Speculation and the price of corn

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Executive summary

The aim of this paper is to investigate the role of speculation on the unusual price fluctuations in corn from 2005 to 2012. Empirical and statistical analyses are conducted to respectively determine and quantify the implications of speculation on the food commodity. One of the main findings of this study is the need for further research on the theory of speculation. The contradicting theories on speculation led this study to emphasise on the need to differentiate between speculation as a price discovery process and excessive speculation as an investment strategy which purpose is to deliberately initiate price fluctuations.

The empirical analysis in this paper shows that excessive speculation was not the sole cause of the price fluctuations in corn. Other variables such as the price of crude oil, the US Dollar, fertiliser prices and the demand for bio ethanol are estimated to have had an influence. A subsequent statistical analysis is run to quantify the implications of each variable on the price of corn. The findings show that the price of crude oil and the US Dollar are the two variables with the highest explanatory value. Fertiliser prices and the demand for bio ethanol also had their share of influence on the price of corn though considerably lower than the price of crude oil and the US Dollar. The statistical analysis also confirms the findings in the empirical analysis, that excessive speculation is not the cause for the price fluctuations in corn. The variables in the statistical analysis fall short in explaining all of the price movements in corn. This paper therefore ends by analysing alternative and intangible variables that affected the price of corn. The findings show that variables such as weather, policies, inventory and general macroeconomic factors also have a substantial influence on the price of corn.
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1) Introduction

From 1972 to 1974 the price of many commodities, here among most cereals, skyrocketed just to fall to their previous levels. History repeated itself in mid 2007 when the price of several commodities drastically rose. The price increase lasted for about a year when suddenly the price of the commodities fell to their previous price levels in a matter of months. For example, the price of corn doubled from July 2007 to June 2008 and just five months later the price of corn approximately fell to its mid 2007 levels. What initially separate these two historical commodity crises is that the latest crisis has been a repeating occurrence. As most commodities settled down and remained somewhat stable for almost a year and a half, several economists described the event as a onetime event where history simply repeated itself (Heady & Fan 2008a & Caballero, Fahri & Gourinchas 2008). However, in mid 2010 commodity prices increased with the same intensity as in mid 2007. Most prices reached their peak in mid 2011 and fell a little until prices began to rise again in the beginning of 2012.

Figure 1
As seen in figure 1, the rise in food commodity prices occurred after the rise in the prices of energy and metal commodities suggesting that compared to other commodities, the food commodity “crisis” isn’t really as important. However, given the role of food as an essential commodity in the survival of man, a small increase in price can have dire consequences as certain food commodities risk becoming too expensive for certain people. As the price fluctuations on most food commodities broke all time records they plunged the world into further economic distress and have had serious social and humanitarian repercussions. Food security is a key political issue for net food importing countries and due to the extreme and sudden high prices many governments had to cut the import level of most food commodities. Consequently food prices rose to even higher levels in those countries sparking social unrest. The Tunisian revolution, also known as the Jasmine revolution, which began in late 2010 was mainly due to food inflation. The revolution in Tunisia a long with the continuous food inflation prompted further social unrest across several net importing countries and started the Arab Spring. The price rise also meant that some net importing countries simply didn’t have the possibility to get the necessary amount of food commodities to avoid famines. From 2008, during the first price rise, there were famines in Myanmar, North Korea, the Horn of Africa, Afghanistan, Bangladesh and Tajikistan. The famine continued in 2010 during the second price rise in most of the Saharan Africa as well as West and East Africa.

The repeating fluctuating prices on food commodities have caught the interest of many economists and the cause of the price volatility has been widely discussed. Blame has been pinned on everything from climate change, increase in world population, population wealth, the production of bio fuels and several other macroeconomic factors. However one factor in particular has attracted a lot of debate: Speculation.

Some authors believe that the entry of financial investors in the food commodity derivative markets has little impact on market prices, whilst other analysts argue that the enormous investments invested in food commodity derivatives, also known as financialization, has caused price fluctuations to such an extent that it cannot be explained by ordinary market fundamentals. And now with a third price rise in the making new data and new theories are available giving the opportunity to do more extensive research.

Food commodities are basic existential commodities for the day to day life of businesses and people around the world. However, there are many different food commodities all of which have experienced

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1 Food commodity index: Cereal, vegetable oils, meat, seafood, sugar, bananas and oranges. Fuel commodity index; crude oil, natural gas and coal. Metal commodity index: Copper, aluminium, iron, tin, nickel, zinc, lead and uranium.
price fluctuation, some more than others. Therefore in order to fully analyse the implication of speculation, a food commodity needs to be chosen that fits certain criteria. First of all, the food commodity in question has to be connected to several possible factors that could explain the general food commodity price fluctuations. Second, reliable data on the different factors need to be available. Corn (Maize in Europe) is the ideal food commodity to analyse has it fits these criterion.

The main purpose of this paper will be to determine whether or not speculation caused the price fluctuations on the price of corn as well as quantify the causal effect of speculation on the price of corn through statistical modelling. The statistical model will implement other variables that are deemed to have a possible causal effect on the price fluctuations on corn. This will allow for a full analysis on the price of corn and especially give a complete statistical analysis on the explanatory value of speculation on corn. Prior to this statistical analysis is a theoretical analysis and an empirical analysis. The theoretical analysis will go through a discussion on the interpretation of speculation in and outside the field of economics and especially focus on the contradicting economical theories on speculation and its implications on this paper. The empirical analysis will be a presentation on the variables that will be used in the statistical model as well as a causality proof of the variables effect on the price of corn. Lastly, a series of intangible variables will be presented and their influence on the price of corn will be determined.

“Can the fluctuations in corn prices be attributed to generic macroeconomic factors or is speculation to blame?”

2) Theoretical analysis

This chapter will begin by discussing the various public assumptions on speculation. Each assumption or rather misconception will be described and clarified as they will be put into perspective with economical theories. The economic definitions and theories on speculation will be presented in relation to the commodity market. The conflicting theories on speculation and in particular their outcome will be discussed and a interpretation will be presented as avoid misinterpretations and create a consistency
throughout the paper. Speculators will then be put into perspective alongside other investor types to clearly identify their differences.

Lastly, the derivative market on commodities will be described in order to give the reader an overview on where speculators act. The valuation theory behind some of the more common derivatives will also be explained in order to put speculation into context, before an empirical and statistical analysis.

2.1 Public assumptions on speculation

The global financial crisis that began in mid 2007 had a ripple effect across all aspects of the world economy. Ripple effects that are still visible now at the end of 2012. Some of these ripple effects have been hard for the general public to understand and have created misunderstandings and misconceptions. Going through private blogs, public debate forums and other online platforms it becomes easy to understand why. There is never a cohesive definition of speculation. The most common misconception ends up being that speculators are the root of all evil as they are behind all financial crashes. Though, on most of these online forums there is never a description on how speculators can affect financial and economic collapses. Whether the misconception, shared by a majority of the general public, is due to an etymologic development or not, is irrelevant as the question on how speculators could affect the economy is still not answered.

The few debate forums that do try and define speculation do so without taking into account scientific papers on the matter. Their definitions end up completely disregarding basic economic theory and instead become highly personalized. Among those definitions is that speculation involves investing irrationally. In other words, investors investment decisions are based on irrelevant information and unexplainable behaviour. Consequently, speculation would then be seen as unnecessarily risky since it would essentially be a random and illogical bet on the future price movement of a commodity. In other words, the definition of speculation among the public becomes a fancy name for gambling.

Another popular misconception is that trading with derivatives is speculation. This is typically a belief found alongside the idea that speculators are irrational. The argument is that, since most investors invest in derivatives without holding a position in the underlying commodity or having an interest in the commodity, they dwarf the price of the underlying commodity by representing an extra demand. In other words, it becomes speculation as soon as you invest in a derivative where the investor does not use
the underlying commodity. However, derivatives work as a hedging tool by giving companies the ability to protect themselves against unwanted price fluctuations. Such a strategy would involve companies investing in a commodity derivative that is relevant to their production. In other words, companies that have a commercial interest in the commodity cannot represent an additional demand. Furthermore, investors with no commercial interest in the commodity can buy as many derivatives as they want however at maturity date they cannot sell them to others than investors with commercial interests. In other words, the demand would at the end of maturity remain the same whether investors have a commercial or non-commercial interest in the commodity. On page 16, the purposes and functions of derivatives are thoroughly explained.

In the last couple of years, derivative trading has increased drastically. The new grown interest does not come from hedgers but from investors that have seen derivate trading as an alternative to the more traditional capital market. This new investment trend coincided with rising prices in several commodities and popular media has blamed these investors for the price fluctuations. In other words, if an investor isn’t hedging he is by definition a speculator. But, correlation does not imply causation and seeing traders in the derivative market as either hedger or speculator is simplifying an otherwise vast investor type base. Furthermore, blaming the derivative market for dwarfing prices is, in theory, illogical. The misconception comes from popular media who, when trying to define speculation, compares the capital markets with the derivative markets. The two markets work very differently. In the capital market, investors determine the price of a security. While in the derivative market, in theory, the price of a derivative contract is determined by the price of its underlying commodity which in turn is determined by its forces of supply and demand as will be explained on page 29. This means that, the popular belief that derivative trading dwarfs prices of the underlying commodity from equilibrium, and is therefore speculation, is false. It is true however, that empirically, investors have affected the price of the derivative contract when the demand was high enough (Fama and French 1987 and Schwartz 1998).

It is clear that the concept of speculation in the popular media takes many forms, whether it be how it is traded or where. It is hard to understand its consequences if there is not a unanimous understanding of the term. The truth of the matter is that the nature of an investment strategy, whether speculative or not, is not determined by the sole use of derivatives, it strongly depends on its purpose. This fact has been clear for the US legislators since 1936, at the end of the Great Depression. In the “Commodity Exchange
Act” US legislators only refers to speculation as *excessive speculation* and made it illegal\textsuperscript{2} in the end of 1930’s.

“Excessive speculation in any commodity (...) under derivative transactions (...) causing sudden or unreasonable fluctuations or unwarranted changes in the price of such commodity.”

The problem is that the legislation only states what makes speculation illegal but doesn’t specify how speculation works. The problem today is that there isn’t a clear understanding and agreement on what caused the sudden fluctuations in the prices of certain commodities nor is it clear whether it was “unreasonable”. The whole case is up to subjective interpretation. The problem is even bigger in Europe, as the case of speculation was not even taken into account until 2008 when a task force was formed to try and determine the causes of the 2008 commodity crisis (EU 2008). To this date there is still no clear and unanimous definition of speculation in the European parliament.

What needs to be understood is that, just like too much of a good thing is bad, so is speculation. If the purpose of the investment strategy is to deliberately dwarf prices from equilibrium there can be talk of speculation. But the question remains on the role of the derivative market. The only way to assure that an investment in the derivative market isn’t speculation is to set up appropriate regulations forcing brokers only to sell derivatives to entities looking to hedge. For example, if a bio ethanol production plant is looking to hedge against corn prices, then their future position can be viewed as a hedge position. On the other hand, if for example a hedge fund is investing in a corn derivative, its position could be considered speculative. This, however, might prove very difficult for two very good reasons. First of all, as will be discussed on page 16, the derivative market is sold in two very different markets. Derivatives are either sold through brokers or over-the-counter. Over-the-counter markets are basically private trades that make it hard to assure that the trade isn’t of a speculative nature. Second of all, and most importantly, the derivative market has a market value of 15 trillion Euros and a notional value of 550 trillion Euros (Deutsche Börse Group 2010) making it a huge part of the world’s financial daily life and regulations could very well diminish its value.

### 2.2 The theory of commodity speculation

The problem of different definitions of speculation in the popular media is recurrent in the scientific world. There are numerous economic scientific papers discussing the effects of speculation but they do

\textsuperscript{2} The terms of practicing excessive speculation are very vague [http://www.law.cornell.edu/uscode/text/7/6a](http://www.law.cornell.edu/uscode/text/7/6a)
not use the same definition. This leads to different conclusions on the effect of speculation on the economy. In most papers speculation was defined as a process of transferring price risks (Tirole 1982). A definition that is very similar to the belief found in popular media that derivative trading is speculation. This highly vague scientific definition is the cause of many misunderstandings as it allows for disagreements about the conditions of a speculative market.

In papers concerning the psychology behind investment behaviours, authors often argue that speculation is defined by the beliefs of an investor. (Hirshleifer 1975) and (Feiger 1976) argues that the difference in beliefs is the key to speculative behaviour. In other words, the nature of an investors belief on the outcome of his investment, whether optimistic or not, determines the nature of an investment. For example, if an investor believes that the price of a commodity will rise he will make a speculative purchase whereas an investor that believes that the price of a commodity will fall he will make a speculative sell.

Keynes described speculation as a beauty contest (Keynes 1936). In a beauty contest, women often parade in front of a panel of judges, who then picks the one that they deem the most beautiful. In Keynes version, the public takes the role as judges. They are asked to choose the women they deem the most beautiful, knowing that the one member of the public who chooses the woman that corresponds to the average choice of the public as a whole will win a prize. The member of the public that wishes to win has to pick, not the face that conform to the objective of beauty but rather the one he thinks will be the likeliest to win (Keynes 1936). In the end, the only reason a woman is selected as the prettiest is because the member of the public believes every other competitors believes she will be chosen as the prettiest, without taking into account the reality. In other words, Keynes interpret speculators as investors that are concerned not with what the commodity is really worth to a man who buys it for keeps, but with what the market will value it, under the mass psychology, in the future.

There is a hypothesis, often referred to as the risk-transfer hypothesis, combining the works of (Keynes 1930) and (Hicks 1937) claiming that speculation is determined by the willingness of an investor to take on risk. In other words, the process of shifting price risk from risk adverse investors to less risk adverse investors is considered speculation. This means that the risk-transfer hypothesis argues that, hedgers that are divesting themselves of price risks are basically relocating the price risk to speculators. However, (Hirshleifer 1975) argues that if all investors had the same beliefs there would be no trade transferring price risk. In other words, risk tolerance does not, at least on its own, define speculation.
The financial crisis of 2007 has breathed new life in the debate of the definition of speculation and its role in the subsequent commodity price crisis. Speculation is often discussed and the scientific literature is filled with modern articles trying to define it. However, as shown there are just as many articles criticising any attempts made and according to (Johnson 1976) there might never be a unanimous definition on speculation. Johnson argues that given speculation is used in several different fields in social science, authors often interpret the word in order for it to fit their context. However, Johnson concludes that all interpretation of speculation in economics should ordinarily be understood as defined by Keynes and Kaldor.

In 1939 Nicholas Kaldor wrote a scientific paper called “Speculation and economic stability” (Kaldor 1939). The article addressed the issue of examining the effect of speculation on the stability of the economy. Kaldor begins by defining speculation as:

“the purchase (or sale) of goods with a view to resell (re-purchase) at a later date, where the motive behind such action is the expectation of a change in the relevant prices relatively to the ruling price and not a gain accruing through their use, or any kind of transformation effected in them, or their transfer between markets“.

Kaldor’s definition involves an investor that has no active participation in the underlying commodity. In other words, speculation on the commodity market is the buying (or selling) of a commodity, where the only motive for doing so is the anticipation of a change in the underlying price.

