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Dynamics of the Oil Price

- The Relationship between Crude Oil and Refining Utilization Rates –

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ABSTRACT

(in progress!)

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1 INTRODUCTION

Over the past 25 years, the oil market has experienced many transitions and events that had significant impact on the oil price. In 1986 oil prices fell to about $12 per barrel caused by a decline in demand following the 1970s Energy crisis. Four years later, following the outbreak of the Gulf war, world oil prices doubled within two quarters to about $37 per barrel. The Asian crisis in 1998 has led to a decline in world oil prices to about $12 per barrel through a weakening demand in Asia and its reduction in imports. In the beginning of the new millennium, we have seen a persistent increase in oil prices, potentially seen as a delayed effect of expansionary monetary policies during 2001 to 2004, high world economic growth and consequently high world demand for oil. The oil price peaked in the summer of 2008 at a price of $140 per barrel, before it dropped two quarters later to $44 per barrel. This represents a decline of more than 70 percent, the biggest percentage drop ever seen over such a short period.[1]

Those events give rise to the question whether the oil market has lost its capacity and flexibility to deal with large disruptions in supply and demand. A gradual erosion of spare production capacity and an inflexible refining industry may be such triggers to reduce the market's ability to balance supply and demand.

In this paper we investigate on the relationship between crude oil prices and fundamental factors which we expect to impact the oil price. Following the most recent academic evidence, we believe in a fundamental model based on Kaufmann (2008). The model takes information on inventories, OPEC production capacity and OPEC's strategic decisions, refining utilization and futures prices to test the relationship between each of the factors with the oil price. The results in Kaufmann (2008) are in line with the economic rationale, except for the relationship of refining capacity utilization. A reduction in spare refining capacity is expected to rise oil prices because it lowers the market's ability to react flexible and offset a potential rise in demand. The results in Kaufmann (2008) imply the opposite. The author explains the counter-intuitive results by an increase in the spread between heavy and light crude oil prices. When refining utilization rates increase, heavy crude prices decline relative to light crude prices. The relative decline of heavy crude prices relative to light crude prices leads to an overall decline in the average price for crude oil. Further, the author explains that higher refining utilization rates lowers oil prices, because refineries use a bigger share of heavy cheap oil in their total product mix. Since light crudes can be processed at lower costs and sold at higher prices, they are usually processed first. When demand increases,

[1] The WTI Spot Cushing is the U.S. benchmark for premium crude oil.

refineries use more of the heavy crude to satisfy demand. The portion of heavy crudes in the total production mix increases, which in turn decreases the average price of crude oil.

With this argument, Kaufmann (2008) may only explain the negative sign of refining utilization for average crude prices. The argument, however, fails to explain a potential negative relationship between refining utilization and light crude prices. In this paper, we would like to examine exactly this relationship. We use the same model and the same data sources as explained in Kaufmann (2008). However, we change the dependent variable from an average oil price to a single-product light crude price, the WTI. The WTI is the U.S. benchmark for premium crude oil. Light crude prices usually follow price changes in the WTI, as Hagstromer and Wlazlowski (2007) point out. If we find significant evidence for a negative relationship between the WTI and refining utilization rates, we are bound to offer an explanation.

Central to this paper is the relationship between light crude prices and refining utilization rates. The goal of this paper is divided into two sub-goals: First, we identify and explain relevant fundamental variables that are expected to drive the oil price. We use this information to justify the selection of our model. We estimate the model and test the relationship between each of the variables and crude prices. The goal is to validate the findings in Kaufmann (2008) by using a single-product price. The focus is on the sign for refining utilization rates. Second, we present an alternative explanation for a negative relationship, which is not restricted to heavy or average crude prices. We build a model and formulate a hypothesis. Our goal is to find significant evidence that validates our hypothesis.

The paper is structured as followed: We first present the main features of crude oil markets in section 2. They determine the variables for our pricing equations which are described together with the data in section 3. In section 4 we present our results. In section 5 we conclude.

2 FUNDAMENTAL ANALYSIS OF THE OIL MARKET

This section analyses the oil market and determines fundamental factors that drive the oil price. The analysis serves to understand the specification of our models. The first part covers the spot market while the latter part sheds some light on the futures market.

2.1 The Spot Market

According to the ITF, the increase in global oil prices between 2003 and 2008 was mainly due to strong global demand growth rates which outpaced oil supply.[2] The following part analyses the demand and supply side of the oil market and its impact on global oil prices.

2.1.1 Demand

World economic growth is one of the most important factors to consider when projecting energy consumption levels. Changes in the rate of world economic growth affect the demand for oil, which in turn causes up- or downturns in the oil price. In the past century, oil consumption has steadily expanded. Between 1997 and 2007, OECD oil consumption grew by about 16 percent, reaching an all-time high of about 51 million barrels per day. In the aftermath of the credit crunch, oil consumption fell by about 14 percent.[3] The speed and the scope of the change in fundamentals may have contributed to the large correction in the oil price.

Many studies propose a link between oil prices and consumption levels (Pyndick (1979), Pesaran, et al. (1998), and Gately and Huntington (2002)). Krichene (2007) and Krichene (2008) focus in particular on the impact of monetary policy on oil demand and oil price. The authors find that decreasing interest rates and a depreciating exchange rate boost oil prices up, while increasing interest rates and an appreciating exchange rate depress oil prices.

Uncertainties in demand include not only changes in consumption related to GDP growth, currency values and interest rates, but also seasonal changes in consumption. It is known that demand for gasoline peaks in the summer due to the peak driving season. Demand for heating oil peaks in the winter. Fluctuations in the demand for those products have impact on the demand for crude oil. Girma and Paulson (1998) find strong seasonality in the demand for gasoline and heating oil. He also finds evidence for a seasonality effect in crude oil prices, which is less pronounced compared to gasoline due to the offsetting effect of heating oil.

