descriptive statistics for relevant time series).

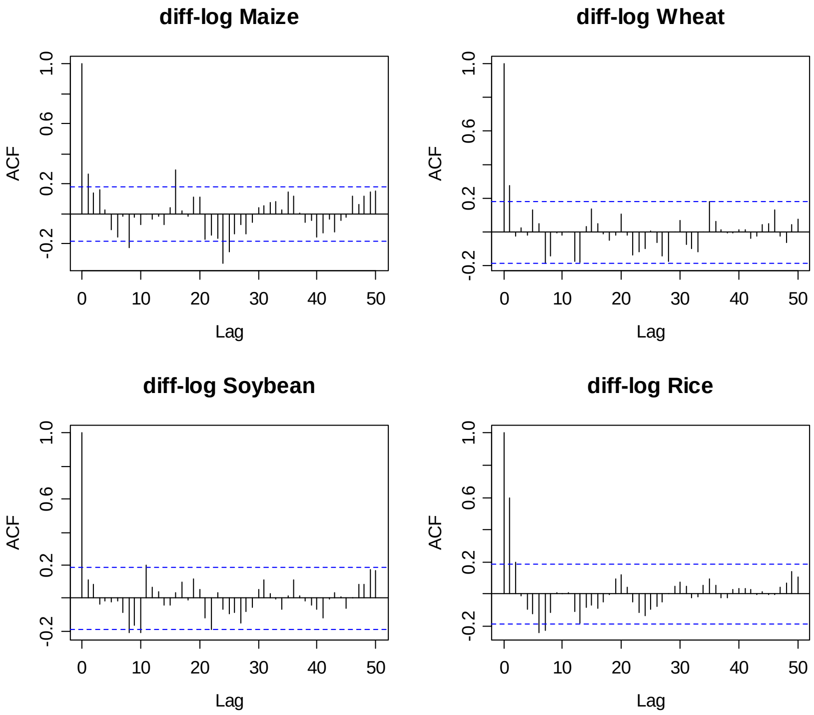
Table 4: Autocorrelation (ACF) for spot prices, on a monthly basis

Diff-log Variable (lag=1)	Autocorrelation
Maize	0.2640885
Wheat	0.2783169
Soybean	0.1122163
Rice	0.5947417

Source: FAO (2011)

Lags outside of the blue line (which is the confidence interval at 0.95) may imply that differencing has to be done and time series is non-stationary. But this kind of interpretation has to be treated with caution and is insufficient for further statistical analysis. Rice shows the highest autocorrelation and soybean the lowest, calculated with a lag of one.

Figure 8: Autocorrelation for maize, wheat, soybean and rice, on a monthly basis



Source: FAO (2011)

3.4.2. Hypotheses for maize and results

Hypothesis with commercial long position

Maize spot prices (X = *Maize*) do not Granger-cause long positions taken by commercial traders on maize futures (Y = *MaizeCommLo*). Now time series are tested for unit roots (H_0: $\phi = 0$; what equals to a non-stationary process of the series and the existence of unit roots) by applying ADF test. Results for X and Y are:

```
        Augmented Dickey-Fuller Test

data:  x
Dickey-Fuller = -3.8193, Lag order = 20, p-value = 0.02051
alternative hypothesis: stationary

        Augmented Dickey-Fuller Test

data:  y
Dickey-Fuller = -1.4634, Lag order = 1, p-value = 0.7993
alternative hypothesis: stationary
```