The idea of buying a commodity in order to resell it later once the price has increased is nothing more than good business, even if the motive for holding the commodity isn’t to gain from it by using it or altering it in any way. Kaldor’s definition of speculation is no different than any other investment and resembles a lot the conclusion made by (Hirshleifer 1977):

“speculation is traders looking to revise their portfolio to attain their final position on more advantageous forms after the anticipated price shift.”

In a later paper (Hirshleifer 1984) continues to argue that speculative trading, as defined above, is undertaken only by individuals whose opinions to the state of the future, diverge from representative beliefs of the world. (Madrigal 1996) goes even further and argues that speculators posses no private information on the fundamental value of assets, but have some superior knowledge about some aspects of the market environment. Thus separating speculators from other more common investors whom
belief are representing the market. This concept of speculation quickly draws attention to how a speculator could profit. If, it is the consensus of the total investors in the market that decide the price of a commodity speculators, as described by Hirshleifer, will end up bankrupt. Hirshleifer’s idea of speculation is therefore contradicting (Tirole 1982). The profitability of speculation and its impact on the market will be discussed on page 43 and shown in Appendix 3.

Kaldor argues that the difference between a speculative purchase and “other kinds of purchases” lies in the last sentence of his definition “not a gain accruing through their use, or any kind of transformation effected in them, or their transfer between markets”. Investors buying a commodity for the purpose of using it, transforming it or even reselling it on a different market are ordinary investors, while speculators are interpreted as investors buying a commodity where the only motive is an expecting price change in the commodity. Kaldor goes on and further analyses the concept, concluding that the difference between speculators and other investors is the difference between the amount held would the price of the commodity remain unchanged (other investors) and the amount held would the price change (speculators) (Kaldor 1939). Kaldor’s conclusion is shared and reinterpreted by (Harrison and Kreps 1978), who interpret speculation as investors who are willing to pay more for a commodity if they had the right to resell it compared to the price they were willing to pay were they obliged to hold the commodity forever. Kaldor’s definition of speculation does not give reason to think that speculation could dwarf prices of a commodity.

If, speculation was the reason behind the commodity price fluctuations then the understanding of speculation as a mechanism to dwarf price must, for the sake of this paper, be clear.

From page 16 and on, the theory of pricing derivatives is shown to be a reflection of the spot market pricing of the underlying commodity. And the spot market price is determined by the demand and supply of the commodity. Therefore, for speculators to dwarf the price of a commodity they must affect either the commodity’s demand or supply side. There are numerous ways to affect the supply and demand of an asset but in terms of a commodity it is more limited due to their nature as basic resources. The only way to affect the price of a commodity without interfering with its production is through excessive physical storage. By storing large quantities of a commodity and holding it back from the market, the speculator will create a lack in supply thus increasing its demand and therefore price.

Excessive speculation is therefore the excessive inventory build up by speculators which motive is to affect or at least speed up the price fluctuation. In other words, excessive speculative investors end up changing the commercial volume and thus the price of previous commercial transactions.
According to (Telser 1958) and (Brennan 1958), there must be two factors for speculation, as determined by Kaldor, to work:

1) **The market.** The market must be strong or semi strong. Furthermore, the commodity must be highly demanded. In other words, it must be a commodity that is vital for the function of several productions.

2) **Carrying cost.** The carrying cost, ie. the total cost of holding inventory must be low. If excessive speculation, as defined above, involves the use of storing a commodity until price increases, the cost of storing it must be low. It also helps if the value to volume of the commodity is high. Furthermore, since excessive speculators cannot know how long it will take before the price of the commodity increases after a low supply, the commodity must be long-lasting.

Both the commodity spot market and the derivative market are at least semi strong and as we will see on page 42 the carrying cost for corn bushels are relatively low, enough to make excessive storage an economical viable strategy (Appendix 3). The reason for the focus of derivative markets in relation to speculation is because the derivative market is greater in terms of volume than the spot market. Furthermore, the derivative market is an excellent tool to create disruption in the supply of a commodity. A derivative contract, depending on its nature, creates an obligation for later delivery. Its effect reduces current available supplies and boosts the subsequent supply when demand has increased. If at time of maturity, the price of the underlying commodity is still not worth selling, physically storing the commodity until the price increase is the last option for a profit.

(Kaldor 1939) classifies ordinary speculators as having a non-commercial interest in the commodity. However, in the corn market, there are about twice as many investors with commercial interest going long as there are non-commercial interest investors going long. Excessive speculation could therefore very well work for investors with commercial interest as well. In theory, if hedgers, in other words commercial interest investors, accumulate enough stocks of a given commodity they could later sell derivative contracts of the commodity to speculative buyers. The effect would be the same as excessive speculation by non-commercial interests as explained by Kaldor. This means that, because hedgers represent the end users of the commodity, the price effect of speculation only occurs to the extent of hedgers demand and their price sensitivity. This illustrates the importance of the role of the commodity. If the commodity is absolutely vital, speculators, as in non-commercial interest investors, can take full advantage and exploit the price sensitivity of hedgers. If hedgers are utterly dependent on the
commodity, their price sensitivity will be very low which would explain the relatively high amount of commercial interest going long on corn futures despite enormous price fluctuations in the underlying commodity (Appendix 2). It is however unlikely that, investors with commercial interest in the commodity would get involved in excessive speculation as it would contradict the principles of hedging. The purpose of hedging is to protect against unwanted price fluctuations in a commodity and not try to enhance them through excessive storage in order to make a profit. Lastly, the volume of corn derivative traded from investors with commercial interest going short are about six times bigger than those with non-commercial interest, confirming that excessive speculators would more likely be non-commercial investors.

In conclusion, for the purpose of this paper, speculation will follow the same definition as defined by (Kaldor 1939). While excessive speculation, which will be at the heart of this paper, will be interpreted as:

“the purchase (or sale) of a commodity with a view to resell (re-purchase) at a later date, where the motive behind such action is the change in the relevant prices relatively to the ruling price through inventory build up and not a gain accruing through their use, or any kind of transformation effected in them, or their transfer between markets”

2.3 The conflicting outcomes of commodity speculation

2.3.1 Is it stabilising?

There are several scientific papers arguing for the role of speculation as a stabilising factor on the market. However some of them have different interpretations of the word stabilising (Chambers & Biley 1996). It is commonly interpreted in two very different ways:

- The first understanding is that of making the equilibrium of the market more constant. In other words, speculation stabilises the different factors affecting the price of the commodity.

- The second understanding is that of a reduction in the price fluctuations of the commodity.

In the end, the price is of course determined by the factors of demand and supply and thus the fluctuations in the price. But there is a vital difference between the two interpretations since they focus
on two very different areas: the different demand and supply factors and price. Later on in this paper, on page 30, the different factors of supply and demand that can affect the price of corn are described. But to simplify this paper will throughout the theoretical chapter interpret stabilising as a reduction in price fluctuations.

The most common theory on whether or not speculation is stabilising for the market is of Milton Friedman from 1953. (Friedman 1953) argued that speculators, in order to make a profit, must buy when the prices are low and sell when the prices are high. This follows this paper's interpretation of speculation. Friedman argues that by buying when prices are low, speculators increase depreciated prices while when speculators sell when prices are high they decrease inflated prices. Another key aspect in Friedman’s theory on speculators effect on stabilising prices is their anticipation of shortages. This is similar to the discussion from (Hirshleifer 1975 and Hirshleifer 1984) arguing that speculators have more information than other investors or at least believe that they have. Once speculators anticipate shortages of a given commodity, they stock up on these commodities early and thus remove them from the market. This, in theory, should alert the market of the future availability of the commodity. Speculators therefore end up sharing their information with the market allowing for demanders to react to the pending price increase. During shortages speculators sell their inventory improving the supply while making a profit. In other words, Friedman argues that because of speculators reaction to an oncoming shortage, there would never be an unexpected shortage. In other words, speculators do not cause shortages but warn others about them. Only excessive speculators can cause shortages through excessive inventory build up.

Friedman concludes by arguing that people who belief that speculation is destabilising rarely understand that it is the same as saying that speculators lose money because the only way speculation can be destabilising is if speculators sell when prices are low and buy when prices are high.

Other authors (Silber 1983) and (Burnside et al. 2006) also argue for the stabilising effect of speculation. They argue that by assuming risk others are not willing to take, speculators are more willing to trade and thus help reduce the bid-offer spread of a commodity. The lower the bid-offer spread the less prices will fluctuate. Furthermore, the increased willingness of speculators towards risk increases the volume traded of the underlying commodity and as a result improve the liquidity of the market and price stability.
2.3.2 Is it destabilising?

There are many scientific papers criticizing Friedman’s theory on the stabilising effect of speculation. Friedman’s argument that speculators only buy when prices are low and sell when prices are high do not coincide with empirical evidence. The matter is far more complicated because there is more than the idea of “buy cheap and sell at high price” (Farrell 1966). Farrell explains that since speculators do not take historical prices under consideration when investing they will buy the commodity when there is a chance of a price appreciation. This may or may not be when prices are low. In other words, speculators increase price destabilisation. Other authors propose a compromise by arguing that speculators will, eventually, increase depreciated prices and decrease inflated prices just like Friedman proved but not before increasing the fluctuation in prices and the intervals of the bid-offer spread thus making it destabilising (Kohn 1978).

By speculating excessively and destabilising the price of a commodity, excessive speculators can make a profit. Whether there is talk of one large excessive speculator or several small excessive speculators conspiring together, they could, in theory, still make a profit by destabilising prices (Hart 1977). As a minimum requirement for destabilising the price of a commodity through excessive speculation there must be enormous quantities stored of the underlying commodity (Hart & Kreps 1986). In other words, Hart & Kreps proved that even though the commodity is not in harm of running short, speculators can buy up large enough quantities and provoke a price destabilization that pays off. Therefore, when Friedman argues that speculators do society a favour by buying up a commodity in anticipation of a shortage and consequently warns the rest of the market of an impending shortage, he did not incorporate the role of excessive speculators.

Several authors contest the theory of Hart & Kreps and try to prove it through empirical evidence. From mid 2007 to early 2009, the price of crude oil was fluctuating at enormous levels. In that time period, the price of crude oil doubled in less than a year just to fall again below its original level. In that period there wasn’t a noticeable statistical increase in inventory that could have argued for excessive speculation (Kilian and Murphy 2010)\(^3\) putting doubt to the fact whether excessive speculation caused prices to destabilise. However, the data used by Killian and other authors only involve public inventory facilities and not private due to the lack of a data source, thus still making excessive speculation a possible destabilising factor. Yet there is one possibility where excessive speculators can destabilise commodity prices without having to store large quantities (Hamilton 2009). If the price elasticity of

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\(^3\) Crude oil is compared to corn as both are commodities that have experienced the same price fluctuations. Furthermore, both commodities satisfy Kaldor’s conditions for speculation in terms of market structure and carrying cost (page 11).
demand of the commodity is zero, almost like corn, a change in the price of the underlying commodity will not affect the quantity demanded. Therefore, if the price elasticity of demand of the commodity is perfectly inelastic, a speculator could still distort the price just by storing a small share of the commodity demanded.

Keynes and Friedman both agree on the definition of speculation but have different opinions on their effect on the market. In Keynes opinion, speculators are less concerned about making forecasts on the expected yield of the commodity but rather concerned with predicting future market prices. Compared to Friedman who believes speculators try to anticipate shortages of a commodity, Keynes believes that speculators try to anticipate changes in the psychology of the market. In other words, Keynes believe that the slightest bit of news, rumours or gossip would be over analyzed and consequently the response would create enormous price fluctuations. If all market participants think that they all think that the price of a commodity is going to increase, the price will rise. On the other hand, if all market participants think that they all think that price on a commodity is going to fall, the price will drop. As explained, through Friedman’s theory, it is hard to argue for speculation as a destabilising factor. However, it is clear that excessive speculation can cause serious destabilization in the price of a commodity.

The fluctuations in the price of a commodity can have severe consequences. Many refer to society as the most important one (Dube and Vargas 2009), (Kubler and Schmedders 2011) and (Simsek 2011). In other words, as commodity prices fluctuate because of excessive speculators, not only will consumers and producers bear the economic burden but so will the speculator himself (Johnson 1976).

2.4 Commodity speculators and other investors

(Madrigal 1996) argued that speculators have a more knowledge on an investment than other investors. However, that does not separate speculators from other investor types. Furthermore, excessive speculators are not the only investors that can affect the price of a commodity. There are three investors in particular that are often mentioned in the scientific literature: Noise traders, herders and positive feedback investors.

Small as well as large noise traders can drastically change the price of a commodity. To do so, noise traders must follow two presumptions. First of all, noise traders must misinterpret the available
information whether private or public. Second, noise traders must be positively correlated in terms of trade, in other words they must either be buyers or sellers. If noise traders buy and sell randomly their trades will cancel each other out instead of reinforcing each other. Noise traders will generally make a profit (Shleifer & Summers 1990) thus making them a common sight in commodity markets. But, the only reason for the profitability of noise traders lies in the fact that they tend to underestimate the risk involved in investing in a commodity (De Long, Shleifer, Summers and Waldmann 1991). However, the end result will eventually create an unwanted fluctuation in the price of the commodity (De Long, Shleifer, Summers and Waldmann 1989).

There is not a common definition for herding but in its most general form, herding is defined as a behaviour that is followed by the masses. The issue of defining herding lies in the fact that investors that are buying a popular asset could just very well be doing it as a reaction to new information. There are generally two different views on herding: the non-rational and the rational. The non-rational view concerns the behaviour of an investor as they blindly follow the rest without analysing the investment rationally. The rational view concerns the lack of optimal decision-making from the investor because of a misinterpretation on certain information. Regardless of which view is used to interpret herding, its impact on the price of a commodity remains the same. By misinterpreting information herders will buy a commodity without knowing whether or not the price represent the true value of the commodity. As a consequence herders can either force the price above or under the equilibrium value of the commodity thus destabilising the price. The consequence is the same for the non-rational view.

As investors trade on good news today there is an understanding that positive feedback traders will stimulate trading tomorrow and further increase the price. Positive feedback investors will end up driving prices away from equilibrium (De Long, Shleifer, Summers and Waldmann 1990). The reaction of positive feedback traders might very well trigger an encouragement for other traders, such as herders, to react in the same way thus aggravating the price fluctuations (De Long, Shleifer, Summers and Waldmann 1990). In other words, even though a part of the price fluctuation is due to rational trading, another part of it, beside positive feedback investors, could be due to other investors anticipating the reaction of positive feedback traders. Given the abnormal trading coming from positive feedback traders on a commodity they force its price away from equilibrium, overvaluing or undervaluing the commodity.

Noise traders, herders and positive feedback investors show the different interpretations an investor can have on information and on data. In other words, investors can disagree on an investment in a commodity even if they were presented with all the necessary information to make a rational decision.
(Kurz 1994). It is those interpretations that make each investor type different than the other and despite the similarities, speculators are inherently rational as Friedman argued. And rational investors trade only to move the price of the commodity in the direction of its fundamentals. In other words, ordinary speculators would, in theory, minimize any price fluctuation created by noise traders, herders and positive feedback investors.

### 2.5 The derivative market

The financial market is huge incorporating bonds, real estate, commodities, currencies and many other assets and financial instruments. One part of this market has steadily become its biggest and most important one: The derivative market. The derivative market has since the financial crisis in 2007 attracted a lot of attention as it was tied to fraud cases and the default of certain participants. However, due to the sheer complexity of the derivative market many cases were mere misunderstandings. The following chapter will enlighten the theory behind commodity derivatives and their purposes.