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[2] Interagency Task Force on Commodity Markets (2008). "Interim Report on Crude Oil".

[3] The percentage changes are based on data accessed from the EIA database.

While OECD countries still account for the largest share of current energy consumption, the highest growth rates are expected in emerging markets.[4] China and India are the fastest-growing nations outside the OECD and they are projected to be key energy consumers in the future. Besides high GDP growth rates, many emerging markets use subsidies to control domestic fuel prices, which artificially boosts consumption levels.

There may be two main reasons for the large responses of the oil price to the overall economic health: One reason is that oil-intensive sectors tend to contract more than average in a downturn.[5] The other reason is that oil demand is known to exhibit high income elasticities and low price elasticities (Krichene (2007), Bentzen and Engsted (1993), Chevillon and Rifflart (2009) and Fattouh (2007)). This implies that any small change in demand would require large shifts in the oil price to clear markets. In the short-run, demand price elasticities range between -0.01 to -0.35 (Krichene (2006), Rice and Smith (1977)). Income elasticites are generally higher and range between 0.58 and unity (Krichene (2002), Philips (1972)).

2.1.2 Supply

Many researchers argue that growth rates in demand have outpaced growth rates in supply. After analyzing the demand side, we will now examine the supply side of the oil market and its implications on the oil price. Uncertainties in supply include changes in the level of inventories, crude production levels, OPEC cartel decisions, geopolitical unrest in countries with large oil reserves and possible interferences related to refining and transport.

2.1.2.1 Inventories

Most analyses of inventory decisions focus on the role of stocks in keeping negative impacts of supply disruptions low (Bohi and Montgomery (1982), Eckstein and Eichenbaum (1985)). The value of holding the physical asset, also called convenience yield, include benefits related to a smooth production when demand is fluctuating and facilitated scheduling of production and delivery. The convenience yield y is defined, so that[6]

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

[4] The U.S. Department of Energy, Energy Information Administration. "International Energy Outlook 2009". Washington DC.

[5] Lipsky, J. (2009). "Economic Shifts and Oil Price Volatility." The International Monetary Fund.

[6] Hull, J.C. (2009). "Options, Futures and Other Derivatives." Pearson Education: p. 118.

where

F_0 is the futures price at time zero, S_0 is the spot price at time zero, u is storage cost, r is the risk-free interest rate and T is the time of maturity. In times of high uncertainty, market participants may value to have the physical asset rather than the futures contract. The convenience yield increases. However, as stocks increase, oil prices eventually decrease, as the dependence on current production diminishes. The theory of storage tells that the marginal convenience yield falls at a decreasing rate as inventory increases. When inventories are low, small changes in the inventory may have a larger impact on the spot price than on the futures price. When inventories are high, the response of spot and futures prices may roughly be the same. Serletis and Hulleman (1994) tests the theory of storage on crude oil based on the Fama and French (1988) approach, which uses the relative variation of spot and futures prices. His results confirm the theory.

OECD stocks have traditionally been low, with record lows in 2003. Since oil demand has been growing over time, inventories have become tighter when perceived under the "days of supply" measure.[7] This measure of risk is normalized for demand. It takes into account, that stocks drop when demand drops and vice versa, but the risk measure remains unchanged.

Inventory levels have long been the only factor to explain oil price behaviour. Till the early 1990s, OPEC had sufficient excess production capacity sufficient excess capacity to keep markets calm. Oil prices could be explained using only data on inventory data (Ye et al. (2005)). Ever since, OPEC is producing near capacity. In the next section, we analyse the impact of little global spare production capacity on the oil price.

2.1.2.2 OPEC Spare Production Capacity

On the supply side, the main players in the oil market are OPEC, which currently represents about 45 percent of global oil supply, and non-OPEC producers. Non-OPEC countries generally operate at or near capacity and, thus, act as price takers.[8] OPEC, on the other side, has long maintained excess production capacity to control large shifts in the oil price. Since the early 1990s, OPEC's spare capacity has declined significantly. As a result, oil markets have tightened with low spare production capacity putting upward pressure on oil prices and leaving markets vulnerable to supply and demand disruptions.

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[7] Days of supply are calculated by inventories divided by the level of consumption.

[8] Berkmen, P., Ouliaris, S. and H. Samiei (2005). "The Structure of the Oil Market and Causes of High Prices." The International Monetary Fund.

Not only has spare production capacity declined, but it is also highly concentrated in a few top producing countries. Geopolitical risk surrounds many of those top producers, either because of actual supply disruptions (Iraq, Nigeria) or because of potential supply disruptions (Iran, Venezuela). Actual disruptions directly impact markets through a loss of physical barrels. Perceived supply disruptions increase uncertainty about future supply.

Barsky and Kilian (2004), Slaibi et al. (2006), Griffin (1985) and Gately and Kyle (1977) have empirically tested the relationship between OPEC spare production capacity and the oil price to be positive. An increase in OPEC capacity utilization tends to drive up prices. OPEC's policy is to offset the expected gap between demand and non-OPEC supply. As demand raises, the call on OPEC increases, OPEC production increases relative to capacity, utilization rates rise, which signals tightness in the market. Kaufmann et al. (2004) discuss in particular how inconsistencies in OPEC behaviour have impact on the oil price. The authors find a statistically significant relation between OPEC quotas, the degree to which OPEC adheres to these quotas and the oil price. Kaufmann et al. (2004) further assess claims that OPEC's ability to influence oil prices has diminished. The results show that OPEC still plays an important role in determining oil prices.