Lag-order *p_x* and *p_y* for each variable is given (*p_x* = 20 and *p_y* = 1). Critical value (p-value) for X is smaller than the significance level of 0.05, but not for Y, which is > 0.05. Therefore, ADF-test rejected null-hypothesis of X, but failed to reject the H_0 of Y. This means time series for X do not have unit roots and is stationary, which is required. Time series for Y follows a unit root process and is not-stationary, as null-hypothesis could not be rejected. Therefore, ADF-test has to be carried out again by taking differences of the logarithmized time series Y (*diff(log(MaizeCommLo))*). Calculated lag order *p_y* derived from the log-variable Y as before is subtracted by one. This procedure has to be carried out until H_0 is rejected and time series is stationary. One can go on by counting the maximum number of differencing the log-variable Y until p-value is < 0.05.

```
        Augmented Dickey-Fuller Test

data:  diff(y)
Dickey-Fuller = -8.5839, Lag order = 0, p-value = 0.01
alternative hypothesis: stationary
```

This results in the maximum order of integration. In this case maximum order of integration is one I(1) as order of integration of variable X is zero and order of integration of Y is one. Maximum order of integration is needed as variable *m* to testing for Granger-causality. Results from Granger-causality test are:

```
        Granger causality H0: x do not Granger-cause y

data:  VAR object var_xy
F-Test = 2.6968, df1 = 25, df2 = 70, p-value = 0.0006027
```

Granger-causality test rejects the null-hypothesis (maize spot prices (X) do not Granger-cause long positions taken by commercial traders on maize futures (Y)) with a p-value = 0.0006027, as the p-value is < 0.05. Vice versa as follows:

```
        Granger causality H0: y do not Granger-cause x

data:  VAR object var_xy
F-Test = 0.5198, df1 = 25, df2 = 70, p-value = 0.9652
```

Granger-causality test fails to reject the null-hypothesis (long positions taken by commercial traders on maize futures (Y) do not Granger-cause maize spot prices (X)) with a p-value = 0.9652, as the p-value is > 0.05. Lag-order *p* of Granger-causality test is 25:

```
> p
AIC(n)
25
```

Hypothesis with non-commercial long position

Maize spot prices (X = *Maize*) do not Granger-cause long positions taken by non-commercial traders on maize futures (Y = *MaizeNonCommLo*). And vice versa, long positions taken by non-commercial traders on maize futures do not Granger-cause maize spot price. Results from Granger-causality test are:

```
        Granger causality H0: x do not Granger-cause y

data:  VAR object var_xy
F-Test = 0.4828, df1 = 2, df2 = 208, p-value = 0.6177
```

Granger-causality test fails to reject the null-hypothesis (maize spot prices (X) do not Granger-cause long positions taken by non-commercial traders on maize futures (Y)) with a p-value = 0.6177 as the p-value is > 0.05. Vice versa as follows:

```
        Granger causality H0: y do not Granger-cause x

data:  VAR object var_xy
F-Test = 3.6271, df1 = 2, df2 = 208, p-value = 0.02829
```

Granger-causality test rejects the null-hypothesis (long positions taken by non-commercial traders on maize futures (Y) do not Granger-cause maize spot prices (X)) with a p-value = 0.02829, as the p-value is < 0.05.

Hypothesis with total reportable long position

Maize spot prices (X = *Maize*) do not Granger-cause total reportable long positions traded on maize futures (Y = *MaizeTotRepPosLo*). And vice versa, total reportable long positions traded on maize futures do not Granger-cause maize spot prices. Results from Granger-causality test are:

```
        Granger causality H0: x do not Granger-cause y

data:  VAR object var_xy
F-Test = 5.2465, df1 = 25, df2 = 66, p-value = 3.421e-08
```

Granger-causality test rejects the null-hypothesis (maize spot prices (X) do not Granger-cause total reportable long positions traded on maize (Y)) with a p-value = 3.421e-08, as the p-value is < 0.05. Vice versa as follows:

```
        Granger causality H0: y do not Granger-cause x

data:  VAR object var_xy
F-Test = 1.3024, df1 = 25, df2 = 66, p-value = 0.1961
```

Granger-causality test fails to reject the null-hypothesis (total reportable long positions traded on maize futures (Y) do not Granger-cause maize spot prices (X)) with a p-value = 0.1961, as the p-value is > 0.05.