A financial derivative is a financial contract between two parties that derive its value from the value of a specific underlying commodity. The contract will as a minimum specify a maturity date and a future price for the underlying commodity. The initial idea behind a derivative is to protect investors against unwanted risk. Some investors may be comfortable being exposed to a given risk, while others prefer to manage it. For example, if an investor wants to reduce his risk to a change in the price of a commodity he invests in a derivative that gives him the opportunity to offset potential losses from a change in price in the underlying commodity. In other words, a derivative protects against risk by issuing a contract between two investors concerning a transaction entered into today to be fulfilled at a future point in time. The investor hedges his position in order to counter potential unwanted future movements in a given market variable. As time increases, the value of the derivative fluctuates according to its underlying commodity. By hedging against price fluctuations, companies not only reduces the potential loss from a price fluctuation but also minimizes the volatility of its cash flows and thus enhance the reliability of their forecasting, lower their capital requirements as well as increase their capital productivity (EU 2008).

The derivative market is not only used by hedgers but has also proven interesting as an investment tool for common investors. They are often seen as an alternative to investing directly in the asset. Furthermore, investors can, through the use of derivatives, take on a position against the market when
they believe the underlying asset will fall in value. Investors would do so by entering in an appropriate
derivative contract selling the underlying commodity that is overvalued. When the commodity falls in
value the investor would as a result profit from it. The growing interest in the trading of derivatives is
not only due to risk management, lower transaction costs and flexible investment positions. In certain
countries, mainly in the US, there aren’t that many regulations on the derivative market which means
that investors can maximize their return generally through tax loopholes. For example, in the US, to
encourage long term investments instead of short term investments, investors get a tax break for holding
any asset for more than a year. By investing in a derivative with a maturity of at least a year, investors
can claim a lower capital gains tax when reselling their derivative by treating it as a long term capital
gain no matter how briefly they hold it, whether days or even seconds\(^4\).

Due to the sheer number of different types of derivatives, they are often distinguished in three different
ways: by how they are traded, their underlying asset and the product type. Derivatives can be traded on
exchanges or over-the-counter (OTC). OTC derivatives are created by an agreement between two
individual counterparties. A majority of the OTC derivatives are tailor made contracts with
individualized terms regarding the underlying commodity, the contract size, maturity date and many
other features. The individualized nature of the OTC derivative means that in theory there are an
unlimited number of possible contracts. On the other hand, exchange traded derivatives are completely
standardized and their contract terms are designed by derivative exchanges. The OTC market counts for
more than 84 percent of the total derivative market (Deutsche Börse Group 2010). A derivative can also
be distinguished by the asset it is connected to. The asset in question can be anything from currencies,
different financial instruments or commodities. CME, the largest derivative marketplace, offer
derivatives for 86 different commodities, which only represents a fraction of the total. There are
countless of different derivatives, and going through all of them won’t be in the interest of this paper.
However there are a couple of derivatives that are often used. This paper will be looking at the theory
behind two of the most commonly used derivatives in the trading of commodity derivatives:
Futures/Forwards and Options.

2.5.1 Forwards

A forward contract on an asset, such as a commodity, is a contract agreed upon today concerning the
future sale or purchase of the underlying commodity at a specified date and price. Forward contracts are
privately executed between two parties and are rarely settle through a physical transaction but rather a

\(^4\) Closing the Derivatives Blended Rate Loophole Act
cash settlement (ESME 2009). The obligation to buy the contract at the agreed price on the specified future date is often referred to as the long position while the obligation to sell the contract is referred to as the short position. When agreeing on a price today, an investor will profit depending on his position and the price movement of the underlying asset. As seen in figure 2 a long position profits when prices rise and a short position profits when prices fall.

When a forward contract is established the forward price, referred to as the price agreed upon to be delivered at maturity, is set such that the original value of the forward contract equals 0. In other words, the forward price should represent the expected future spot price of the underlying asset given an expected interest rate. The forward price will eventually vary from period to period as the spot price changes and consequently so will the value of the forward contract. At maturity date, the value of the contract will, in case of a purchase, be given by the spot price at maturity less the forward price. And in case of a sale, the value of the contract will be given by the forward price less the spot price. Figure 2 show the profit of a given position at maturity. The figure does not include any cost of carry or gains earned when purchasing the assets at date 0.

![Figure 2](image-url)
Figure 2 illustrates how both the long and short positions break even when the spot price is equal to the forward price. Furthermore, the long position maximum loss is the forward price that was agreed on at date 0, whereas the maximum gain can be unlimited. Yet on a short position, the maximum gain is the agreed upon forward price and the maximum loss can be unlimited.

Calculating the value of a forward contract is a two step deal. The different forward prices involved must be calculated in order for the value of the forward contract to be estimated. The forward price of a commodity is the price at which you would agree to buy or sell the commodity at a given maturity date. The value of a forward contract is zero at the time when it is first entered into. As time passes, the underlying commodity price changes, and the value of the contract may become either positive or negative. Given a forward contract on a commodity with price $S_0$ the expected forward price $F_0$ will be given by

$$F_0 = S_0 \cdot d(0, T)$$

where the discount factor includes a risk-free rate $r$, and $T$ is the time to maturity.

If $F_t$ is the forward price at date $t$ for the underlying commodity, $F_0$ is the forward price agreed when the contract was signed and $f_t$ is the value of the forward contract, then

$$f_t = (F_t - F_0) \cdot d(0, t)$$

The conditions above are very common among financial assets but don’t always hold for commodities. There are two main reasons for this: the cost of physical inventory and the convenience yield (Casassus and Dufresne 2005). As stated figure 2 did not illustrate the effect of storage costs or benefits in holding a given asset. In theory, a forward contract on for example corn would be entered into before harvest. Once the corn is harvested it would be delivered straight to the owner of the contract and thus not go through any form of storage. But, as this paper is focusing on the effect of speculation through inventory build up, the theory behind forward contract valuation including storage cost will be explained.

The general theory of no arbitrage is still applicable when there are costs of storing. In other words, the forward price should represent a forward contract value of 0 at the time of signing the contract. However, the costs of holding physical inventory will increase the cost of carry which was depicted for

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5 $D(0, T)$ refers to $D(t, T) = D(0, T) / D(0, t)$ which is the discount factor. The interest rate in the discount factor can either be compounded or continuous compounded
financial assets as the risk free interest rate in equation (1). $d(0,T')$ will then, if continuously compounded, be

$$e^{(r+c)\cdot t} \quad (3)$$

Where $r$ is the risk free rate and $c$ is the rate of storage cost in proportion to the spot price.

The value of the forward contract would be calculated in the same way as equation (2).

In certain cases it could be considered more beneficial for investors to hold an asset rather than investing in a forward contract of the asset in question. This is in particular the case for forward contracts on financial assets such as coupons from bonds or dividends from shares. Such a benefit is referred to as the convenience yield (Kaldor 1939). For commodities the convenience yield is not as straightforward as there are no inflows of cash. But assuming that an inventory build up would create a shortage of the commodity and subsequently a rise in the price, physically holding the commodity at the time when the price is high would be beneficial. (Kaldor 1939) argues for the convenience yield in regard to a forward contract which has the obligation of delivery at maturity date by interpreting the stocks of commodities as a "convenience". In other words, given that the stock is not already sold forward, the possibility of making use of the commodity the moment they are wanted represents a convenience yield.

The price of a forward, given a commodity convenience yield and the storage cost, will be the same as equation (1)

$$e^{(r+c-y)\cdot t} \quad (4)$$

Where $r$ is the risk free rate and $y$ is the convenience yield.

In an empirical perspective, a forward contract can be personalized in numerous ways, including in terms of maturity. An investor can easily enter into a forward contract allowing for delivery at any time between the opening date and maturity of the derivative and thus take full advantage of the benefits involved in physically holding the commodity. Furthermore, investors can easily switch position from long to short should their convenience yield change. In other words, the convenience yield remains highly subjective and will therefore in this theoretical part of the paper not be incorporated when explaining the arbitrage relationship between spot and forward/futures prices.
The reason that the price of a forward should represent a contract value of 0 is due to arbitrage. Assuming that the risk free rate is the same for borrowing and lending and supposing the price of a forward is overvalued relative to the spot price and the cost of storage, the market would take advantage of the situation and push it back to its original value of 0 by:

1) Borrow $S_0 + c$ at the rate of $r$
2) Buy a unit of the commodity at $S_0$ and pay for storage $c$
3) Then short a forward contract on the commodity in question with maturity $t$
4) An arbitrage profit will be made of $F_0 - (S_0 + c) \cdot d(0, t)$

Doing so will eventually make $F_0$ fall and $S_0$ rise and thus eliminating the arbitrage opportunity.

And if the price of a forward is undervalued relative to the spot price and the cost of storage, an investor would:

1) Sell the commodity now at $S_0$ and avoid paying the cost of storage $c$
2) Invest the money in a risk free rate $r$
3) Then go long on a forward contract on the commodity in question
4) At maturity the profit would be $(S_0 + c) \cdot d(0, t) - F_0$

Doing so will eventually make $F_0$ rise and $S_0$ fall and thus eliminate the arbitrage opportunity.

2.5.2 Futures

Futures are in essence no different from forwards. Futures tend to bear less risk than forward contracts since they are standardized. Furthermore, the theory of arbitrage that, the value of forwards when signing is worth 0, is the same for futures. The principles are therefore the same. However, valuing a futures contract is difficult for mainly two reasons.

First of all, the choice of delivery of the underlying commodity makes it difficult to calculate the value of the futures contract since when a futures contract reaches its maturity date it can either be settle in cash or by physical delivery. As stated on page 18, forward contracts are often settle in cash. The possibility of delivery makes the futures contracts more attractive to the short position compared to an identical forward contract. Intuitively, this would mean that speculators looking to sell their stored commodities would prefer a futures contract over a forward contract. Consequently, if there are more sellers than buyers in the futures market for a given commodity, the price of the futures contract would
fall. On the other hand, the presence of a delivery option could be considered degrading for hedgers that are entering into a contract on a long position as there is an uncertainty about the quality of the commodity that will be delivered. However, when trading futures contracts, a clearing house is often overseeing the trade. The clearing house mainly ensures the contract is fulfilled and also takes care of testing the quality of the commodity should it be delivered, thus eliminating the risk of quality uncertainty. Second, is the daily marking to market method used in futures market. When dealing with futures you are subsequently dealing with derivative brokers and investing in futures occurs through a margin account. The broker will be lending the investor enough cash to purchase the future. An increase in the spot price of the commodity at the end of the trading day will increase the value of the futures contract and will be represented as an excess margin that can be withdrawn from the account. Futures contract will therefore always be worth 0 at the end of the trading day.

The excess margin represents a cash flow in which interest can be earned. (Duffie and Stanton 1992) and (Amerio 2005) showed in each there way that depending on the correlation between interest rates movements and the futures price movements, futures prices may be cheaper or more expensive than forward prices.

1) If futures prices and interest rate are positively correlated, then futures prices will be higher than forward prices
2) If futures prices and interest rate are negatively correlated, then futures prices will be lower than forward prices
3) If futures prices and interest rate are uncorrelated, then futures and forwards price will match

If the futures price increases then so would the margin account for a long position and supposing the price of a futures contract is positively correlated with the interest rate, the investor would earn interests at a higher rate. Now if the futures price would fall, the margin account for a long position would fall as well but the loss would be financed at a lower interest rate due to the positive correlation. Therefore, given positive correlation, an investor that is long would prefer daily marking-to-market rather than the one time settlement at maturity offered by forward contracts. The opposite can be said about an investor holding a short position. In other words, long investors would prefer futures to forwards while investors holding a short position would prefer forwards to futures. The higher demand for futures would therefore imply that futures prices are higher than forward prices.
The complete opposite is applicable when there is a negative correlation. Therefore, (Amerio 2005) concluded that, the combination of these two arguments would mean that there is no price difference between futures and forwards when there is no correlation between futures price and interest rate.

Empirically, there have been several studies that have concluded that the difference between the price of futures and the price of forwards are very small (French 1983) and (Dezhbakhsh 1994). Therefore, this paper will not differentiate when valuing futures and forwards.

One problem with a forward or a future contract is the obligation to settle the contract at maturity which can in worst cases cause a loss. So it is natural to wonder if there is a type of contract where the buyer/seller has the option not to buy/sell the underlying asset. The answer is affirmative thanks to options.

2.5.3 Options

There exists many different types of options, all of which depend on when, where and who are trading. However, there are two that are often used to describe the theory of options, which also happens to be the most traded among commodities (CME DataMine). An option is a contract to buy or sell a specific asset. The contract contains a specific price at which the contract can be exercised before or at maturity, which is often referred to as the strike price. And that is where the difference lies. In a future/forward the buyer/seller is commonly forced to buy/sell the asset at a predetermined date, whereas with options, the buyer/seller can, but is not required to, sell/buy the asset. And if the investor does not utilize his option, the option expires and it no longer has value and no longer exists.

A call option gives the right but not the obligation for the option holder to buy an asset at a predetermined strike price or walk away. If an investor is long on a call option, he will only exercise the option when the spot price is higher than the strike price. Therefore the payoff would be defined as:

\[
\text{Long call payoff} = \max\{0|S_T - \text{Strike price}\}
\]

(5)

Where \( S_T \) is the spot price at maturity date \( T \)

The payoff does not take into account the cost of acquiring the call option, in other words the price of the option. Therefore the profit earned by the buyer of the call option is:

\[
\text{Long call profit} = \text{Long call payoff} - \text{future value of call price}
\]

(6)

The profit for an investor going long on a call option is depicted by the red coloured area in figure 3.

The payoff and the profit from an investor holding a short position is the opposite of that of an investor holding a long position:

\[
\text{Short call payoff} = \min\{0|\text{Strike price} - S_T\} \quad (7)
\]

And the profit

\[
\text{Short call profit} = \text{Short call payoff} + \text{future value of call price} \quad (8)
\]

The profit for an investor going short on a call option is depicted by the green coloured area in figure 3.

Figure 3

The price of the option is the maximum profit an investor can earn when going short on a call whereas the maximum profit for an investor going long is, in theory, infinite.

A put option gives the right but not the obligation to the option holder to sell an asset at a predetermined strike price or walk away. If an investor is long on a put option, he will only exercise the option when the spot price is lower than the strike price. Therefore the payoff would be defined as:

\[
\text{Long put payoff} = \max\{0|\text{Strike price} - S_T\} \quad (9)
\]
Just as with the case of the call option, the payoff does not take into consideration the cost of acquiring the position. The profit earned by the buyer would be similar to equation (6). The profit for an investor going long on a put option is depicted by the green coloured area in figure 4.

The payoff for the short position of a put option is given as

$$\text{Short put payoff} = \min[0, S_T - \text{Strike price}] \tag{10}$$

The profit of a short position put option is similar to equation (8). The profit is depicted by the red coloured area in figure 4.

![Figure 4](image)

When investing in options on the commodity market, an investor will typically invest in a commodity futures option. A commodity futures option gives the investor the right but not the obligation to buy or sell an underlying commodity futures contract. The option is therefore in essence nothing more than a possible trade of a futures contract. It is very different from conventional commodity options which would, for example, involve an investor holding a long position on a call option and who would make a profit when the market for the underlying commodity futures rises. The investor would in this example exercise the option and buy the commodity futures contract at the strike price. Lastly the investor would take delivery of the underlying commodity associated with the futures contract and resell it on the open market.
market. The profit would then be the difference between the option strike price and the market spot price less the fee paid for the option.