The supply of crude oil is known to be price-inelastic in the short-run (Krichene (2002), Krichene and Askari (2008)), i.e. the quantity supplied is not very responsive to changes in the crude oil price. The relatively low price-elasticity of supply may be due to little surplus production capacity and low inventory levels, which limits the ability in the short-run to bring new supplies online. If both supply and demand are not very responsive to prices, it requires large movements in prices to re-establish market equilibrium.

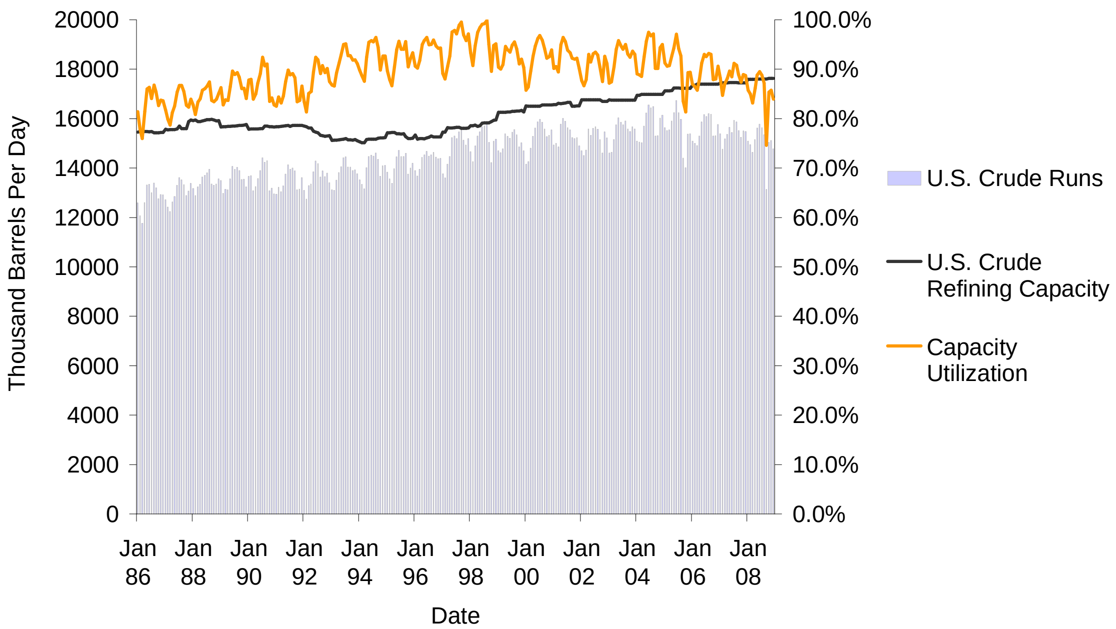
Inelasticity and tight market conditions have led to greater oil price reactions to actual or perceived disruptions in supply. Consequently, large and rapid oil movements in the past may not be inconsistent with fundamentals. During 2008, however, the market has seen an incomparable rise in the oil price that raises the question of additional forces. The discussions mainly circle around two factors, which may have contributed to the enormous swing in the oil price: declining refining utilization rates and increasing trading activity on the futures market. Both factors will be analyzed in the following sections.

2.1.2.3 The Refining Industry

The refining industry is a market by itself, with its own demand and supply factors. This section does not aim to give a full picture of the industry. The focus is on factors and relationships relevant for the research of this paper. Further, we are bound by data restrictions. A full time-series collection of refining utilization rates is available to us only for the U.S. market.

The biggest concentration of refining capacity is located in the U.S. Currently, it accounts for more than 20 percent of the crude oil distillation capacity worldwide with a production of 17,672 thousand barrels per calendar day.[9] During the 1980s and early 1990s, the total number of refiners in the U.S. has declined. Many small refineries with simple distillation had to close operations after a Federal subsidy system ended in 1981.[10] Refineries that remained in service improved on efficiency and enhanced their conversion (or upgrading) capacity. As a result, refining capacity stayed relatively stable over the past years.

Figure 1: U.S. crude oil refining capacity and inputs 1986 - 2008



Over the past years, utilization rates moved within a range of 99.9% in 1998 and 74.6% in 2008. In 2005, the U.S. refining industry was hit by the Hurricanes Katrina and Rita which resulted in a sharp and sudden decline in utilization rates. Utilization rates, which are calculated by crude refining capacity divided by crude runs, follow a seasonal demand

[9] The figures are taken from the EIA database.

[10] Energy Information Administration (na). "Oil Market Basics." The Energy Information Administration. The publication date is not available, but it is assumed to be 2005 based on the data used in the tables.

pattern. Demand in the U.S. is centered on gasoline, which peaks in the summer. Refining utilization rates, thus, are highest during the summer season.

Gasoline is a high value light product. Alongside with other light products, as liquid petroleum gases and naphtha, gasoline can be recovered at the lowest temperatures during the distillation process. Middle distillates, such as jet fuel and kerosene, need slightly higher temperatures, while heavy products, such as residuum, can be recovered at the highest temperatures. The yield of light products recovered per barrel crude oil during the distillation process depends on the quality of the crude oil. Lighter crudes have a higher yield of light products. Heavier crudes generate a lower yield of light products.[11]

The refining process can be classified into simple distillation and conversion (or upgrading). During simple distillation, the crude oil is heated and different products are recovered at different temperatures. High value light products are recovered at the lowest temperatures, i.e. the least amount of effort for refiners. Low value products need higher temperatures, hence, more effort for refiners. Refineries, which have conversion (or upgrading) capacity, have the additional advantage to transform low value products into higher value products via further processing. Conversion refineries are less dependent on the quality of the input. They are able to increase the yield of high value light products even with heavy crudes as their input. This makes conversion refineries more attractive, relative to simple distillation refineries. As a result, conversion refineries in the U.S. are usually running at full utilization. Simple distillation refineries, which do not always run at capacity, represent the spare refining capacity in the United States.[12] We learned that demand in the U.S. is centered on light products, such as gasoline. With simple distillation as the only spare capacity, demand from refineries may be more focused on light crude oil, as it delivers a high yield of light products. Heavy crude as input would result in a high yield of heavy products, where there is few demand for by the market. Hence, spare refining utilization may be more sensitive to the price of light crude oil, than to the price of heavy crudes.