Hypothesis with volume traded

Maize spot prices (X = *Maize*) do not Granger-cause total traded volume on maize futures (Y = *VolCorn*). And vice versa, total traded volume on maize futures do not Granger-cause maize spot prices. Results from Granger-causality test are:

```
        Granger causality H0: x do not Granger-cause y

data:  VAR object var_xy
F-Test = 1.8798, df1 = 25, df2 = 66, p-value = 0.02179
```

Granger-causality test rejects the null-hypothesis (maize spot prices (X) do not Granger-cause total traded volume on maize futures (Y)) with a p-value = 0.02179, as the p-value is < 0.05. Vice versa as follows:

```
        Granger causality H0: y do not Granger-cause x

data:  VAR object var_xy
F-Test = 1.3718, df1 = 25, df2 = 66, p-value = 0.1545
```

Granger-causality test fails to reject the null-hypothesis (total traded on maize futures (Y) do not Granger-cause maize spot prices (X)) with a p-value = 0.1545, as the p-value is < 0.05.

3.4.3. Hypotheses for wheat, soybean and rice

All hypotheses for wheat, soybean and rice are calculated in the same manner as it is given in subchapter *3.4.2. Hypotheses for maize and results*. A summary of all lags from ADF-test, all specified hypotheses with according maximum order of integration from ADF-test, lags from Granger-causality test and p-values can be found in the *Appendix* section.

4. Interpretation of findings

The goal of this thesis is to investigate the causal relationships between long positions with agricultural commodities futures and changes in agricultural commodities spot prices. Besides providing theoretical foundations and empirical evidence this thesis shall shed light on the – sometimes – misleading debate.

Results from the Granger-causality test

On basis of the assumptions of commentators like Gilbert (2010) and Cooke and Robles, M. (2009) it has been expected that the financial variables – number of long open interest and volume traded – are Granger-causal for the according spot price. This is approved just once out 32 hypotheses. Non-commercial long positions (speculative open interest) with maize shows evidence (p-value < 0.05) that this financial trading activity is Granger-causal for the spot price of maize. The remaining five out of six rejected cases indicate the opposite. Results show evidence that spot prices do Granger-cause financial trading activities.

Commercial open interests and non-commercial open interest

At first glance it surprises that long positions taken by commercials mostly exceed long positions taken by non-commercial traders. It has been assumed that speculative demand fairly exceeds the demand for futures contracts by hedgers.

The point is that swap dealers predominantly act on behalf of index-funds. Swap dealers agree on a suitable tailored swap with their client, whereas their client bets on rising prices. Hence, the counterparty – the swap dealer – tries to offset the risk associated with the OTC derivate by going long on the futures market. A swap dealer hedges his/her swap position with relevant contracts on the futures market. Actually, the swap dealer is the one who holds the long positions on the futures market, but again in order to offset the associated risk.

There is already a widespread discussion going on whether swap dealers should be removed from the commercial category. CFTC (2008) published the “staff report” which recommends doing so.

Rising demand for futures contracts

Demand for agricultural commodity futures has been rising. Most of the demand resulted from index-based investments which are investing long-only. Irwin and Sanders (2011, 11) sum up the main idea of Petzel (2009) who states that “unleveraged futures positions of index funds are effectively synthetic long positions in physical commodities, and hence represent a new demand”. Often this argument is claimed in context of spot price formation.

However, rising demand for long futures positions does not mean that there is rising demand for the physical product. Or the other way around, strong rising demand for short positions on futures does not mean that markets face oversupply of the physical commodity. On futures markets long positions always equal short positions. Therefore, the number of actors betting on rising prices always matches the number of actors betting on decreasing prices. Again, only a fraction of all futures contracts end with delivery.