There are many different ways to settle a commodity futures option. If an investor chooses to exercise an option, a settlement in cash or physical delivery can be made. Since a futures contract allows for delivery, though only on specific maturity dates, an option holder would follow the same steps as for a conventional commodity option. This would mean that excessive speculators can use options as an instrument to stock up on the underlying commodity. The choice of whether or not to accept the commodity futures contract offered by the option, minimizes the risk for excessive speculators. By investing in options rather than futures, speculators get the possibility to exercise their contract as soon as it is financial beneficial for them or when they believe the price is still low enough that it would make sense to store the commodity for resale later. However, most investors will chose not to exercise their option in order to avoid losing any remaining time before maturity, paying commissions and paying margin deposits for the acquired futures. Therefore, investors that hold in-the-money options prefer settling their options in cash, by entering in an offsetting position prior to the maturity date, much like futures.

Just as there are different types of options, there are just as many different ways to price an option. (Merton 1973) found a way to price options on dividend paying stocks by discounting the dividends. Through Merton’s work, (Black and Scholes 1973) came up with a model to price option that were based on non-dividend paying stocks. Both pricing models involve the pricing of European options. In other words, options that can only be exercised at maturity date. (Cox, Ross & Rubinstein 1979) argued for a model called the binominal option pricing model which purpose was to price American style options, in other words, options that can be exercised at any time from conception to maturity date.

Neither of these common pricing models can be used when pricing options on commodities. This is mainly due to the non-randomness involved in commodity prices. For example, the prices of corn will rise before harvest and fall after the harvest (Shepherd 1993). This non-random movement does not follow the two common pricing models main assumption, which is the use of a geometric brownian motion (GBM). A GBM is used to model random behaviour that evolves over time with a mean of 0. Furthermore, the Black-Scholes formula assumes that the price of the underlying asset is continuous, in other words the asset must take a specific value. Therefore the Black-Scholes formula does not assume any price jumps on the underlying asset. Yet again, given the enormous price fluctuations commodities
have experienced in the past years, it is clear that the Black-Scholes formula, in its common form, is not usable to price commodity futures option.

However, (Black 1976) found a way to price commodity futures options. The key was to take into consideration the forward price of the commodity instead of the spot price, because the forward price does not display the same non-randomness as spot prices. As stated, spot prices on corn would rise before the harvest just to fall again after harvest, yet the forward price, that is to be delivered after harvest, will not be as high since it will take into account the fall in price following the harvest (Vishwanath and krishnamurti 2009). By replacing the use of spot prices with forward prices, the Black-Scholes formula now becomes usable for commodity futures options.

Price of a call option is:

\[ C = e^{-rt[F \times N(d_1) - X \times N(d_2)]} \]  

Price of a put option is:

\[ P = e^{-rt[X \times N(-d_2) - F \times N(-d_1)]} \]

Where,

\[ d_1 = \frac{\log \left( \frac{F}{X} \right) + \left( \frac{\sigma^2}{2} \right) \times T}{\sigma \sqrt{T}} \]

\[ d_2 = d_1 - \sigma \sqrt{T} \]

\( F \) is the forward price of the underlying commodity

\( X \) is strike price

\( r \) is risk free interest rate

\( T \) is the maturity date
is the volatility of the forward price of the commodity

Commodity futures options are more expensive than regular futures or forwards. The price difference comes from the lower risk involved in options compared to futures, as excessive speculators can choose when and if to exercise the option. Though despite the slight price difference, excessive speculators can still use options to stock up on the underlying commodity.

When going through the theories of the different derivatives, the conclusion is that their nature is a zero-sum game. Therefore, in theory, the nature of the derivatives and their zero-sum game puts to doubt the idea that derivative trading on commodities, and therefore speculation, creates a price rise. Therefore, if speculation through derivatives isn’t profitable, only hedgers would benefit from investing in derivatives. Consequently, only hedgers would exchange commodities and speculators would therefore not have an effect on the price of the commodity. It is however important to understand that, as discussed in previous chapters, seeing the nature of investors as black and white, hedgers versus speculators, is highly unrealistic. As Friedman said: “The case is often far more complicated.” (Friedman 1953)

3) Empirical analysis

3.1 The dependent variable

3.1.1 Corn

Corn has always been a highly demanded commodity as it has a wide variety of uses. The commodity has experienced an unusual incline in demand since 2005, so much so that the world production increased by 25% from 2005 to 2012 (FAO 2012). As demand has increased, new sources of supply have shown great promises. Argentina is today the fifth largest corn producer and the second largest corn exporter. Due to its geographical location, south of the Equator, Argentina can plant its corn after determining the yield of the US corn production thus providing a fast alternative of supply to bad US harvests. Other countries have followed the trend of planting according to estimated weak US corn yield to take advantage of high prices. Corn production in China has since 2005 increased drastically, with an
average of 5.6% per year, and is rapidly catching up to US levels (FAO 2012). Yet, its export levels have been extremely volatile. In 2005 China was the second largest exporter while since 2009 it has begun importing everything from minor to enormous quantities (FAO 2012). There is a general consensus that this volatility in corn prices is due to a rise in demand from producers of cattle, poultry and other meats. Furthermore, China's corn exports are also determined by the export subsidies and tax reliefs offered by the government. Corn prices in China are relatively higher than those in the world market. Therefore in 2005, China offered subsidies and tax breaks to encourage exporting because corn stocks became too expensive for the government to maintain.

Lastly, because of the wide variety of uses for corn it can be substituted by other types of cereals, such as wheat or soybeans. There is however a general lack of flexibility as many countries does not wish to change their levels of imports of one cereal over another. This is due to a preference in the types of animals feed, traditions and a preference to maintain a certain level of one specific cereal due to production facilities (FAO 2012).

All in all, corn is the world's most produced cereal as well as the most traded of all cereals (FAO 2012). The high levels of US production means that the majority of world corn prices are generally determined by the forces of supply and demand in the US. This makes it an ideal commodity to analyse as most variables have to be related to the US which in turn makes data search easier.

### 3.2 The independent variable

#### 3.2.1 Crude oil

There are several ways of calculating the price of crude oil since it can be extracted from different parts of the world. Each geographical production area has their crude oil and thus a total of 216 different types of crude oil exist in the world as of 2012 (OPEC 2011). The 216 different types of crude oil can be categorized into larger geographical benchmarks. There are three well known benchmarks that are often used when referring to the price of crude oil: West Texas Intermediate which is sourced in the United States, Brent blend which is sourced in Europe and Dubai crude which is sourced in the Middle East.

In 2011, US corn production represented 61% of the world’s corn production (FAO 2012). At the same time, the US are fare from self sufficient in oil, they remain the biggest importer with a total of 10.5 million barrels a day representing 45% of their total consumption (EIA 2011). Consequently their corn production is dependent on other sources of oil than their own geographical production source of West
Texas Intermediate. Given the past years political and diplomatic tensions between the US and the Middle East, the US have begun cutting down on their dependency on Middle Eastern oil and have become more favourable towards Brent Blend amongst others. The second largest corn producer, China, is not self sufficient in oil either and has long been dependent on good relations with neighbouring countries. However, the economic growth of China has meant that its need of oil has grown at a rapid rate that neither China nor its neighbouring countries could offer. The large production capacities in the Middle East have become a great source for exporting China’s ever growing demand that now represents almost 80% of China’s crude oil imports (OPEC 2011). The fourth biggest corn producer, Europe (EU-27), has a total crude oil import that stems from Africa (17.36%), Middle East (18.36%) and especially from Russia (36.07%) (EU 2011). The large import of crude oil from Russia can be represented by the Urals oil benchmark (OPEC 2011).

Because the world’s largest corn producers are so dependent on oil from several sources, the dependent variable oil price will incorporate the crude oil of West Texas Intermediate, Brent Blend, Dubai crude and Urals oil. The final price of crude oil used in this paper is a rough representation of the four benchmarks as a percentage of yearly average production of corn from the three biggest corn producers\(^6\).

\[\text{Corn price} = \text{US (55\% WTI, 45\% Brent)} + \text{China (80\% Dubai, 20\% Ural)} + \text{EU (35\% Urals, 65\% Brent)}\]

\(6\) US (55\% WTI, 45\% Brent) China (80\% Dubai, 20\% Ural) EU (35\% Urals, 65\% Brent)
Figure 5 shows the calculated price of crude oil alongside the price of corn. The two fluctuates at about the same rate since 2005. Two main reasons could explain this trend. First of all, corn production involves large quantities of fuel use through machinery, planting and harvesting.

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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<td>Cost of fuel ($)</td>
<td>65.48</td>
<td>70.99</td>
<td>78.03</td>
<td>105.36</td>
<td>71.98</td>
<td>93.26</td>
<td>109.91</td>
</tr>
<tr>
<td>as a % of total operating cost</td>
<td>14.22</td>
<td>13.95</td>
<td>13.79</td>
<td>14.42</td>
<td>9.87</td>
<td>13.60</td>
<td>13.92</td>
</tr>
</tbody>
</table>

Table 1

Table 1 shows the cost of fuel in corn production per planted hectare in US dollars and as a percentage of total operating cost of corn production. From 2005 to 2011 the cost of fuel per planted hectare has increased by 168%. The increase in fuel cost in itself is very interesting but the sudden drop in price from 2009 and the subsequent spike in 2010 is what makes it particularly interesting. The highly fluctuating price in fuel cost can lead to a discussion of speculation, not in corn as in this paper, but in crude oil. Regardless of what caused the increase in oil price, it is worth noting that the cost of fuel as a percentage of total operating cost has remained almost steady throughout the years. Corn farmers are therefore buying the necessary fuel to cultivate their corn despite its increase in price. The second explanation for the similar fluctuations between corn prices and crude oil prices can be the large quantities of corn that have been exported and that have therefore been highly subjected to transport costs (IMF 2012). In the US, 81% of all domestic transportation and 10% of all export of corn occurred through trucks (USDA 2010). The exportation of US corn mainly occur through sea navigation, thus 60% of all US corn export occurs through the use of barges and container ships (USDA 2010). Both transportation measures are greatly dependent on the price of oil and if the price rises so will the costs of transportation. In other words, the additional shipping costs would have explained the price fluctuations of corn. Similar transport data can be found on two other large corn exporters, Argentina and Ukraine (WFP 2011), who together with the US represent 71% (FAO 2012) of all world corn exports.
Figure 6 shows the world export of corn since 2005 (FAO 2012). Prior to 2005 there had been a rise in corn export and the historical tendency continued until late 2007 when corn exports suddenly imploded just to reach previous levels again in 2009. Since then world exports have not experienced the same growth rate prior to the financial crisis. However it did experience a dip again in 2010 while corn prices where slowly rising again. The relative slow growth in world corn export since 2010 does not come as a surprise, it is very likely that it can be explained by one factor in particular: panic (Headey and Fan 2008).

The sharp rise in corn price in 2010 created a state of panic among several corn producing countries. The fear that the corn price peak of 2008 would repeat made several of these countries, in the interest of national food security and domestic consumption, initiate an export ban on corn. Among these countries were Russia and Australia. The United States has since 2005 gradually lowered the amount of corn exported from 58 million metric ton to 28 million metric ton in 2012 (as of August 2012) (USDA 2012 a). The decline means that the demand for US corn represented by export was less than 20% of world export (USDA 2012 a), the lowest ever since 1975. The lack in higher US corn exports since 2010 comes despite an ever growing corn production. In other words, for the US in particular, food security is not the reason for the declining exports. The ever growing bio ethanol and livestock industries are constantly demanding more corn and are shown first priority through national policies (see more on page 67).
Given that the price of crude oil plays such an important role in the production of corn, this paper will test and quantify in a multiple regression analysis how much the monthly oil price affect the monthly price of corn.

3.2.2 US Dollar

There are several ways to calculate the value of the dollar. The Federal Reserve publicise three different indexes on a monthly basis. Each index measures a weighted average of different foreign currency values to the value of the dollar: The Broad Index, the Major Currencies Index and the Other Important Trading Partners Index (OITP) (US Federal Reserve 2012). The main function of these indexes is to measure the competitiveness of US goods in international trade. In other words, the exchange rates used in the indexes belong to economies that interact in international trade with the US. Each foreign country is given a weighted average in relation to the amount of goods that are imported and exported with the US. The foreign exchange rates can affect the competitiveness of US goods as they can influence the price of these goods through their relative buying power. Therefore, the weighted average in the different indexes changes over time as the different countries export and import shares changes.

The two indexes, major currency index and the OITP index are both related to the Broad index. The major currency index is a weighted average of a few foreign currency found in the Broad Index that are commonly used internationally. The currencies in question are the Euro, the Japanese Yen, the British Pound, the Canadian Dollar, the Swedish Krona and the Swiss Franc (US Federal Reserve 2012). Since these currencies are often used outside their own country they are often traded in financial markets. Therefore, the major currency index is mostly used to measure financial market pressures on the dollar. This would be highly relevant in connection to the speculation variable that will be elaborated on page 42. Furthermore the major currency index is the only index where the Japanese Yen has the highest weighted share. This is particularly important as Japan is by far the largest importer of corn with a total of 16 million metric tons a year (USDA 2012 a). However, the only reason the Japanese Yen got such a high weight in the major currency index is because there are so few currencies. The index ends up diminishing the value of other importing currencies to the dollar, such as the Argentinean pesos, the Saudi Riyal or the Korean Won.

The alternative index, OITP, is no better as it represents the 20 remaining countries from the Broad index that are not included in the Major currency index (US Federal Reserve 2012). Large importers and exporters of corn end up being neglected and results in a flawed valuation of the dollar compared to the world’s corn exporters and importers.
The Broad Index is a mixture of the two previous indexes and thus represents a large group of major U.S. trader’s foreign currency values to the US dollar. The Euro, the Yuan, the Yen, The Canadian Dollar and the Mexican pesos are among a total of 26 currencies valued in the Broad Index (US Federal Reserve 2012). The countries that are part of the Broad Index represent the largest importers and exporters of corn which would arguably make the index a valid variable to measure the effect of the value of the dollar on corn prices. There are however a few issues as well with this index worth noticing. First of all, this time the Japanese Yen weight in the Broad Index is less than 8%, almost three times lower than the Euro despite being the largest importer of corn in the world. This leads us to our second issue, the Euro. With a total weight of 23%, the largest weight among all the other currencies, the ”Euro area”, as described in the index, does not include all EU states that are fixed to the Euro. The reason for this is the import and export relationship these countries have with the US. In order to be part of the Broad Index, the US must have a bilateral import and export share of at least 0.5 % and none of the ten countries that were admitted to the EU in 2004 fulfil such a requirement (US Federal Reserve 2010). The issue is that added together the import and export shares of these countries would mount up to a considerable share worthy to be implemented in the Broad Index. Especially since Bulgaria, Hungary and Romania are large corn producers (FAO 2012). Regardless of the issues involved in each of the three indexes, the Broad Index is the best representation of corn trading across the world.