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[11] Energy Information Administration (na). "Oil Market Basics." The Energy Information Administration. The publication date is not available, but it is assumed to be 2005 based on the data used in the tables.

[12] Purvin&Gertz (2008). "Study on Oil Refining and Oil Markets." Prepared for the European Commission: p.25.

Refiners are intermediaries between the crude oil market and the refined product market. Refiners acquire crude oil, process it and sell refined products. The gross refinery margin, also called crack spread, is the difference between crude oil prices and product prices.[13]

Figure 2: Time-series of the WTI and Gasoline gross margins

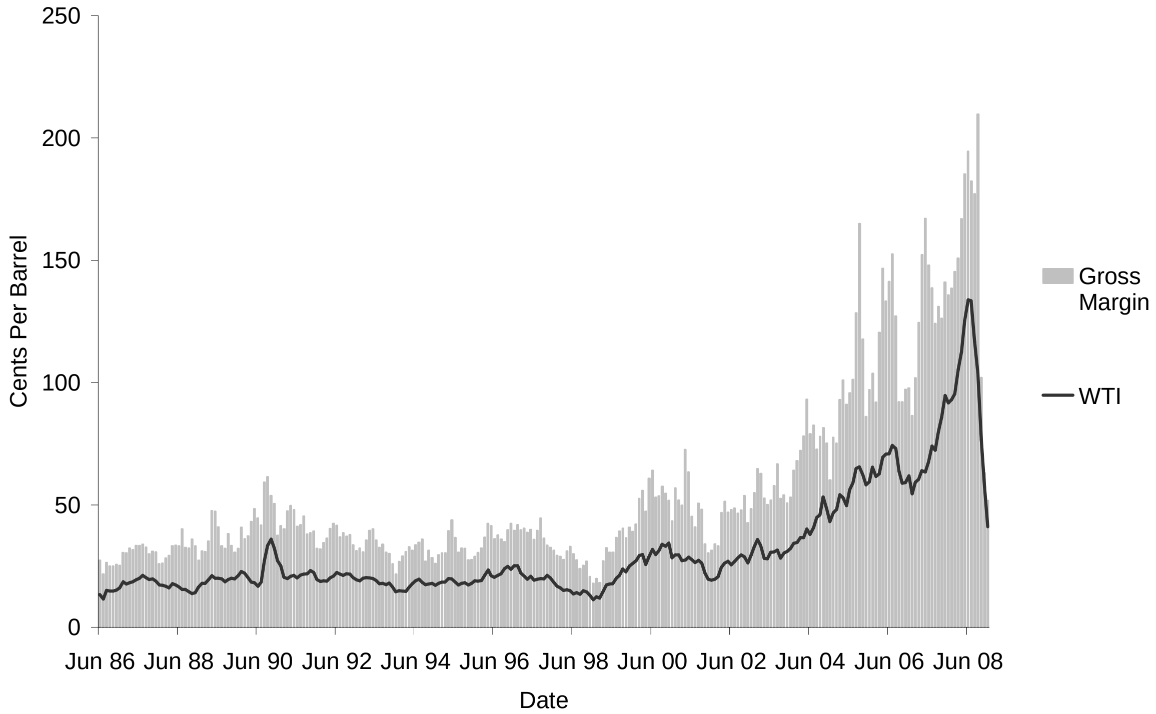

Figure 2 gives a picture of the historical development of the West Texas Intermediate (WTI) and the crack spread for motor gasoline. The WTI, which is the U.S. benchmark for premium crude oil, has a relatively high natural yield of gasoline.[14] Motor gasoline is therefore a suitable benchmark to calculate the crack spread in our case.

Profits in the refining industry are tied directly to the crack spread.[15] A larger crack spread is expected to increase profitability, which may be an incentive for refiners to ramp up production. Our question here: May we use the crack spread to explain the relationship between crude prices and refining utilization rates? To approach this question, we first

[13] Energy Information Administration (2002). "Derivatives and Risk Management in the Petroleum, Natural Gas, and Electricity Industries." The Energy Information Administration.

[14] Energy Information Administration (na). "Oil Market Basics." The Energy Information Administration. The publication date is not available, but it is assumed to be 2005 based on the data used in the tables.

[15] Energy Information Administration (2002). "Derivatives and Risk Management in the Petroleum, Natural Gas, and Electricity Industries." The Energy Information Administration.

examine crack spreads by analyzing the relationship between crude and product prices and second we examine the relationship between crude prices and utilization rates.

The relationship between crude and product prices

The crack spread is the difference between the price of crude oil and the price of refined products. Kisselgoff (1979) was one of the first to examine the relationship between the crude oil and the product market. He finds that when crude prices rose in 1974, the percentage margin for refineries declined significantly. Razavi and Fesharaki (1984) test the short-run relationship between the crude oil and the product market. They find that a $1.00 change in the crude price will impact the product price by only $0.51. Those results imply that a one-unit decrease in crude prices is linked to a half-unit decrease in product prices. The crack spread for refiners increases when crude prices decrease. On the other hand, a one-unit increase in crude prices relate to a half-unit increase in product prices. The crack spread decreases when crude prices increase. Asche et al. (2003) tests the short-run and the long-run relationship. He proposes that in the long-run, changes in crude prices feed through to product prices, while the reverse is not true. In the short-run, the feedback mechanism works in both ways. Gjolberg and Johnsen (1999) also find a long-run equilibrium price relationship between crude oil prices and product prices.