<u>The role of information</u>

The efficient market hypothesis focuses on the role of information. Information is seen as the key element in price formation on the financial market. Depending on the degree of informational efficiency all available information is incorporated in the new price of the asset immediately. Additionally, the EMH assumes that prices discovery builds on fully rational and individual considerations by market participants. However, in situations of high uncertainty on financial markets it is possible that individuals act irrational. It is likely that actors start to follow the actions of a group. This kind of herd behaviour may leads to rising demand for long or short futures contracts.

The fundamentalist hypothesis assumes that fully rational actors use information of demand and supply in order to build their price expectations. In addition to market fundamentals, the financialization hypothesis incorporates non-fundamental factors to be responsible for asset prices, which, sometimes, deviate from the fundamental equilibria. However, it is important to highlight the possibility of misinterpretation of information. The latter hypothesis includes this idea, but of course, well informed market participants are not immune to misinterpretation of information.

<u>Volatility</u>

Sport price volatility for some agricultural commodities increased in recent years. It can be assumed that higher liquidity on the futures markets (the higher the open positions are) facilitates futures price discovery and reduces futures price volatility. However, a higher relative volume (relative to open interests) may leads to rising volatility. The relationship between futures prices and spot prices should be investigated in-depth.

In context of food price volatility stocks play a significant role. Stocks have the ability of balancing oversupply, shortfalls and overdemand. In academia there is a widespread accordance that market fundamentals demand and supply are responsible in driving up food prices in the years 2007-

2008. There are a multitude of papers which list demand and supply factors extensively. Gilbert (2010) and Mitchell (2008) provide a comprehensive one of fundamental drivers.

The conditions in supply and demand have changed in recent years. Rising demand for feedstuff (due to rising demand for meat), increasing competition for acreage and augmenting demand for biofuels are essential in spot price discovery. On the supply side, below expectations productivity growth rates in developing countries are likely to result in long-term effects on commodity prices. Furthermore, Robles et al. (2009, 2) suggests that a “malfunctioning of the world grain markets” led to an intensification of the already existing crucial situation, as “dozens of countries” imposed export restrictions. Hence, stocks could not calm down increasing food prices.

Advancement of the statistical analysis

It has to be mentioned that the choice of variables (long or short positions; storage data; traded volume on OTC markets; futures prices; etc.), the length of the times series, data point intervals (days, weeks, years, etc.), data transformation (use of log data, nominal or real price data, etc.) and so on may influences the empirical result significantly.

The selection of the information criteria are subject to a widespread discussion. The Akaike Information Criterion (AIC) is said to overestimates the lag-order. A more conservative criterion, e.g. Bayesian Information Criterion, could be applied as well. Different criteria lead to different lag orders and very likely lead to different results.

5. Conclusions

The debate about the role of speculation in driving up food prices is a very controversial and emotional one. On the one side, there are academic theories and empirical findings which describe various phenomena. Most of these findings have gone through a peer-review process and are published in sound journals. The major part of these articles cannot deliver empirical evidence that speculation led to rising spot prices. On the other side, there are reports which either do not deliver any empirical tests or use non-standard statistical methods. Often, these reports refer to each other mutually and have not gone through a peer-review process. Furthermore, as it appears in public discussions, there is no doubt that financial speculation is the major driver of rising commodity spot prices. Debates take place emotionally, as food stuff is of everybody's concern. It seems that some empirically tested inconvenient truths are ignored. However, based on the assumptions of Gilbert (2010), for instance, the research question of this thesis is: *Are there causal relationships between the changes in agricultural commodity spot prices and the changes in positions on agricultural commodity futures between the years 2002 and 2011?*

This thesis identifies little theoretical linkages between financial trading activities and changes in spot prices. So far, no direct link between those two elements could be derived. However, the theory of storage can deliver a possible link between futures prices and spot prices.