The US dollar is chosen as a variable that could explain the price fluctuations because the US dollar is the currency that is mostly used when trading corn (Deutsche Börse Group 2010). In theory, if the value of the dollar is lower than the value of the currency of a given country it would mean a reduction in price of a particular good for the given country. For example, the relatively low value of the US dollar would make it easier for international buyers to purchase corn. In other words, as the value of the US dollar drops it will take less foreign currency to purchase a bushel of corn and there would be a higher demand for corn. The increase in demand would consequently result in a higher price. In other words, a fall in the value of the dollar will end in higher corn prices and vice versa (Mitchell 2008) as seen in figure 7.
Therefore, this paper will test the value of the US dollar in a multiple regression analysis to determine how much the monthly dollar value affected the price of corn.

3.2.3 Fertiliser

Fertiliser is an essential part of corn production as it aids the growth process of the plant and thus increases the output of corn. Fertiliser is essentially three nutrients: Nitrogen, Phosphate and Potash. As seen in figure 8 the prices of the three elements show the same fluctuations as previous variables, which could cause the prices of corn to increase.
Fertilisers are generally used twice or thrice a month and prices will fluctuate depending on how harsh the winter is prior to sowing the crops. If the winter was warm, in other words it ended early, then farmers would be able to sow in March or April and let corn grow with less fertiliser which in turn would mean that the prices on fertiliser would fall. Conversely, if winter was cold and ended late, the sudden need for additional fertiliser would create a rise in price. This means that the prices of fertiliser generally follow the fluctuations of the weather during the winter. These changes in fertiliser price due to the weather were often minuscule, increasing by just 7% from late 1994 to late 2004 and never changing more than an average of 1% a month (FAO 2011). However, suddenly in 2005 everything changed. Prices of nitrogen, phosphate and potassium\(^7\) began increasing violently up to 2008 just to see their prices fall again in 2009. What is interesting is that when the price of corn in 2011 experienced a similar second price as in 2008, the prices of the three nutrients did not experience the same price rise from 2008. This would indicate that the price of corn fertiliser did not have a big cause in the 2011 corn price peak as other variables. As seen in table 2, the price of fertiliser per planted hectare of corn rose accordingly.

\(^7\) Same as potash
Given that there are many fertilisers, each blending different types of the three nutrients: nitrogen, potassium and phosphate, and that corn farmers in different countries use different amounts of these nutrients, generally due to the national laws each country has on pollution, soil matter and ecology, there is not a common fertiliser price index (FAO 2011). In order to reflect the average world consumption of fertiliser by corn farmers, an average consumption of the three nutrients by the four largest corn producers (US, China, EU and Argentina) in the world has been calculated. For example, the EU doesn’t allow fertilisers to contain more than 28 % nitrogen whereas in the US the limit is well above 60 % (USDA 2012 b) and (EU 2011). The average nitrogen, phosphate and potassium used per bushel of corn (0,0254 mt) is seen in table 3.

<table>
<thead>
<tr>
<th>Nutrients (kg) per bushel</th>
<th>Phosphate</th>
<th>Potash</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0,28</td>
<td>0,67</td>
<td>0,56</td>
</tr>
</tbody>
</table>

Table 3

Figure 9 shows the world price of fertiliser used for corn given table 3. This paper will test the price of corn fertiliser in a multiple regression analysis to determine how much the price of fertiliser has affected the price of corn.

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8 The use of fertiliser depends on the soil and its tests. Therefore the average is at best an approximation of world fertiliser prices for corn: http://www.fieldcrops.org/Corn/Pages/FertilisersforCorn.aspx
Bio fuel, bio ethanol, methanol, biodiesel etc. are just one of many distinctive and different forms of fuel. Both bio fuel and biodiesel are made out of vegetable oil and are therefore not worth taking into account. Bio ethanol on the other hand is made out of several cereals here among corn. There are two ways of creating bio ethanol, fermentation ethanol and synthetic ethanol. A distinction between the two is needed in order to clearly identify the variable. The process of fermented ethanol is produced from corn or other biomass cereals. Bio ethanol would affect the price of corn as the industry would demand more bushels of corn to supply its clients. The process of synthetic ethanol is made out of by-products of petroleum and would therefore demand crude oil rather than corn. The most common type of bio ethanol produced is fermented, counting for more than 90% of all bio ethanol produced in the world (RFA 2012). Despite the large account of fermented bio ethanol, the variable bio ethanol will include data of the synthetic ethanol process due to data scarcity. In other words, when calculating the effect of bio ethanol on corn prices, a minor fraction of the variable may slightly distort the conclusion.
The US only produces bio ethanol through corn and about 40 % of US corn production is used for ethanol (Wallander, Claassen and Nickerson 2011). This, represents about 60 % of all bio ethanol produced in the world (RFA 2012) emphasizing the importance of US corn production. The US, Europe, Asia and Brazil produced, together, 91.6 % of world bio ethanol in 2011 (RFA 2012). However, the source of bio ethanol in Brazil does not come from corn but mostly from sugar canes. Asia, not including China, mainly uses rice to produce bio ethanol. China, despite being the second largest corn producer in the world, doesn’t turn much of it to ethanol. The reason lies in the latest political incentives. In China the government has slashed corn ethanol subsidies to 500 Yuan from 1276 Yuan per ton last year (Jewison and Gale 2012). The main reason lies in the countries ever growing meat consumption. China is saving large quantities of corn to feed its livestock. About 4 to 5 million metric tons of corn is going to ethanol every year in china, only representing 3% of its total yearly corn production (Balat, Balat and Öz 2008). In Europe, bio ethanol is produced either synthetically or whit wheat or corn. It is difficult to determine which process or biomass products are used the most. But given the latest investments in wheat to ethanol plants in Hungary, the already existing large wheat to bio ethanol facilities in Sweden, France, Spain, Germany and the United Kingdom (EUBIA 2007), it is assumable that corn is not the most used cereal to produce bio ethanol in Europe. Therefore, given the world bio ethanol production and the US producing most of its bio ethanol through corn, it is estimated that the US represents about 90 % of all bio ethanol produced with corn in 2011, the remaining 10 % is mainly being produced in the EU, Canada and South Africa. The variable bio ethanol will therefore only take US bio ethanol production into consideration.

Bio ethanol impact corn prices by being an additional source of demand. In 2005 only 12 to 14 % of world corn produced was used for ethanol (RFA 2012) and despite the large growing demand at the time, it had very little impact on corn prices. Now however, where more than 40 % of US corn is used for ethanol and world demand keeps growing as seen on figure 10, it has a significant impact on the price of corn.
Another source of demand can be found in relation to crude oil. About 65% of world crude oil is used for the production of diesel and gasoline (OPEC 2011). Bio ethanol is regarded for some as a substitute for gasoline and diesel fuel. In other words, an increase in price of crude oil relative to bio ethanol will result in an increase in demand of bio ethanol and thus corn prices. The growing demand for bio ethanol and the past years increase in price of oil concludes this theory.

This paper will test the price of bio ethanol in a multiple regression analysis to determine how much the price of bio ethanol has affected the price of corn.

### 3.2.5 Excessive speculation

Speculators can affect the spot price of corn by trading heavily. The increasing demand for corn futures acts as an additional force of demand for the commodity. As more and more speculators invest in futures and options for corn it gives an inaccurate expectations on the future commercial demand for corn. An increase in the spot price of corn is thus bound to happen as it anticipate the future growing demand. However, speculators are not commercial demanders and have therefore no use of the commodity the derivative reaches its maturity date. They can choose to store the commodity in hope of
selling it later but in the end it is the relevant buyers of derivatives such as millers or bio ethanol producers, that will determine whether or not they need to buy. In other words, speculation can drastically increase the price of derivatives until maturity, but only increase spot prices by a small fraction. Furthermore, this form of trading can only a prise rise and not a price fluctuation. Excessive speculators can affect the spot price of corn by manipulating the laws of supply and demand. By investing in large amounts of corn and physically storing the commodity they can create an artificial demand in the future for more corn. The consequences of the increased demand would result in higher price.

Corn can either be sold on the spot market or the derivative market. There exist three major corn derivative exchanges, the NYSE Liffe in Paris, the Tokyo Cereal Exchange (TGE) in Japan and the Chicago Board of Trade (CBOT) in the US. CBOT is by far the largest derivative exchange in corn. As of the 1st of October 2012, the total amount of corn contracts that have not yet been settled, also known as open interest, is 1.819,838 and 95% of all open interests are traded on CBOT (CFTC 2012). Due to the large trading, CBOT is a good source for data to determine the implication of speculation.

On page 21 it is argued that excessive speculators only make a profit if the expected future spot price is worth more than the current spot price plus the cost of carry. Therefore it is important to determine, on an empirical level, whether or not it makes economic sense to store corn now to resell it later. From 1981 to the 1990’s the CBOT storage rate was 0,015 US dollars per bushel a day. From 1990 to 1999 the storage rate grew by 0,005 US dollars to 0,016 US dollars per bushel of corn a day. Up to 2008 the storage rate used was 0,015 US dollars per bushel of corn per day. The rate of storage was usually determined every 10 years because since the 1980’s to 2008 the price of corn had remained stable and therefore it was deemed irrelevant to constantly change the storage cost (CME 2012). This was the case for all agricultural commodities. But ever since the first food commodity price spike, the rules were slightly altered and an experimental variable storage rate system (VSR) was set in place. This new tentative rule was set in place only for wheat while the storage rate for corn was changed and raised to 16,5 US cents per bushel per day. A VSR system is though already used in most corn elevators that are approved and used as external storage facilities by CBOT. However given a lack of transparency and data restrictions by CBOT’s corn elevators this paper will use the fixed storage rate and not the VSR to determine the profitability of excessive speculation. All commodity futures, once settled, must go through a clearing house. CBOT has its own clearing house who assures the quality and quantity of the underlying commodity. The commodity is then temporarily stored in its inventories until it is shipped to its final destination. A corn future on CBOT is either traded as a full contract (5000bushels) or a small
contract (1000 bushels), where a large majority is sold as full contracts (CME 2012). The price of a futures or option contract is always shown as US cents per bushel of corn.

Appendix 3 shows the spot and futures prices of corn in cents per bushel. There are big inconsistencies in the spot and futures prices (Appendix 1) which can be explained by the convenience yield. When the spot price is lower than the futures price the convenience yield is negative while when spot prices are above futures prices the convenience yield is positive. In other words, the convenience yield is an indicator of whether it more profitable to invest in the futures or spot market. The prices between the red fields in Appendix 3 show the release and the maturity dates of the futures. A future contract can have a maturity date of 3, 5, 7, 9, 12, 15, 17, 19, 21 and 24 months (CME 2012). With a monthly storage cost of 0.495 US cents per bushel, the storage cost is added for every month after maturity to the prices of the futures. Whenever the corn future at the given month needs to be stored after maturity to be sold later for a profit, the price will be marked in yellow. If the futures price is not marked in yellow the investment in the given futures contract would have been profitable at maturity. Stored or not any futures contract will have been profitable after maturity if stored long enough. The prices shown below the maturity date are the spot prices per bushel of corn. The blue fields show when the most expensive futures contract cannot be sold and have to be stored. For example, a future with maturity in May 2007 bought in February 2007 at 435 cents a bushel, would, given the storage costs, not have been profitable from June 2007 to November 2007. However on December 2007 the bushel including the storage cost would have been profitable to sell on the spot market. Again, due to data scarcity not all prices were available and are marked by n/a.

An upward sloping futures curve, as seen in figure 11, is consistent with a futures price that reward inventory holders despite the cost of carry (Roache and Erbil 2010). This is called backwardation. The cost-of-carry argument, storing the commodity, is difficult to explain when there is a downward sloping futures curve (Roache and Erbil 2010). It is hard to argue for the rationality behind the inventory held by excessive speculators when there is a decline in corn spot prices. This is referred to as contango see figure 11. In other words, excessive speculators will dump their remaining inventory once the initial price rise from the lack of corn supply has reached its maximum, explaining, in theory, the enormous price fluctuations corn has experienced.

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9 Storage costs from page 42 were given the appropriate time periods chosen and timed by 30 days
Figure 11

(Kaldor 1939) does not explicitly argue that an increase in inventory would result in a fluctuation in price but he merely explains that in order to induce excessive storing, expected spot prices of a commodity has to rise sufficiently over time to compensate inventory holders for the costs associated with storage. In other words, corn prices would have had to rise so much that there would be an arbitrage opportunity between futures price and spot price, contradicting the theory of futures being a zero sum game. Therefore when the market is in backwardation it is a perfect time for excessive speculators to enter into a long position.

Excessive speculation can occur through two ways. The first one is proposed in (Kilian and Murphy 2010) and refers to a sudden shock in demand for more inventory that is driven by shifts in the future expectations of the commodity that has not been captured by demand and supply. In other words, excessive speculators will buy large quantities of the commodity to store and thus create an increase in the demand. The subsequent shift in demand gives excessive speculators the possibility to act as a new source of supply. The price of corn in particular can reach extreme levels since the demand of corn is almost perfectly inelastic\(^\text{10}\). A second way for excessive speculation to occur is suggested by (Hamilton 2009). Hamilton explains how speculators can affect the incentives of producers by purchasing large quantities of futures and thus signalling higher expected spot prices. Producers will get the incentive to hold back the commodity from the market and stock up in order to take advantage of the expected price increase. Hamilton concludes that producers would have been misled by the speculative purchases of

\(^{10}\)Page 4 describe the enormous dependency of food on everyday life. In other words, a price change in corn will have no influence on quantity demanded.
futures contract into lowering their current production in response. In other words, Hamilton suggests that the producers of the commodity act as excessive speculators. This goes against our definition of excessive speculation on page 12 where we argue that it can only occur through non-commercial investors. Therefore the speculation variable will be focused on Killian and Murphy’s proposal.

For excessive speculators to achieve a profit two factors are necessary. First of all, there must be an arbitrage opportunity. This has been proven as well as discussed in the previous couple paragraphs. Second, the regulative forces whose job is to prevent high price fluctuations must lack the ability to do so. The national inventory levels of a given country acts as buffer stocks which can be used to absorb shocks to demand and supply, thus dampening the impact on spot prices. Given that enormous price fluctuations did occur, it is arguable that the role of inventory as buffer stocks did not work, whether due to speculation or other factors.

There are many issues involved in gathering data on inventories, the most common being the absence of a common data source. In addition to the lack of data availability, there is the question of how to define the relevant inventories. Most commodity futures contracts that are called for physical delivery at the relevant exchange clearing house is checked for quality among other things, but there isn’t any data available on stocks that are held off exchange. For example, US corn bound for domestic or international shipping would most of the time end up at in harbours such as Chicago Burns harbour, Peoria, Lockport-Seneca and Ottowa-Chillicothe (CME 2012) but there are no data available from these harbours. Beside the definition of relevant inventories there is a timing issue. Information about inventories is often published with a lag and subsequently revised. This creates a timing issue in matching variation of prices to variation of inventories. All of these factors make measuring excessive speculation extremely difficult.

The best way to quantify excessive speculation would be the number of non-commercial corn derivatives that has been settled physically and not in cash. However given the lack of data available, excessive speculation will have to be measured in another way. When referring to the quantity of futures traded two measures appear: volume and open interest (CME 2012). Volume is the total amount of trading activity. In other words, it is the total amount of contracts that have changed hands in the commodity market for a single trading day. The greater the amount of trading during a market session the higher the trading volume will be thus representing a measure of intensity behind a price trend. Consequently the greater the volume the more an investor can expect the existing trend to continue rather than reverse. Open interest on the other hand is the total number of outstanding contracts that are held by market participants at the end of each day. Open interest measures the flow of money into the
futures market. For each seller of a futures contract there must be a buyer of that contract. Thus a seller and a buyer combine to create only one contract.