The relationship between crude prices and utilization rates

Some experts intuitively believe in a positive link between utilization rates and crude oil prices.[16] The motivation centers around the concept that a lack of spare refining capacity nurtures perceptions of tightness in future supply, which puts pressure on the oil market. Empirical tests, however, show a significant negative relationship. Kilian (2007) examines the relationship between crude oil prices and refining utilization rates. His empirical results indicate a negative relationship. Kaufmann (2008) also carries out empirical tests on the relationship. He finds significant evidence that higher refinery utilization rates reduce the average price of crude oil. He explains that higher refinery utilization rates reduce the average crude price because the spread between heavy and light crude prices widens. On a relative basis, heavy crude prices decline more than light crude prices. As a result, the average price of crude oil declines. The author further argues that higher refining utilization rates lowers oil prices, because refineries use a bigger share of heavy oil. Light crudes are usually processed first, because they can be processed at lower costs and sold at higher prices. With increasing demand, refineries use more of the cheaper heavy crude oil. The

[16] Purvin&Gertz (2008). "Study on Oil Refining and Oil Markets." Prepared for the European Commission: p.27.

share of heavy crude oil in the total production mix increases and the average price of crude oil decreases.

In this paper, we propose an alternative explanation for the negative relationship between refining utilization rates and crude prices. We hypothesize, that crack spreads increase when crude oil prices decline and consequently utilization rates go up. Reversely, crack spreads go down when crude prices incline and utilization rates decrease. We may have strong evidence in favour for our hypothesis, if we find a significant positive relationship between the crude and the product price, which is less than unity. A one unit decrease in crude prices that comes with a less-than-one-unit decrease in product prices implies that crack spreads for refiners increase. Crack spreads are assumed to be a direct indicator of the profitability in the refining industry. Hence, we may argue that refining utilization rates increase when crude prices decrease, because profitability, proxied by the crack spread, increases. The benefit of our explanation compared to the explanation given in Kaufmann (2008) is that our hypothesis is not restricted to an average crude price. Even though, we debut our tests on light crude prices, the hypothesis may work for heavy as well as average crude prices.

In the following section we give a short overview of the futures market. It sets out how we can derive information from the futures market to explain crude oil prices.

2.2 The Futures Market

A futures contract is an agreement between two parties to buy or sell a given amount of an asset at a fixed time in the future for a fixed price.[17] As an example, the New York Mercantile Exchange (NYMEX) West Texas Intermediate (WTI) April 2010 oil contract is an agreement to deliver 1000 barrels of WTI crude oil at Cushing, Oklahoma during April 2010.[18] The buyer and the seller agree to a price when they enter into the contract. According to the Commitments of Traders (COT) reports, published by the U.S. Commodity Futures Trading Commission, activity in the crude oil futures market has more than tripled between 2003 and 2007, when total open interest peaked at about 1.5 million.[19] In 2009, total open interest fell to about 1 million and has slightly been picking up lately.[20]

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[17] Hull, J.C. (2009). "Options, Futures and Other Derivatives." Pearson Education: p.6.

[18] CME Group website. "Energy Products Contract Specifications."

[19] Open interest is the total of all futures contracts entered into and not yet offset by exercise.

[20] The U.S. Commodity Futures Trading Commission. "This Month in Futures Markets – February 2010."

Futures prices in commodity markets are often determined by the spot price plus an additional term, the cost of carry. The cost-of-carry represents the cost of owning the physical commodity. Costs may occur through storage and/or opportunity cost of capital. Consumption commodities, such as crude oil, exhibit an additional factor in the pricing equation of futures, which is often referred to as the convenience yield. The convenience yield represents the benefit of owning the physical commodity. Benefits include, for example, the opportunity to profit from temporary shortages or the advantage to keep a production process smooth and running. The convenience yield signals the market's expectation about the future availability of the commodity. The greater the possibility of future shortages, the higher will be the convenience yield.[21]

The pricing equation for a storable consumption commodity, such as crude oil, may be expressed by the following equation:[22]

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

where

F_0 is the futures price at time 0, S_0 is the spot price at time 0, r is the interest rate, u are the storage costs, y is the convenience yield and T is time to maturity.

The term structure of futures prices (see figure 3) reflects the relationship between the price and the maturity of the futures. When the price declines as the time to maturity increases, the market is often said to be in backwardation. When the futures price increases as the time horizon increases, the market is said to be in contango. In times of backwardation, the futures price is below the current spot price. In times of contango, the futures price is above the current spot price.

Conditions on the futures market may switch between contango and backwardation. With few exceptions, oil futures markets have been mostly in backwardation.[23] This phenomenon may be linked to the concept of the convenience yield. The convenience yield is the benefit of owning the physical asset and it measures the market's expectations about the future availability of the commodity. The higher the perceived risk of future shortages in supply, the higher the convenience yield. If the convenience yield are high enough and exceed the cost