On the one hand, the missing direct link between financial trading activities and spot prices are futures prices. Hence, the efficient market hypothesis, the fundamentalist hypothesis and the financialization hypothesis are outlined. The crucial role of information is their common element. Both, the efficient market hypothesis and the fundamentalist hypothesis follow the rationality assumption of market participants. Thus, the aggregated behaviour of all actors is captured. The financialization hypothesis questions the rationality assumption and admits irrational behaviour to market participants. Such an approach, a less idealized approach, is essential for a deeper understanding of price discovery, and challenges prevailing economical assumptions. The development of a bottom-up agent based futures price modelling approach would be a possible alternative, as the financialization hypothesis highlights the crucial role of the microstructure on futures markets (financial investors and their behaviour).

On the other hand, the missing direct link between financial trading activities and spot prices might be information. Price formation on the spot market increasingly incorporates information about the futures market (traded volume; open positions; futures prices; etc.). Also, misinterpretation of information about futures trading may leads to deviated spot price, as wrong information is incorporated in spot price discovery. The information about rising demand for futures contracts might be seen as a signal for rising physical demand by mistake. Hence, spot prices are adapted accordingly on the basis of wrong interpreted information. However, in this thesis, such a link is not empirically detectable.

If the microstructure on futures markets really influences the futures price in a long-run, then the well functioning of futures markets is not given. In the case of empirical verifiability of the financialization hypothesis, regulatory steps shall be considered. Primarily, futures markets are for hedging purposes and only to some extent for speculative purposes. Thus, access to futures markets for sellers and buyers with an interest in the physical commodity shall be facilitated. According to Staritz (2012) regulations could comprise: i) the reduction of OTC trade, ii) increasing transparency on commodity exchanges and OTC markets, iii) introduction of position limits, and iv) introduction of a transaction tax on commodity derivate trading.

Still, the impact of agricultural futures markets on agricultural commodity spot prices is not clarified, as well as the role of futures markets on international spot price volatility. Therefore, policy makers are advised to enhance risk reducing measures on the demand and supply side of the physical product, before limiting futures markets. Overall risks for farmers have risen in recent years. Thus, comprehensive reforms in the world trade regime should be considered. Especially LDC and developing countries are most severely exposed to price volatility, because they are either dependent on imports or exports of agricultural commodities. Reducing the dependency on international trade would be a first important step, as price variation is transferred from an international to a national level. Also, the role of storage is crucial. Developing countries are well advised in building national commodity stocks in order to achieve independency from world market price movements. Storage should be reorganised and extended. Regional commodity prices may stabilize.

Furthermore, speculation has to be recognised comprehensively. Until now, speculation was used in the context of financial markets. However, speculation also takes place on the spot market. Again, the role of storage is essential. Intermediaries, for instance, buy, store and sell the goods at a later point in time. This can be described as speculation as well, because these actors are betting for augmenting spot prices. Due to storage it is possible to keep commodities off the market, even if they are urgently required. Again, this situation is crucial in developing countries and should be subject of control.

There is lack of evidence that financial trading activities are Granger-causal for a change in spot prices as it is approved just once out of 32 tested hypotheses. However, evidence has been found that spot prices for maize, soybean and rice are Granger-causal for the change in long positions and total traded volume on the particular commodity. If financial trading activities are the major driver of rising commodity prices this causal linkage should be clearly detectable in the data. However, results show evidence that spot prices do Granger-cause financial trading activities. This unexpected finding leads to the question whether traders (e.g. with rice) have reacted to changing (rice) spot prices. Provided empirical evidence is far from conclusive, but is worthy to do further research.

6. References

Baffes, J. 2007. "Oil Spills on Other Commodities." *Resources Policy* 32 (3): 126–134.

Bailey, R. E. 2005. *The Economics of Financial Markets*. Cambridge University Press.

Brockwell, P.J. and Davis, R. A. 2002. *Introduction to Time Series and Forecasting*. Springer Texts in Statistics. Springer.

Burke, S. P. and Hunter, J. 2005. *Modelling Non-stationary Economic Time Series: a Multivariate Approach*. Palgrave Macmillan.