In order to quantify excessive speculation, the number of derivative contracts that end up being delivered by non-commercial investors is of great interest. By subtracting the number of non-commercial derivatives long by non-commercial derivatives short, the number of derivatives that have not been settled by offsetting positions before maturity date remain and thus represent, to a certain extent, the amount of non-commercial derivatives bound for physical delivery, see figure 12. The quantification only represents excessive speculation to a certain extent because the lack of offsetting position is not equivalent to physical delivery. As discussed on page 19 most derivative contracts can either be settled through delivery or through cash settlement after maturity. If non-commercial investors aren’t interested in taking delivery of the commodity, it is possible to simply pay the difference on the maturity date between the futures value and the spot price. In other words, the variable excessive speculation in this paper will be an approximation.

Figure 12
The Commodity Futures Trading Commission (CFTC) used to only distinguish two categories of market participants: those that hedge an existing exposure, which it categorized as “commercial”, and those that do not hedge which is categorized as “non-commercial” (CME 2012). However, it has become widely perceived that, as a consequence of the growing diversity of market participants in futures exchanges and the greater complexity of their activities, the data from the traditional categories failed to reflect all the different investment activities (UNCTAD 2011). This is because those hedging, and therefore defined as commercial market participants, have normally been considered as investors that use transactions in futures contracts to reduce risk. However, many market participants who report positions as hedges, and who therefore fall under the commercial category, are in fact commodity swap dealers, who hedge to offset financial positions. If their positions were held as commodity futures contracts instead they would be categorized as “non-commercial”.

4) Statistical Analysis

A regression analysis will allow this paper to analyse and determine if there is a significant relationship between a dependent variable, price of corn, and several independent variables.

In this chapter, the theory and the limitations of a regression model will be presented as to offer a proper and accurate conclusion of the findings.

The various variables that are going to be used in the multiple regression model as well as their potential impact have been presented in the previous chapter. The model will eventually quantify the effect of the different independent variables on the price of corn. In other words, the model will value how much the dependent variable corn changes as the independent variables change by one unit.

The dependent variable will be the monthly world spot price of corn. While the independent variables will be:

1) Crude oil price
2) Value of US Dollar
3) Fertiliser
4) Bio ethanol
5) Speculation
The equation of our model expresses the dependent value, corn spot price, as a linear function of our five independent variables and an error term:

$$Y_t = \beta_0 + \beta_1 x_{t,1} + \beta_2 x_{t,2} + \beta_3 x_{t,3} + \beta_4 x_{t,4} + \beta_5 x_{t,5} + e_t$$

Where,

$Y_t$ is the monthly corn spot price.

$\beta_0$ is the regression constant. In other words, $\beta_0$ shows the spot price of corn when all other variables are 0.

$\beta_n$ is the coefficient of one of the five independent variables.

$x_{t,n}$ is the value of one of the five independent variables in month $t$.

$e_t$ is the residual. In other words, it is the difference between the actual corn spot price and the calculated corn spot price given the independent variables.

When using a statistical modelling in order to make an empirical conclusion, several misconceptions can occur. Therefore, to avoid such misconceptions a strict process must be followed and according to a SAS support document\textsuperscript{11} there are several processes that can be followed. One of the processes that were suggested was from (Montgomery, Peck and Vining 2012)

\textsuperscript{11}http://support.sas.com/documentation/onlinedoc/jmp/902/Modeling_Multivariate.pdf

Figure 13
4.1 Data and objective

All data were taken solely from reliable sources. The reliable sources were determined by their authors, whether it was scientific articles, national or international institutions. This being said, even though the source of the data is to be trusted, the data used may not fully represent the different variables. In other words, certain assumptions had to be made in this paper, in particular the independent variable excessive speculation. The data used therefore represent the best fit to our variable. The main objective of this paper is first to determine whether or not the effect of excessive speculation caused fluctuations in the price of corn, and if so by how much.

4.2 Model specification

A regression model is ideal to quantify the level of excessive speculation on the price of corn. In order to conclude precisely the effect of excessive speculation on corn prices it is imperative to determine if other factors could affect the price. Therefore a multiple regression model is chosen. There are many ways to determine whether a linear or a non-linear regression model is to be used. (Wang 1987) argues for a residual plot to detect nonlinearity in linear models. The plot will on its vertical axis refer to the value of the residual and the horizontal axis will refer to one of the independent variables. This will allow for an observational conclusion on the whether the plot is linear or non-linear. In other words, if the points in the residual plot are randomly dispersed around the horizontal axis, a linear regression model is preferred. Otherwise, a non-linear model is more appropriate. The problem with this is that the residual of the regression model is unknown until the model has been estimated. Therefore, the residual plot works better as a final verification tool. Another way, far simpler in its design, is proposed by (Montgomery, Peck and Vining 2012). By outlining the different variables to one another in a big scatter plot matrix, one can verify through observation whether or not the variables are approximately linear. Given the scatter plot matrix, see figure 14, a linear regression model was chosen over a non-linear model.
4.3 Parameter estimation

The five independent variables or parameters were chosen because, they through analytical discussions in the previous chapter and through a review of empirical literature, they were deemed to have the greatest influence on the price of corn. However, it is not unlikely that other variables could have affected the price of corn. These other variables will be discussed in an upcoming chapter on page 67. The model will therefore only represent the influence the five independent variables have on the price of corn making the model inherently incomplete.
4.4 Model adequacy check

In order to check the adequacy of the model, a couple of common problems related to regression models needs to be attended to in order to get the best possible result:

4.4.1 Omitted explanatory variables

This occurs when an important variable is missing or is not specified. The consequences are that the user of the model can overemphasize the importance of the used variables. Statistically, it would mean that the p-values of the respective variables cannot be trusted. In line with the rest of the paper a cautious attitude will be taken when concluding. In other words, variables that have not been used and that can be considered an important causal factor is elaborated on page 67.

4.4.2 Nonlinear and linear relationships

As previously concluded, none of the variables in figure 14 were observed to have a nonlinear relationship.

4.4.3 Data outliers

If among the data used for the different variables there is a set of extreme values, they can pull the modelled regression away from its true value resulting in a biased outcome. These outliers should not be removed from the data sample but should, with the help of the scatter plot matrix, be identified. Once identified, their influence on the data set can be determined through the use of Cook’s distance. Cook’s distance creates a second identical regression model and tests the influence of the outlier by removing it. The distance is determined to be large if it is greater than $5/n$, where $n$ is the number of observations:

$$\frac{5}{91} = 0.059.$$ 

Figure 15 shows that there are a couple of data points that present themselves outside the 95% confidence interval. However only one data observation can be considered as an extreme value as proved by the Cook’s distance test, figure 15.
Figure 15

The point in question is the fertiliser price on August 2008, which was the highest price amongst the data.

4.4.4 Multicollinearity

Multicollinearity occurs when one or several combinations of independent variables are strongly correlated and therefore become redundant as they would lead to an over counting type of bias and none of them will get credit for their influence. To search for multicollinearity, each independent variable is tested for high correlations. However, it is not easy to determine what high correlation is and it can lead to biased assumptions. A simpler way is to look at the variance inflation factor (VIF). VIF quantifies the severity of the multicollinearity by measuring how much the variance of an estimated coefficient $\beta_n$ increases due to collinearity. If VIF is equal to 1 the variables do not exhibit multicollinearity, while the higher the VIF increases the higher the multicollinearity between two variables will be. This being said there are no statistical VIF limits which one can assume a worrying level of multicollinearity (Freund, Littel and Creighton 2003). Yet, it has been argued that if VIF > 10, then multicollinearity is high (Freund, Littel and Creighton 2003). The VIF is tested in all variables in figure 16.
Both the variables of crude oil and the value of the US Dollar shows high VIF factors which shouldn’t come as a surprise as the price of crude oil throughout the world is denominated in US dollar. Despite the relative high VIF values of these two variables they are below 10 and their effect on the price of corn has been explained and verified in the previous chapter.

4.4.5 Inconsistent variance in residuals

Inconsistent variance in residuals infers that the regression model is very good at explaining small values of the dependent variable, but becomes unreliable for larger values. It is vital for this paper to ensure that there is a consistency among residuals as it is the change from minor to large values of the dependent variable that is of interest. Once again there exist several ways to test for the consistency of residuals (White 1980, Park 1966, Breusch & Pagan 1979). However, heteroskedasticity can often be observed by plotting the residual values to the dependent variable. Figure 17 shows no sign of heteroskedasticity thus confirming that the model is adequate to be used.

![Parameter Estimates Table](image)

![Bivariate Fit of price By Residuals](image)
### 4.4.6 Autocorrelation

Autocorrelation occurs when the residuals of the different variables are correlated at different time levels. In other words, the correlation between variables is measured in their original time frame as well as in a lagged period. When testing a regression model for autocorrelation the Durbin-Watson test is often used. If the result is 2 there is no case of autocorrelation whereas if the result is 0 there is sign of a positive autocorrelation and if the result is 4 there is sign of a negative autocorrelation.

![Durbin-Watson](image1.png)

**Figure 18**

The Durbin-Watson test in figure 18 shows that there is a very high autocorrelation in our model questioning the adequacy of the model. Normally, in order to restore the adequacy of the model, all data needs to be transformed. Several ways exist to transform data\(^ {12}\), the simplest and most satisfactory in terms of a linear regression is subjecting the data at a given time ordert or lag: \(x_n - x_{n-t}\). Correlated data among two variables are redundant as they risk being seen as one similar variable and not two. However, correlation is not causation. The high VIF factors in the independent variables oil and dollar shows that these two are relatively high correlated. In figure 19 the three other independent variables, excessive speculation, bio ethanol and fertiliser are tested for autocorrelation. The results show that the two variables crude oil and the value of the dollar misconstrue the Durbin-Watson test making data transformation unnecessary. These two variables are inherently correlated but as long as it does not ruin the final result of the model and their independent causation are argued for, see page 31-36, autocorrelation can be tolerated.

![Durbin-Watson](image2.png)

**Figure 19**

\(^{12}\) Box-Cox or Log differencing
4.4.7 Normal distribution of residuals

If the residuals of the regression model are not normally distributed with a mean equal to zero, the P-value associated with the relevant coefficients will be unreliable. To test for normal distribution among residuals, the residuals are plotted in a histogram and checked for signs of skewness or lack of kurtosis. Figure 20 shows a normal distribution among the residuals.

![Figure 20: Normal distribution of residuals](image)

4.5 Use of model

If there is a significant linear relationship between the independent variables and the dependent variable the slope will not equal zero. Therefore, the null hypothesis states that the slope is equal to zero.

\[ H_0: \beta_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0 \]

The null hypothesis will be rejected at a specific significance level, in this case 95%. In order to reject the null hypothesis, the P-value of each independent variable will be tested. The P-value represents the tail probability for the null hypothesis. In other words, if the P-value falls within the tail value of the significance level, the null hypothesis can be rejected. Consequently, there will be a statistical significant linear dependency between the independent variables and the mean of the dependent variable.
The P-value, \( \text{Prob } > |t| \), of the different independent variables are shown in figure 21. All variables have a P-value well below the significance level of 0.05 except for the independent variable US Dollar value and the intercept.

Whether the intercept has a high P-value or not is not vital for the model. It simply means that when all the independent variables are zero, the price will not be a valid representation of the true value.

The high P-value of the US Dollar is due to the autocorrelation found with the Durbin-Watson test in figure 18 and figure 19. The positive autocorrelation was due to the correlation between crude oil and the US Dollar. If there is a positive autocorrelation the residual, a measurement of accuracy of whether the sample used represents the population, will tend to be over estimated. As seen in figure 21 the residual, \( \text{Std Error} \), of the US Dollar is relatively higher thus inflating the t-ratio and subsequently inflating the P-value above the tail value of the significance level. Furthermore, coefficients are not affected by autocorrelation and thus the coefficient of the US Dollar still represents its impact on the price of corn. Lastly, as stated on page 54, autocorrelation is acceptable as long as the final model is
correct. The US dollar’s impact on corn prices has been argued for several times and will therefore be interpreted as being within the significance level.

The F-value shown in the Analysis of Variance in figure 21 is very similar to the P-value. It test whether or not the model as a whole is statistical significant and with a value of less than 0.0001 the model can be interpreted as being correct.

The coefficient of the intercept shows the mean of the dependent variable when all of the independent variables are 0. If all the relevant independent variables were depicted in the regression model the intercept would equal 0. In other words, with a coefficient of -100.89 other independent variables have been left out. However, with an $R^2$ of 0.879, 88% of the variance in the dependent variable can be explained by the independent variables crude oil, bio ethanol, the US Dollar, fertiliser and excessive speculation. Therefore, the remaining 12 % is explained by other independent variables making the model highly representative of the true value of the dependent variable.

$$Corn \ price_t = -100.89 + 1.015Crude \ oil_{t,1} + 0.79US \ Dollar_{t,2} + 0.044Fertiliser_{t,3} + 0.003Bio \ ethanol_{t,4} + 0.00003Excessive \ speculation_{t,5}$$

![Figure 22](image-url)
The coefficients of each independent variable, as seen above, show that for each change in one unit of the independent variables, the dependent variable will change by the coefficient of the independent variable around the dependent mean if and only if the other independent variables are fixed. For example if all independent variables are fixed except for \( \text{crude oil}_{t-1} \) then for each change of 1 US Dollar in the price of \( \text{crude oil}_{t-1} \), \( \text{Corn price}_t \) changes by 1,015 US Dollar. The variables crude oil and US Dollar are among those that have the highest coefficients making them the two variables with the most explanatory value. It is noticeable that excessive speculation in this case has a coefficient very close to 0 making it a variable with very little explanatory value. The final estimation on the price of corn given the five variables is shown in figure 22.

It is important however, to understand that the coefficients in a regression analysis only represent the numeric changes of an independent variable compared to a dependent variable. Since each variable are measured differently, whether it be in US dollars, metric tons or the difference in the amount of derivatives bought and sold, it is difficult to compare the full influence of one coefficient to another. In other words, the coefficients are statistical quantities of the true influence.

<table>
<thead>
<tr>
<th>Summary of Fit</th>
<th>Crude oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSquare</td>
<td>0.709241</td>
</tr>
<tr>
<td>Observations</td>
<td>91</td>
</tr>
<tr>
<td>Term</td>
<td>Estimate</td>
</tr>
<tr>
<td>Intercept</td>
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<tr>
<td>oil</td>
<td>2.533393</td>
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<td>Term</td>
<td>Estimate</td>
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<tr>
<td>Intercept</td>
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<td>speculation</td>
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<tr>
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<tbody>
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<tr>
<td>Term</td>
<td>Estimate</td>
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<tr>
<td>Intercept</td>
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<tr>
<td>Term</td>
<td>Estimate</td>
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<td>Intercept</td>
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<td>bio</td>
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<table>
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<tr>
<th>Parameter Estimates</th>
<th>Crude oil</th>
</tr>
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<td>Observations (or Sum Wgts)</td>
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<tr>
<td>Term</td>
<td>Estimate</td>
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<tr>
<td>Intercept</td>
<td>64,465244</td>
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<tr>
<td>fertiliser</td>
<td>0.1314233</td>
</tr>
</tbody>
</table>

Figure 23
In figure 22 each independent variable is depicted with the dependent variable. In other words, figure 22 shows the level of change each independent variable affect the dependent variable if it was given that it was the only explanatory variable. It is noticeable that for both variables crude oil and US Dollar the R-square and their coefficients are relatively higher, arguing that these variables have indeed a higher explanatory value than the rest of the variables. Both bio ethanol and fertiliser have an R-square of around 60 % giving them a large explanatory value. On the other, excessive speculation only has an R-square of 42 %, disputing the idea that excessive speculation is the sole cause behind the price fluctuations.