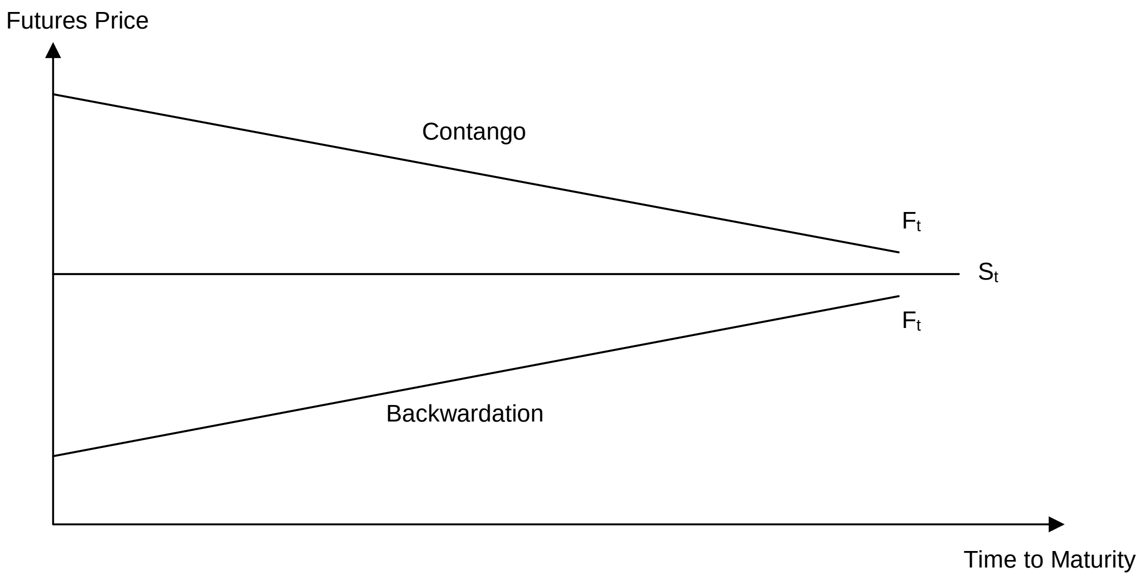
[21] Hull, J.C. (2009). "Options, Futures and Other Derivatives." Pearson Education: p. 117/118.

[22] Hull, J.C. (2009). "Options, Futures and Other Derivatives." Pearson Education: p. 118.

[23] Interagency Task Force on Commodity Markets (2008). "Interim Report on Crude Oil", p.24.

of carry, then future markets are likely to shift into backwardation. With a low or negative convenience yield, future markets are likely to stay in contango.

Figure 3: The term structure of futures prices



We apply this concept to our analysis. We believe that markets react differently in different states. We define two states of the market: Normal market conditions and abnormal market conditions. Under normal conditions, markets may react according to fundamentals. Under abnormal conditions, markets may respond more sensitive to disruptions in supply or demand, whether actual or perceived, than it would be the case under normal conditions. We derive information on the state of the market from the futures market. Backwardation indicates that market participants have perceptions of possible shortages in the near future. In those times, markets may react more sensitive to any actual or perceived disruption in supply or demand. Backwardation is our indicator for abnormal markets. Contango, on the other hand, indicates that market participants are confident about sufficient supply in the near future. Market reactions may follow fundamentals. Contango is our indicator for normal markets.

3 DATA AND METHODOLOGY

We collect two data sets. The first data set consists of quarterly observations on the WTI spot price, OECD crude oil stocks, OECD crude oil demand, OPEC crude oil production capacity, OPEC crude oil production, OPEC quotas, OPEC's share of global oil production, OPEC countries' crude oil production allocations, U.S. refining utilization rates, the near-month and the four-month futures contract price. This data set is used to estimate the long-term and short-term relationship between crude oil and its fundamental factors. We chose the WTI spot price as our dependent variable for two reasons: First, we are interested in the price behavior of light crude oil, in particular the relationship between light crude oil and refining utilization. Second, we are bound to refining data on the U.S. market. The WTI is the U.S. benchmark for light crude oil. With the exception of OPEC production capacity, the data can be accessed online from the database of the Energy Information Administration. For OPEC production capacity we received annual values from Erik Kriel of the EIA. Quarterly observations for OPEC production capacity are interpolated by assuming a constant growth rate between annual observations. The data set starts in Q1 1986 and ends in Q4 2008. We restrict our analysis to the post-1986 period, when market forces regained power after OPEC adjusted to a more market-oriented pricing conduct (Fattouh (2007)). In total, we have 92 observations.

The second data set includes annual observations on the WTI spot price, U.S. conventional gasoline prices, U.S. GDP figures, U.S. long-term interest rates, refining utilization rates and absolute profit numbers of the oil industry. The data set is used to estimate the relationships between (1) crude and product prices, (2) crack spreads and refinery utilization rates and (3) crack spreads and profits in the industry. The ultimate goal is to provide an explanation for the negative relationship between light crude oil prices and refining utilization rates via the crack spread. The WTI spot price is our benchmark for light crude oil prices. The U.S. conventional gasoline price is an average of the three U.S. benchmark prices for conventional gasoline, which include the New York Harbor, the U.S. Gulf Coast and the Los Angeles, CA conventional gasoline regular spot price. The U.S. conventional gasoline price is our proxy for light product prices for three reasons: First, light crude oil has a relatively high yield of light products during simple distillation. Second, simple distillation is assumed to be the only spare refining capacity in the U.S., as conversion refineries are usually running at full capacity. Third, the U.S. market is centered on the demand for light products, such as gasoline. The U.S. GDP is measured via the income approach. The long-term interest rates are proxied by rates on the 10 year U.S. government bond. The absolute profit in the oil industry is an average of the top five players in the oil industry, including BP, ExxonMobil, Total 5, Royal Dutch/Shell and Chevron. All five companies are integrated players in the oil market, i.e. they are active in the upstream (oil extraction) as well as downstream business (refining and marketing).[24] The data set starts in 1986 and ends in 2008. We chose to collect annual observations for the second data set in order to be consistent. The data on absolute profits in the oil industry is available to us on an annual basis only. The hypotheses, which we test with the second data set, are interlinked. Hence, we apply annual data consistently on all equations. GDP figures and interest rates are collected from Datastream. Absolute profits of the oil industry are collected from the OPEC Statistical Bulletin 2008. All other data is collected from the EIA website.