CFTC. 2008. Staff Report on Commodity Swap Dealers & Index Traders with Commission Recommendations. http://www.loe.org/images/content/080919/cftcstaffreportonswapdealers09.pdf

CFTC. 2011a. CBOT Exchange Volume Comparison Report – Monthly. http://www.cftc.gov/MarketReports/CommitmentsofTraders/HistoricalCompressed/index.htm or ftp://ftp.cmegroup.com/webmthly/

CFTC. 2011b. Commitment of Traders: Open Interests in Futures. http://www.cftc.gov/oce/web/data.htm

CFTC. 2012a. Commitments of Traders: Explanatory Notes. http://www.cftc.gov/MarketReports/CommitmentsofTraders/ExplanatoryNotes/index.htm

CFTC. 2012b. Disaggregated Commitments of Traders Report: Explanatory Notes. http://www.cftc.gov/ucm/groups/public/@commitmentsoftraders/documents/file/disaggregatedcotexplanatorynot.pdf

Colman, D. and Young, T. 1989. *Principles of Agricultural Economics: Markets and Prices in Less Developed Countries*. Cambridge University Press.

Cooke, B. and Robles, M. 2009. "Recent Food Prices Movements: A Time Series Analysis." *IFPRI Discussion Paper* (942). http://www.ifpri.org/publication/recent-food-prices-movements.

Domanski, D. and Heath, A. 2007. "Financial Investors and Commodity Markets." *BIS Quarterly Review*. http://econpapers.repec.org/article/bisbisqtr/0703g.htm.

FAO. 2011. Agricultural commodity cash prices. http://www.fao.org/economic/est/prices

Fama, E. F. 1970. "Efficient Capital Markets: A Review of Theory and Empirical Work." *Journal of Finance* 25 (2): 383–417.

Geman, H. 2005. *Commodities and Commodity Derivatives: Modelling and Pricing for Agriculturals, Metals, and Energy*. Wiley Finance Series. John Wiley & Sons.

Gilbert, C. L. 2010. "How to Understand High Food Prices." *Journal of Agricultural Economics* 61 (2): 398–425.

Groß, J. 2010. *Grundlegende Statistik mit R: Eine anwendungsorientierte Einführung in die Verwendung der Statistik Software R*. Vieweg+teubner Verlag.

Hens, T. and Schenk-Hoppé, K. R. 2009. *Handbook of Financial Markets: Dynamics and Evolution*. Elsevier.

Hull, J. 2002. *Fundamentals of Futures and Options Markets*. Prentice Hall.

IFPRI. 2011. Email conversation with Miguel Robles and Cristina Chiarella.

Irwin, S. H and Sanders, D. R. 2011. "Index Funds, Financialization, and Commodity Futures Markets." *Applied Economic Perspectives and Policy* (February 2).

Jacques, I. 2006. *Mathematics for Economics and Business*. 5th ed. Financial Times/ Prentice Hall.

Lütkepohl, H. and Krätzig, M., eds. 2004. *Applied Time Series Econometrics*. Cambridge: Cambridge University Press.

Malkiel, B. G. 2003. "The Efficient Market Hypothesis and Its Critics." *Journal of Economic Perspectives* 17 (1) (March): 59–82.

Mitchell, D.. 2008. "A Note on Rising Food Prices." *SSRN eLibrary* (July 1). http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1233058.

OECD. 2011. Price Volatility in Food and Agricultural Markets: Policy Responses. *OECD Policy Report.* Including contributions by FAO, IFAD, IMF,OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF. http://www.oecd.org/document/20/0,3746,en_2649_37401_48152724_1_1_1_37401,00.html

Peirson, G. 2008. *Business Finance*. McGraw-Hill Australia.

Robles, M., Torero, M. and von Braun, J. 2009. "When speculation matters." *IFPRI Issue Brief 57*. February 2009.