In order to fully analyse the effect of speculation on the price of corn, the model is run again but this time, excessive speculation is not added.

In figure 23 the regression model has an R-square of 84 %, only 3,9 % lower than the previous model yet again pointing that excessive speculation has an extremely small explanatory value for the price fluctuations of corn. Furthermore, the coefficients of crude oil and US Dollar are still amongst the largest variables, similar to the previous regression model in figure 21.
In order to finally conclude the significance of excessive speculation, the regression model is run again with every combination of the independent variables with and without the variable excessive speculation. Table 4 illustrates this. The difference between the R-square’s are minimal, fluctuating with an average of 3%. At every time the coefficients of excessive speculation were the lowest among the independent variables. Despite the overwhelming evidence that excessive speculation is not influential, the variable in question is always within the confidence intervals of 95%. Therefore excessive speculation has an effect on the price of corn however it is very little, so little in fact that it can be deemed irrelevant.

<table>
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<tr>
<th>Excessive Speculation</th>
<th>Crude Oil</th>
<th>Bio ethanol</th>
<th>US Dollar</th>
<th>Fertiliser</th>
<th>R-square % With excessive speculation</th>
<th>R-square % Without excessive speculation</th>
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</thead>
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<td></td>
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<td>70,9</td>
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<td></td>
<td>76,2</td>
<td>73,7</td>
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<td>74,2</td>
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<td>80,4</td>
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</table>

Table 4

4.6 Interpreting the results

4.6.1 US Dollar

Figures 21 and 23, point towards the US Dollar as the most important variable affecting the price of corn. This follows the description of the variables on page 34 where the US Dollar was emphasized as being the potential most important variable. The enormous relative export share by the US is undeniable and is therefore undoubtedly the main reason for its important explanatory value. Table 4 shows that
every time the US Dollar is part of the regression model the total explanatory value of the model, R-square, is higher. These statistical and analytical findings add to the growing empirical literature by other scientific authors arguing that the US Dollar is indeed a causal factor in the price of corn (Pfeiffer 2006), (Akram 2009) and (Zhang, Lohr, Escalante and Wetzstein 2010).

Being that the US Dollar has a great influence on the price of corn, producers, consumers and investors can use the expected future value of the US Dollar as a variable to anticipate the future price of corn. Not only does it allow producers to better hedge against price fluctuations but, in theory, it also means that excessive speculators are able to better predict when to begin storing and when to start selling their stored corn. In order to reduce the possibility of excessive speculation, the fluctuations in the US Dollar needs to be minimized and/or the relationship between the US Dollar and corn needs to be minimized as well.

In order to minimise the fluctuations in the US Dollar, the demand and supply of the currency needs to remain stable. This, however is extremely difficult as the derived demand for the US Dollar is determined by the amount of trade of US goods and foreign investment. Therefore the US Dollar is constantly fluctuating against other currencies. Furthermore, it is not as evident on the supply either. The supply of the US dollar is determined by the political agenda of the US and its Federal Reserve. The Federal Reserve will in order to stabilise the value of the Dollar change its money policy. This paper will not elaborate further on the macroeconomic theories regarding the supply and demand of money as it seems illogical that the general supply and demand of the US Dollar will change just for the sake of corn. Instead focus will be on the financial exchange possibilities regarding the corn market.

Given that the US by far is the largest exporter of corn to date, the US Dollar will inherently continue to affect the price of corn. However, new corn producers have appeared across the world namely in Argentina, Ukraine and Brazil. Since 2005 these countries have increased their share in the corn world export while the US has restrained its corn exports due to the increasing demand in the bio ethanol industry. The world demand for corn has only increased since 2005 and shows no sign of changing. Therefore it is not unlikely that, has the US lowers their exports of corn and several other countries take over the supply, the US Dollar explanatory value will fall. That being said, in 2011 alone, the equivalent of 7 billion metric tons of corn was bought on CBOT making corn prices highly dependent on the value of the US Dollar (CME report). A derivative will usually be sold and bought hundreds of times before reaching its final destination and given that these derivatives are traded in US Dollar it is not surprising that the price of corn will follow the currency. Therefore, in order to help minimize price fluctuations in corn, current non US exchange markets need to develop their portfolio and if not, then existing corn
exchange markets such as NYSE Liffe or TGE need to promote their derivatives better. However, with a combined trade equivalent to 70 million metric tons of corn (NYSE Liffe Data Product) and (TGE Historical Data), there is a long way to overtake the influence of the US Dollar and CME. Furthermore, large corn export countries such as Argentina and Brazil are bad contenders for evolving derivative corn trading in their exchanges as their money policies are strongly connected to the US Dollar. Argentina have in the past couple of months taken new measures to lower the influence of the US Dollar in the Argentine economy by restricting the use of the US Dollar on certain national and private investments. However, the Mercado a Termino de Buenos Aires (MATBA) and the Rosario board of trade, two of the largest corn derivative exchanges in Argentina, still use the US Dollar to quote and settle their trades and will most likely continue to do so as it is much easier for them. Brazil, another large corn producer and exporter, also trade corn derivatives in US Dollars. Even larger import countries, that are dependent on corn, do not plan to trade corn derivatives in their own currency. The Mexican Derivative Exchange (MexDer) plans to expand their derivatives portfolio with corn derivatives at the end of 2013 in order to minimize the risk of corn shortages in the country by having a quick and dependent source. Furthermore, it will help increase a much needed activity around corn production in the country. The derivative contracts will be quoted in pesos but will derive their price from CBOT. Therefore the US Dollar will keep an important influence on the price of corn.

4.6.2 Crude oil and Bio ethanol

Figures 21 and 23 show that the price of crude oil is the second more important influence. This comes as no surprise as the price of crude oil is strongly correlated with the US Dollar. In other words, a change in the price of crude oil will mean a change in the US Dollar, which subsequently will mean a change in the price of corn (Naylor & Falcon 2010).

Crude oil does not only affect the price of corn indirectly through its impact on the US Dollar. As explained on page 33 crude oil, or rather its by-products, are a major input in the production of corn and regardless of their prices, corn farmers will buy the fuel necessary to produce (see table 1). The high dependency of fuel on corn production is due to the industrialization the agricultural world experienced in the 1950’s. In table 1 it is noticeable that the average cost of fuel was much low when the price of crude oil fell from November 2008 to June 2009. However, it does not explain why the price of corn remained steady during that period. Bio ethanol is often described as a substitute for gasoline and diesel, and had from mid 2008 to late 2009 been relatively more expensive. Consequently, consumers and producers that otherwise bought the cheaper bio ethanol and blended it with the more expensive gasoline or diesel during that time period would have been incentivised to buy gasoline or diesel. The
demand for bio ethanol stagnated from mid 2008 to mid 2009 (see fig 10) and as a result so did the price of corn. Crude oil is also highly related to the production of fertiliser both directly and indirectly. Nitrogenous fertilisers are produced with the nitrogen and hydrogen found in crude oil while fertilisers made with phosphate and potash are produced from minerals that have to be mined and processed with the use of crude oil.

Given the explanatory value of crude oil on the price of corn, the price of crude oil needs to be stabilised in order to minimize the fluctuations in the price of corn. Just with the US Dollar, crude oil is closely related to global macroeconomic activities, which are outside the field of this paper. Focus will be turned instead towards sustainable implementations suited for the industry. Bio ethanol is currently cheaper than gasoline and has been so for a long time despite occasional occurrences that only lasted for a couple of months, namely in 2005, 2007 and 2009. During these periods corn farmers were incentivised to buy gasoline rather than bio ethanol. This substitution between gasoline and bio ethanol is the perfect remedy to remove the dependency of crude oil on the price of corn. However, it will take time before bio ethanol can completely substitute gasoline because the powerful engines used by farmers to produce and harvest corn cannot be driven by bio ethanol. Machines fuelled with alternative fuels still need to be built. However, in order to speed up the process of innovating agricultural machines there needs to be funds invested in research and development. Unfortunately, in many countries, agriculture is not a very prosperous investment thus holding up investment expenditures (Alston et al. 1999). Furthermore, there is general consensus that expansion of corn planted as well as productivity among corn farmers will be less than prior years. In the US, from the 1970’s corn had experienced a rise in R&D investments which lasted until 2006. Since then, public as well as private R&D had ceased growing (OECD 2011). Productivity among US farmers had since the 1950’s increased on average by 1,74 % every decade mainly due to the industrialization that lasted until the beginning of the 1970’s (USDA 2012 c). Since then, productivity has not grown as fast. From 2000 to 2009 productivity only rose by 0,63 % and output only grew by 0,7 % (USDA 2012 c). The yield of corn fell due to the fall in productivity that in turn is linked to the fall in R&D expenditures. Without the necessary R&D the supply response for a sudden demand jump in corn will inevitably be slow.

The roles of energy efficient alternatives to replace farmers dependency on crude oil is self evident. Despite the lack of R&D investments in agricultural machines running on alternative energies, figure 10 does show that the demand for bio ethanol continued to increase emphasizing the world’s interest in alternative energies. Furthermore, figure 5 shows that from August 2010 the growth in the price of corn surpassed the growth in the price of crude oil reaffirming the interest of bio ethanol derived in particular from corn. The main reason for this is the “10 % blending wall”. The blending wall refers to the
maximum amount of bio ethanol allowed to be blended with gasoline for engines produced prior to 2006. Estimates put the blending wall to be reached in the beginning of 2013 and new limits are to be published in late 2012. Latest rumours points that the blending wall could double in size to 20 %, explaining first the immense interest in bio ethanol production and consequently the growth in the price of corn and second that corn farmers will, though in the far future, be less dependent on the price of crude oil. The relationship between crude oil and the price of corn may even be prolonged, especially for the largest producer of corn, the US, depending on the results of the presidential elections. Mitt Romney plans to cut spending thus increasing the chance of seeing the amount of R&D expenditures in agriculture fall\textsuperscript{13}. Barack Obama on the other hand mentions corn production and bio ethanol as investment opportunities to further develop rural areas\textsuperscript{14}.

4.6.3 Fertiliser

Given the direct and indirect dependency of crude oil on fertilisers and the dependency of crude oil and fertilisers on the price of corn, it would seem logical for corn farmers to reduce their dependency on crude oil by switching to organic fertilisers. Currently, China and the US are by far the largest users of inorganic fertilisers making the price of their crops, highly subjected to the price of crude oil. However, neither countries have plans of reducing their use of inorganic fertiliser (FAO 2011). This is mainly due to the disadvantages with organic fertilisers. The costs of farming corn will increase due to the additional transport of organic fertilisers that are generally more voluminous than inorganic fertilisers. Furthermore, additional labour will be needed to properly handle the relatively more complex composition of organic fertiliser, not only increasing the costs for farmers but also reducing the productivity of the industry (FAO 2011).

4.6.4 Excessive speculation

The view that speculation has contributed to the past years price fluctuations in commodities has led to more awareness among governments on the need for the introduction of greater regulation to limit this activity. However, the question of how much and what form of regulation is polemic. At the 2011 G20 summit in Paris, French president Nicolas Sarkozy introduced the discussion of speculation on commodity prices. The discussion was taken further when the G20 finance ministers met. Different regulatory possibilities were discussed here among a tax on financial trade, an increased transparency on exchanges and setting a limit for non-commercial actors to invest.

\textsuperscript{13} http://www.mittromney.com/coalitions/farmers-and-ranchers-for-romney
\textsuperscript{14} http://www.barackobama.com/rural-issues
The discussions at the G20 summit pushed European finance ministers a year later to implement a tax on financial transactions, the so called Robin Hood tax. 11 countries in the EU decided to implement the Robin Hood tax which in its original form is 0.1 % on the trade of stocks and bonds and 0.02 % on the trade of derivatives. If all goes according to plan and none of the involved countries draw back their resolution, the tax will be implemented during 2013. However in the US, where most of the trading in corn occurs and thus speculation and the supposedly excessive speculation, secretary of treasure Timothy Geithner is opposed to a Robin Hood tax. Though it is possible that with the upcoming election in the US and thus a new Secretary of Treasure, a change in policy could occur. Taxing derivatives lowers the profitability of speculation by making investments more costly. Determining the tax percentage necessary to minimize speculation is difficult, mainly because inventory costs are different from one commodity to another. In general, the tax percentage must be low enough to encourage non-speculators to trade so as not to lower the liquidity in the market. On the other hand it must be high enough to discourage speculators and excessive by making it unprofitable for them to affect demand and supply by storing enormous amounts of corn.

Given that the majority of corn produced comes from a few countries and the countries importing corn are only few, it makes it easier to determine supply and demand. Given the small numbers of countries involved and their influence in trading corn, transparency is already an important part of their respective regulatory system. Promoting greater “national transparency” in the corn market at this point will not lower any form of speculation. On the other hand promoting “financial transparency” on corn exchanges can help lower excessive speculation. It is arguable that by requiring trading firms and exchanges to regularly report trade data and most importantly, as this has been a key difficulty in this paper, publicly release them, regulators will be better able to monitor excessive inventory build up in the market. Furthermore, publicly releasing data can reduce price fluctuations and fix prices to the values of supply and demand. Such transparency would be especially beneficial to the enormous derivatives market that, are mostly executed over-the-counter and not in derivative exchanges. In such a setting, broader access to information about market activity might act as a confidence-builder for market participants. Improved financial transparency would also reduce the costs of trade, which in turn would attract new traders to the market and boost liquidity, while being protected against market manipulation by excessive speculators. In the US, regulators are currently taking significant steps towards improving financial transparency under the 2010 Dodd-Frank Act. However, it is going to take time before they are turned into laws (Wilmarth Jr. and Rev 2010).

Excluding all or a large majority of the non-commercial investors from the commodity market is a highly dangerous regulation that can backfire and in particular leave corn users with a lot of risk. By
implementing position limits, in other words making it impossible for an investor to have a position above a certain level, it would remove the derivatives market’s primary mechanism: hedging. The regulatory proposition can be found in the 2010 Dodd-Frank Act. Fortunately it was overruled in late September 2012 by the US Federal Court as it was deemed not to “eliminate or prevent excessive speculation”. Even the compromise proposed after the ruling of restricting excessive speculation by increasing margin requirements, in other words the amount of cash traders must put up as collateral, is dangerous. By increasing margin requirements smaller traders will be squeezed out of the market and trading will end up being concentrated on a handful of large firms that have the resources to meet the margin requirements. In other words, with fewer traders the liquidity will be reduced and the prices of commodities will fluctuate more.

However, given our empirical analysis excessive speculation is the variable with the least explanatory value. Figure 21 does not show a substantial lowering of its R-square compared to figure 23 again proving that speculation is not a highly determining factor on the price of corn. In table 4 R-square does not change drastically between the different combinations of variables again emphasizing the lack of explanatory value of the variable. But just as the root of the problem of speculation in commodity markets is a lack of a common definition, the interpretation of excessive speculation in this paper is mere one of several possibilities. The best data to interpret excessive speculation would be the derivatives physically settled and not the approximation this paper illustrates. That being said this papers approximation remains a valid indicator of the effect of excessive speculation and at no time can it be interpreted as a variable that majorly affect the price of corn, postulating the reason for the political interest on the matter.