The methodology is split into two parts. First, we present the crude oil pricing model to estimate the long-term and short-term relationship between crude oil and fundamental variables. We use the first data set for this part of our analysis. The focus is on the relationship between light crude oil and refining utilization. According to previous research, we expect a negative relationship. Second, we propose a model to explain a potential negative relationship. We call it the crack spread model. The concept is based on the crack spread, its dynamics and how it relates to refining utilization rates. We apply the second data set for this part of the analysis.

The Crude Oil Pricing Model

Based on our analysis of the oil market, we believe in a crude oil pricing model that is established in Kaufmann (2008). We amend the test in that we use the WTI spot price instead of an average crude price and we use an updated data set. The equation is defined as:

$$price = c + \beta_2 days + \beta_3 caputil + \beta_4 caputil^2 + \beta_5 caputil^3 + \beta_6 refine + \beta_7 nymex + \varepsilon \quad (1)$$

where

price is the WTI spot price. Days is the length of forward consumption of OECD crude oil stocks. It is the amount of OECD stocks of crude oil divided by OECD demand for crude oil. Caputil is a modified proxy for the utilization of OPEC production capacity. The values are calculated by dividing OPEC production by OPEC capacity, multiplied by OPEC's share of global oil production, and divided by the rate that OPEC cheats on its quota. The cheat rate is the difference between OPEC production and OPEC quota, divided by OECD oil demand. The cheat rate is important in that it may increase utilization but reduce oil prices because

[24] The U.S. Department of Energy, Energy Information Administration. "Ranking of U.S. Refineries."

supply increases. Refine is the US refining utilization rate. Nymex is the difference between the four-month futures contract for the WTI and the near-by futures contract for the WTI.

Caputil is modeled in a non-linear fashion with two inflection points. The two inflection points define the normal operating range. Within this range, changes in utilization rates are assumed to have a small impact on prices. Outside the normal operating range, prices are expected to increase exponentially. The assumption behind the non-linear specification is that producers prefer to stay within the normal operating range. Well below the range, fixed costs may be higher than the contribution margin.[25] Well above the range, high utilization may impede maintenance service to ensure the long-term viability of the production site.

We use the Augmented Dickey Fuller test statistic in order to test for stationarity in the time series properties of the variables (Dickey and Fuller, 1979). With non-stationary data, blind application of OLS would lead to inefficient coefficient estimations.[26] One way to tackle the problem is by taking the first difference. This approach, however, can provide us only with the short-run relationship. We are interested in the long-run equilibrium relationship as well and take a different approach. We apply a well established cointegration test by Engle and Granger (1987), who set out that a linear combination of non-stationary data series can still be stationary. The authors propose a unit root test on the residuals of the linear estimation. In case the null of no unit root can be rejected, the variables are said to be cointegrated and we can assume a long-term relationship. If the variables are cointegrated, we can then apply an error correction model to analyze the short-run dynamics of the equation.

We test equation (1) for serial correlation in the error correction term. Serial correlation in the residuals is often connected to a dynamic structure in the dependent variable which has not been captured by the model yet.[27] To account for serial correlation, we modify equation (1) in that we include leads and lags of first differences of the regressors (Stock and Watson (1993)):

[25] The contribution margin is the difference between the price and the variable costs. It is the amount which is available to cover fixed costs.

[26] Asteriou, D. (2006). "Applied Econometrics: A modern approach using EViews and Microfit." Palgrave Macmillan: p. 330.

[27] Brooks, C. (2008). "Introductory econometrics for finance." Cambridge University Press: p. 153.

$$price_t = B'X_t + \sum_{j=-J}^{j=J} \eta_j \Delta days_{t-j} + \sum_{j=-K}^{j=K} \lambda_j \Delta caputil_{t-j} +$$

$$\sum_{j=-M}^{j=M} \gamma_j \Delta caputil^2{}_{t-j} + \sum_{j=-N}^{j=N} \theta_j \Delta caputil^3{}_{t-j} + \sum_{j=-P}^{j=P} \sigma_j \Delta refine_{t-j} + \sum_{j=-R}^{j=R} \omega_j \Delta nymex_{t-j} + \xi_t \quad (2)$$

where

$$B = [c, \alpha, \beta, \chi, \delta, \phi, \varphi], X = [1, days_t, caputil_t, caputil^2{}_t, caputil^3{}_t, refine_t, nymex_t]$$

To test for cointegration, we follow the Engle and Granger two-step procedure. The first step is to ensure that all variables are non-stationary in their levels. The second step involves a stationarity test on the residuals. We perform an ADF test on the error correction term. The residuals are saved from the OLS estimation of equation (2). If we can reject the null that the residuals contain a unit root, the equation can be considered to be cointegrated and a valid long run relationship exists between the variables.

In case the equation is cointegrated, we can use the residuals to estimate an error correction model (ECM) and analyze the short-run dynamics of the equation. We estimate a simple ECM via OLS, where the first difference of the dependent variable of equation (2) is regressed against the lagged error correction term. The adjustment rate is the coefficient of the lagged error-correction term. It represents the speed by which the deviation from the long-term equilibrium in the dependent variable is being corrected in each period.

Cointegration relationships can also be tested using the full information maximum likelihood estimator of a vector error correction model developed by Johansen (1988). The Johansen approach is useful when there are more than two variables in the model. In this case, there is a chance that there is more than one cointegrating vector, assuming oil prices are not strictly endogenous. Cointegration testing after Johansen extends a single equation cointegration model to a multivariate one. The Johansen method is known to be sensitive to the lag length. A Vector Autoregression (VAR) is estimated to select the optimal lag length of the model which minimizes the SIC. Before the test, one needs to specify the cointegration equation. EVIEWS provides six different options with different degrees of freedom. The Pantula Principle is a method which can help to identify the right option. The method suggests to carry out the cointegration test for each of the options and compare the trace statistic from the most restrictive option (intercept in the cointegration equation, but no intercept in the VAR) to the least restrictive (intercept in the cointegration equation, and intercept in the VAR). One selects the option at which the null of no cointegration cannot be rejected for the first time. If the null of no cointegration is rejected for all options, we may assume no long-term relationship between the variables. If there is a cointegration relationship for one or more linear combinations, we can assume a long-term connection and estimate the ECM to examine the short-term dynamics of those relationships.