Schulmeister, S. 2009. "Trading Practices and Price Dynamics in Commodity Markets and the Stabilising Effects of a Transaction Tax." *Österreichisches Institut für Wirtschaftsforschung*. January 2009.

Staritz, C. 2012. "Financial Markets and the Commodity Price Boom: Causes and Implications for Developing Countries." Working Paper 30. *Österreichische Forschungsstiftung für Internationale Entwicklung*. April 2012.

Toda, H. Y. and Yamamoto. T. 1995. "Statistical Inference in Vector Autoregressions with Possibly Integrated Processes." *Journal of Econometrics* 66 (1–2): 225 – 250.

Todaro, M. P. and Smith, S. C. 2009. *Economic Development*. Pearson Education.

Tomek, W. G. and Robinson, K. L. 2003. *Agricultural Product Prices*. G - Reference, Information and Interdisciplinary Subjects Series. Cornell University Press.

UNCTAD. 2011. "Price Formation in Financialized Commodity Markets: The Role of Information." *United Nations*: 1–80.

Wooldridge, J. M. 2009. *Introductory Econometrics: a Modern Approach*. South Western, Cengage Learning.

Yahoo Finance. 2012. Dow Jones-UBS Commodity Index (^DJUBS) and Dow Jones-UBS

Agriculture Subin (^DJUBSAG), April 9, 2012.

http://finance.yahoo.com/q/hp?s=^DJUBS+Historical+Prices respectively

http://finance.yahoo.com/q/hp?s=^DJUBSAG+Historical+Prices.

Appendix

1. R syntax

Packages needed are *tseries* and *vars*.

```
x <- # log spot variable
y <- # log financial variable

	# Information:
	# ?VARselect
	# ?adf.test

p_x <- max(VARselect(x, lag.max = 25, type="both")$selection[1]-1,0)
adf.test(x,k=p_x)
p_y <- max(VARselect(y, lag.max = 25, type="both")$selection[1]-1,0)
adf.test(y,k=p_y)

	# Augmented Dickey-Fuller Test

m <- # maximum order of Integration I(d)

p <- VARselect(cbind(x,y), lag.max = 20, type="const")$selection[1]
if(m>0) {
	EXO <- matrix(NA,ncol=0,nrow=length(x))
	for(i in 1:m) {EXO<-cbind(EXO,c(rep(NA,p+i),x[1:(length(x)-
	(p+i))]),c(rep(NA,p+i),y[1:(length(y)-(p+i))]))}
	}
var_xy <- VAR(cbind(x,y),type="const",p=p,exogen= EXO )

	# Information:
	# ?causality

causality(var_xy,cause="x")$Granger
causality(var_xy,cause="y")$Granger

	# Granger causality H0: x do not Granger-cause y
```

2. Short and Long hedge

	Short hedge	
	If prices rise up to 110	If prices decrease to 90
Spot maize price today = 100	Gain (+10)	Loss (–10)
Short maize futures price today = 100	Loss (–10)	Gain (+10)
Net result	+/– 0	+/– 0
	Long hedge	
	If prices rise up to 110	If prices decrease to 90
Spot maize price today = 100	Loss (–10)	Gain (+10)
Long maize futures price today = 100	Gain (+10)	Loss (–10)
Net result	+/– 0	+/– 0

Source: Peirson (2008)

3. Lags from Augmented Dickey-Fuller test (ADF Test)

Variable	Lag order p
Maize	20
Wheat	5
Soybean	23
Rice	1
MaizeCommLo	1
WheatCommLo	5
SoyCommLo	0
RiceCommLo	1
MaizeNonCommLo	1
WheatNonCommLo	19
SoyNonCommLo	3
RiceNonCommLo	7
MaizeTotRepPosLo	12
WheatTotRepPosLo	18
SoyTotRepPosLo	12
RiceTotRepPosLo	6
VolCorn	12
VolWheat	16
VolSoy	24
VolRice	4