It has to be said that only 11 countries in the EU have voted in favour of the Robin Hood tax and plan to implement it. That is only two votes over the minimum to make it a general EU law. In other words, it is not a popular option. This is due to each country’s economical interest in financial transactions. An additional tax on financial transactions will simply lower the growth of the sector. Furthermore, other countries, such as the United-Kingdom do not see speculation as a cause for the commodity crisis. So why is the blame put on speculation? As argued on page 6, speculation can, though very little, increase the price of commodities like corn. However, speculation alone does not explain the sudden subsequent lowering on the price of the commodity. In other words, politicians are interested in speculation solely because of its price inflating capabilities.

Given the overall agreement for financial regulations after the financial crisis in 2007, every possible problem regarding financial transactions were of course looked upon. However, caution has to be made
not to blindly regulate transactions as the consequences can be quite severe. Since the first commodity price fluctuation back in 2007 the media coverage on speculation as a cause has lowered. This is can mainly be explained by the ever growing economical literature concluding that speculation is not the real cause of price fluctuations in certain commodities. It has to be said again that speculation is interpreted differently in the various articles and that is exactly where the main issue lies. There is no common understanding of who speculators are, what separates them from other investors and how they can create a price fluctuation on a commodity. In other words, before implementing regulations there should be a greater understanding of speculation.

5) Analysis of intangible variables

The empirical analysis in this paper studies the variables that have been argued as being the most influential over the price of corn. However, as stated, there are numerous other variables that can affect the price. These variables can be divided into two segments: short term and long term. In other words, certain factors have been going on for a while and have slowly but steadily increased the possibility for price fluctuations. At the same time, occasional non predictable events have caused short term disruptions in both the demand and supply of corn and thus price.

5.1 Long term

5.1.1 Income growth

Since the beginning of the millennium China and India, the most populated countries in the world, have experienced a drastic rise in income per capita (World Bank Data). It has been suggested that this rapid growth in personal wealth has helped increase the fluctuations in the price of corn because people with higher incomes have a tendency to switch their foods to more dairy products as well as white and red meat (Von Braun 2008). As explained on page 30, corn is the preferred nutrition for the livestock industry and it is therefore dependent on the price of corn. Therefore, the rise in the demand of dairy and meat products as seen in figure 24, is due to a rise in the personal income in China and India. The rise in demand consequently increased the price of corn. The additional income is mainly due to the
urbanisation these countries have experienced. China experienced in 2003 a structural transformation of its society. The number of people employed in the agriculture industry began declining again (World Bank Data). China adopted several policies to try to lower migration from rural to urban areas however given the demand for labour and higher, urbanisation was inevitable. India has undergone a similar change. This new meat eating trend explains China’s sudden enormous corn imports. After importing minor amounts of corn from 2005 to 2008, China suddenly increased its import of corn by more than 2600% and it is still increasing (FAO 2012). In other words, income growth as an explanatory variable for the price fluctuations in corn is not a global happening but rather an exceptional long term trend in India and especially China (Mitchell 2008).

Figure 25

5.1.2 Meat consumption

China and India are not the only countries that have experienced a growth in meat and dairy consumption. The EU, the US and Brazil have, since 2005, experienced a growth in all categories of meat (poultry, veal, beef and swine) as well as in dairy products. The overall idea is that an increase in meat and dairy production would lead to a higher feed demand. However, feed demand has been relatively low compared to the increase of livestock. In 2005 almost 60 % of US corn was used for
livestock feed compared to 2012 where only around a third of US corn is used (USDA 2012 d). The general feed demand generated by the increased meat consumption would have been met by increased production was it not for the diversion of corn into bio ethanol (Haniotis 2008).

5.1.3 Population growth

The overall growth in meat and dairy consumption does not only come from the income growth in China and India but is also to a certain extent due to the growth in world population. From 2005 to 2012 world population increased by 500 million people to reach the 7 billion mark (World Bank Data). The larger the population the higher the demand will be and with the UN expecting world population to reach 8 billion in 2020 demand for food will only grow.

5.1.4 Subsidies

In the US around 7 billion dollars in subsidies were offered to corn farmers in 2006 (USDA data), while in the EU the Common Agriculture Policy (CAP) used nearly 4 billion Euros in corn subsidies in 2006\(^\text{15}\). Since then, product specific subsidies have been cut in both countries. US corn subsidies were almost halved in 2011, and the CAP’s budget has been cut by 23 % (EuroStat). Without subsidies the intensive farming incentives farmers had during the years of high subsidies have been removed and the supply has fallen as a consequence. All in all, policy changes have meant that demand has increased while supply has been reduced.

5.1.5 Inventory

For several years now, developed countries have been trying to reduce the level of stocks held for commodities, corn among them. The large quantities of corn stocked were expensive and since the late 1990’s, policies were implemented to lower the inventory levels. The large accumulation of corn stocks came from an over production due to the subsidy policies described above. In other words, the new agricultural policies in the US and EU have gone from being heavily subsidized and encouraging over-producing to being far more environmental friendly and rewarding countryside stewardship rather than output, with the consequence of reducing general supply. The low supply and high demand have meant that the amount of corn otherwise stored in national inventories has been used to fill the gap. And with the continued demand growing, it has hindered the rebuilding of inventories and stocks have remained relatively low. The role of these inventories is two part yet highly connected with one another. First of

\(^{15}\) Total CAP subsidies is 50€ billion. 40% of subsidies goes to cereals. 20% of cereals produced in EU is corn. In other words corn subsidies = 20% of (40% of 50€billion)
all, inventories work as an additional source of supply in case of unexpected demand or low supply. Second, inventories help keep the price of corn steady by working as a buffer. For example, as the price of corn increases due to higher demand, low supply or in this case both, national inventories can sell their corn at a margin of the spot price and thus lower general prices or vice versa. However, when inventory levels are low, the risk of stock exhaustion increases and so does the expected future spot price. For both the US and China, the two largest corn producers, the yearly end of stocks of corn has declined (FAOSTat). A way to forecast the effect of inventory levels on the price of corn given the comparative production and consumption levels is to measure the stock-to-use ratio. The stock-to-use ratio shows the level of carryover stock as a percentage of the total demand:

\[
\left( \frac{\text{Beginning stock} + \text{Ending stock}}{\text{Total demand}} \right) * 100
\]

Historical data shows that when corn reaches a low stock-to-use ratio of around 30% there is an increase in price fluctuations. In figure 25 the stock-to-use ratio of the five largest corn producers are shown as an average. Just during the food crisis in the mid 1970’s the stock-to-use ratio in 2008 has the same level.

Figure 26

<table>
<thead>
<tr>
<th>Stock-to-use ratio</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1960</td>
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<tr>
<td></td>
<td>1970</td>
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<td></td>
<td>1980</td>
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<tr>
<td></td>
<td>2000</td>
</tr>
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<td></td>
<td>2010</td>
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</tbody>
</table>

**World stock-to-use ratio**

World average stock-to-use ratio
5.2 Short term

5.2.1 Weather

The weather is a vital part of the final harvest output for corn farmers. It is a phenomenon that is not controllable and can therefore have unexpected and disastrous effect on the supply of corn. Since 2005 several countries have experienced harvest failures due to unfavourable weather or natural disasters.

In 2006 and 2007 Australia experienced a series of unfortunate weather and natural disasters. It began by a drought hitting in particular the northern part of the country and ruining most of the harvest. The small part that was saved was later destroyed by heavy floods and typhoons. The drought of 2006 also hit Indonesia, the Philippines and south central China. The supply in corn, especially in 2006, was severely minimized and as a response the US increased their production for 2007. Unfortunately, the bad weather continued through 2007 and worsened the harvests in Ukraine, the EU and Canada making the additional supply from the US insignificant. In 2010 Russia experienced a severe drought that led to catastrophic fires that ravaged their entire corn yield. 2012 has been one of the hottest years in the US as well as the driest and it has had disastrous effects on the corn yield. And this despite farmers having planted the most acreage of corn in 70 years (FAOStat). The United States department of agriculture will publish their final report on the total production of the 2012 corn harvest in January 2013 but estimates that approximately 25 % of the corn harvests were lost (USDA Feed Outlook: October 2012). There have been three enormous corn price fluctuations in the past five years. Weather has clearly had an effect on the supply of corn though its actual influence is hard to calculate.

5.2.2 Export bans

The bad harvests meant that several countries had to prioritize their domestic consumptions. Consequently several countries lowered or even completely banned exports of corn. The bad harvest in 2006 and 2007 meant that Australia lowered their exports by 86 % while EU and Ukraine together lowered theirs by 28 % (EuroStat). In 2010 Russia put a complete export ban on corn which was lifted in late 2011 and with the current demand for corn higher than ever Russia has set in motion policies that will lower their corn exports by half by the end of 2013 (WAOB\textsuperscript{16} Outlook: October 2012). Indian corn harvest in 2012 also suffered from drought and the government is currently contemplating on either an export ban or an export tax (WAOB Outlook: August 2012). Even Argentina that usually works as a buffer when the US has a bad harvest had an export ban in 2009 as all countries sought to buy their corn

\textsuperscript{16} World Agriculture Outlook Board
Furthermore, there are rumours that Argentina plans on repeating their export ban due to bad weather conditions for the 2012 corn harvest (WAOB Outlook: October 2012).

Export bans are designed to protect domestic consumers and industries from the effects of high corn prices. From the point of view of net exporting countries such a policy might seem logical. As world prices increase, domestic prices are protected and remain relatively stable. However, when several countries follow the same policy, as demonstrated above, corn disappears from global markets and consequently prices become over inflated. In other words, export bans worsen the very price rise countries try to avoid. Furthermore, it has a particular impact on net importing countries. As soon as rumours flourish of a possible export ban on corn, panic ensues and countries buy huge quantities to stock up on the commodity to ensure domestic consumption thus forcing the prices further up.

Figure 26 illustrates the long and short term variables that have influenced the price of corn. It is therefore clear that the influence of the variables chosen in this paper to be quantified, only represents a fraction of the explanation in the price fluctuations of corn.
In this paper an elaborate discussion on the theory behind speculation in commodity trading was introduced. In particular the common misconceptions and the various interpretations of speculation were introduced and compared. By illustrating the various definitions of speculation a difference was made between speculation and excessive speculation. The difference between the two lies in their investment purpose. Excessive speculators deliberately distort prices to their advantage by altering the forces of supply and demand. In this paper, the alternation in supply and demand was described as happening through vast inventory build ups. Excessive speculators will buy up large quantities of a commodity and store it to create a lack in supply thus pushing prices up before selling of their inventory for a profit. This was merely one of several possible interpretations of excessive speculation concluding that the issue is not only determining whether or not excessive speculation caused the price fluctuations in certain commodities, but also how to define speculation.

This paper’s main subject was to identify the implications of speculation on the price of corn and quantify its influence. Several quantifiable variables were introduced as alternative causes to the price fluctuations in corn and were, along with speculation, analysed and quantified in a statistical model. A multiple linear regression model was conducted. The statistical adequacy of the model was verified by following a strict process and deemed statistically usable. This paper did three regression tests: a multiple linear regression model with all variables in order to determine each variable’s explanatory value. An individual linear regression model was run to test each individual variable as an explanatory value to the price of corn. And finally a multiple linear regression test, testing a mixture of all variables and comparing them respectively with and without excessive speculation.

The value of the US dollar is one of the variables that has the biggest influence on the price of corn. The almost perfect inverse relationship between the US Dollar and the price of corn is due to the currency’s role in the trading of corn. In every regression model the US Dollar is, statically, one of the variables with the highest significance in determining the price of corn. Statistically speaking, every time the US Dollar increases its value by one Dollar in respect to its trading partners, the price of corn rises by 0.79 Dollars. The price of crude oil is also a very important variable in determining the price of corn. Its importance in the production process of corn prior and during harvesting is undeniable. This is especially shown by the cost of fuel being a steady percentage of the operating costs despite the price fluctuations. Lastly, the price of crude oil indirectly affects the price of corn through the enormous
quantities that are traded and therefore needs to be transported. The regression model shows that the price of crude oil is, statistically, highly significant in determining the price of corn. For every time the price of crude oil increases by a Dollar, the price of corn increases by 1,015 Dollars. Bio ethanol produced from corn has since 2005 surpassed most anticipations. Subsequently, bio ethanol represents an additional source of demand for corn. The continuous growth in bio ethanol production despite the price fluctuations in corn makes bio ethanol the only variable in this paper that causes a price rise in corn instead of a fluctuation. Furthermore, given the substitutive role between bio ethanol and the by-products of crude oil the demand for bio ethanol, and thus the price of corn, grew as the price of crude oil increased. Despite not being, statistically, as significant as the US Dollar and the price of crude oil, bio ethanol remains an important factor in determining the price of corn. For every 1000 barrels of bio ethanol produced from corn, the price of corn will rise 0,003 Dollars. Fertilisers are often used by corn farmers to increase their output but their uses are highly dependent on the weather. In other words, fertiliser as a production cost will vary from year to year not only due to its price fluctuations but also due to the weather. The price of fertilisers calculated in this paper illustrates a much greater price peak in 2008 than 2011, making it obvious that fertiliser had a higher impact on the price of corn in 2008 compared to 2011. The difference in fertiliser prices during these fluctuations is due to the price of crude oil. Crude oil and some of its by-products are not only an important part of the production process of fertiliser but also a part of its constitution. Fertilisers are not as, statistically, significant as the price of crude oil or the US Dollar however it is clear that fertilisers are more significant than the demand for bio ethanol. For every one Dollar price rise in fertilisers, the price of corn increases by 0,044 Dollars.

Lastly, excessive speculation was measured as an explanatory variable to the price of corn. Prior to the statistical regression model, excessive speculation as an investment strategy has been proven to be profitable. However, this highly convoluted investment plan is not deemed statistically significant to affect the price of corn. That being said, due to lack of data available, the variable is not a completely accurate measurement of excessive speculation since it measures the difference between the amount of derivatives bought and sold. The remaining derivatives could have been settled either in cash or physically making the variable an estimation rather than a precise measurement. Alternative variables that weren’t easily measurable such as weather, policy changes and other macroeconomic factors, were also presented as alternative factors that caused the price fluctuations and price rises in corn.

This paper emphasizes on the need for a better understanding of speculation and hopefully this paper can work as an incentive to further analyse the subject. A common understanding of what speculation is and its functions are essential for further research. Furthermore, this paper shows that excessive speculation, as defined in this study, is not a statistical cause for the price fluctuations in corn.
Therefore, once further research has analysed speculation, its implications on the price of corn can be retested. Lastly, this paper only measures the influence of five variables on the price of corn. In order to fully analyse the causes in the price fluctuations a calculable solution needs to be found on the alternative variables that were presented.
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Appendices

Appendix 1

Since January 2010 corn spot prices became more expensive than futures prices. This means that corn is a commodity that is currently extremely demanded, so much so that investors are willing to pay more for the commodity to hold it rather than buy it for later.
Appendix 2

Non-Commercial Weekly Futures & Options Contracts and Price of Corn

Commercial Weekly Futures & Options Contracts and Price of Corn
Appendix 3

See excel file: “Price analysis.xcl”