4. Results from Granger-causality test

Null-hypotheses (H_0 and H_0')	Max. integration order (m) from ADF test	Lag p from Granger-causality test	p-value from Granger-causality test	*Granger-causality test:* H_0 rejected / failed to reject (sign. lev. P<0.05)
1. Maize (X) do not Granger-cause MaizeCommLo (Y)	1	25	0.0006	Rejected
1. MaizeCommLo (Y) do not Granger-cause Maize (X)			0.9652	Failed to reject
2. Maize (X) do not Granger-cause MaizeNonCommLo (Y)	1	2	0.6177	Failed to reject
2. MaizeNonCommLo (Y) do not Granger-cause Maize (X)			0.0282	Rejected
3. Maize (X) do not Granger-cause MaizeTotRepPosLo (Y)	2	25	3.421e-08	Rejected
3. MaizeTotRepPosLo (Y) do not Granger-cause Maize (X)			0.1961	Failed to reject
4. Maize (X) do not Granger-cause VolCorn (Y)	2	25	0.0217	Rejected
4. VolCorn (Y) do not Granger-cause Maize (X)			0.0217	Failed to reject
5. Wheat (X) do not Granger-cause WheatCommLo (Y)	2	2	0.739	Failed to reject
5. WheatCommLo (Y) do not Granger-cause Wheat (X)			0.8423	Failed to reject
6. Wheat (X) do not Granger-cause WheatNonCommLo (Y)	2	3	0.4367	Failed to reject
6. WheatNonCommLo (Y) do not Granger-cause Wheat (X)			0.0873	Failed to reject
7. Wheat (X) do not Granger-cause WheatTotRepPosLo (Y)	2	13	0.2137	Failed to reject
7. WheatTotRepPosLo (Y) do not Granger-cause Wheat (X)			0.6375	Failed to reject
8. Wheat (X) do not Granger-cause VolWheat (Y)	2	16	0.5583	Failed to reject
8. VolWheat (Y) do not Granger-cause Wheat (X)			0.6742	Failed to reject
9. Soybean (X) do not Granger-cause SoyCommLo (Y)	3	25	0.8942	Failed to reject

9. SoyCommLo (Y) do not Granger-cause Soybean (X)			0.3785	Failed to reject
10. Soybean (X) do not Granger-cause SoyNonCommLo (Y)	3	22	0.0006	Rejected
10. H0: SoyNonCommLo (Y) do not Granger-cause Soybean (X)			0.5316	Failed to reject
11. Soybean (X) do not Granger-cause SoyTotRepPosLo (Y)	3	22	0.5601	Failed to reject
11. SoyTotRepPosLo (Y) do not Granger-cause Soybean (X)			0.9355	Failed to reject
12. Soybean (X) do not Granger-cause VolSoy (Y)	3	24	0.7801	Failed to reject
12. H0: VolSoy (Y) do not Granger-cause Soybean (X)			0.7658	Failed to reject
13. Rice (X) do not Granger-cause RiceCommLo (Y)	1	2	0.8407	Failed to reject
13. RiceCommLo (Y) do not Granger-cause Rice (X)			0.2142	Failed to reject
14. Rice (X) do not Granger-cause RiceNonCommLo (Y)	1	2	0.5749	Failed to reject
14. RiceNonCommLo (Y) do not Granger-cause Rice (X)			0.5749	Failed to reject
15. Rice (X) do not Granger-cause RiceTotRepPosLo (Y)	2	2	0.6262	Failed to reject
15. RiceTotRepPosLo (Y) do not Granger-cause Rice (X)			0.2541	Failed to reject
16. Rice (X) do not Granger-cause VolRice (Y)	1	3	0.0129	Rejected
16. VolRice (Y) do not Granger-cause Rice (X)			0.7587	Failed to reject