In the following, we propose an alternative explanation for a potential negative relationship between crude oil prices and refining utilization rates. We call it the crack spread model. The concept is based on the crack spread, its dynamics and how it relates to refining utilization rates.

The Crack Spread Model

In this section, we analyze the crack spread and its relationship to refinery utilization rates. Our ultimate goal is to find an explanation for the negative relationship between crude oil prices and refining utilization rates. We carry out the examination in three steps: First, we test the relationship between the crack spread and crude oil prices. The crack spread is the gross margin for refiners. Our hypothesis is that an increase in crude prices leads to a decrease in the crack spread, and vice versa (hypothesis 1). Second, we test for a link between the crack spread and utilization rates. We hypothesize that a decrease in the crack spread is directly linked to a decrease in utilization, and vice versa (hypothesis 2). We assume that crack spreads are a direct indicator of profitability. We test this assumption in a third step, where we examine the relationship between the crack spread and profits in the industry. We hypothesize a positive link between the crack spread and profitability (hypothesis 3). Lower crack spreads are expected to feed directly through to lower profitability. If we combine the three hypotheses, we may have an explanation for the negative relationship between crude oil prices and refining utilization rates. When crude prices incline, crack spreads decline. If profits are a direct indicator of profitability in the industry, then a decline in crack spreads limits the incentive to ramp up refining utilization. Reversely, when crude prices decline, crack spreads incline, which increases the incentive for refiners to ramp up refining utilization. In the following, we explain the models to test our hypotheses.

In hypothesis 1, we examine the link between crack spreads and crude prices. In order to avoid crude prices to appear on the left hand side as well as right hand side of the equation, we estimate the following relationship:

$$gasoline = c + \beta_2 wti + \beta_3 gdp + \beta_4 r + \varepsilon \qquad (3)$$

where

Gasoline is the average of the three U.S. benchmarks for conventional gasoline prices.[28] Gasoline is our proxy for light refined product prices. According to Razavi and Fesharaki (1984), refined prices increase when either costs increase or when demand for refined products increase. Costs incorporate the price for crude oil and the interest costs. We take the WTI as a proxy for light crude prices and we take the rate on the 10 year U.S. government bond as our proxy for long-term interest costs. Demand for refined products is proxied via U.S. GDP numbers. We focus on the relationship between Gasoline and the WTI. We hypothesize that the relationship is positive, however, less than unity. If the WTI decreases by one, then Gasoline decreases by less than one. Crack spreads increase. If the WTI increases by one, Gasoline increases by less than one. Crack spreads decrease. In other words, the crack spread decreases when the WTI increases. Reversely, crack spreads increase when the WTI decreases.

In hypothesis 2, we test the relationship between refining utilization and the crack spread and estimate the following equation:

$$refine = c + \beta_2 spread + \varepsilon \tag{4}$$

where

Spread is the difference between the WTI spot price and the U.S. conventional gasoline price. We hypothesize a positive relationship between refinery utilization rates and the crack spread. We assume in our hypothesis, that changes in the crack spread feed directly through to profitability in the industry. Hence, a rising crack spread would serve as an incentive for refiners to increase utilization. A falling crack spread would be an incentive to limit utilization.

In hypothesis 3, we test the assumption that crack spreads are a direct indicator for profits in the industry. We estimate the following equation:

$$profit = c + \beta_2 spread + \varepsilon \tag{5}$$

where

Profit is a measure of absolute profits of the oil industry. We would prefer a profit measure of the refining industry itself, but are bound by data restrictions. Nevertheless, we find this measure to be an adequate indicator for profitabitlity in the refining industry, since the top players in the U.S. refining industry are integrated players. We hypothesize a positive

[28] The three U.S. benchmark prices for conventional gasoline include the New York Harbor, the U.S. Gulf Coast and the Los Angeles, CA conventional gasoline regular spot price.

relationship between Profit and Spread. A positive relationship implies, that higher crack spreads increase profitability for refiners, which is an incentive to increase utilization.

If we link all three hypotheses, we may explain the negative relationship between crude prices and refining utilization rates. A decline in crude oil prices increases the crack spread (hypothesis 1). An increase in the crack spread leads to an increase in refining utilization rates (hypothesis 2), because higher crack spreads promise higher profits (hypothesis 3), which serves an incentive for refiners to ramp up utilization. The same argumentation applies to the case in reverse.

We debut our tests on light crude oil. As spare refining capacity in the U.S mainly consists of simple distillation, we believe that refiners are most interested in the price of light crude oil, which has a relatively high yield of high demand light products, such as gasoline. Nevertheless, the crack spread model is constructed in a way that it may be applied to heavy or average crude oil as well.

4 EMPIRICAL RESULTS

This section summarizes our results. The structure follows the order set out in the methodology. First, we summarize the findings related to the crude oil pricing model. Second, we analyze the results related to the crack spread model.

The Crude Oil Pricing Model

We test for stationarity in our data series, since blind application of OLS would lead to inefficient coefficient estimations. We perform ADF tests on all the variables. Days and all Caputil series are I(0). Refine is I(2). The other variables are I(1).

Table 1: ADF test results for unit roots

ADF Test in levels							
	Days	Caputil	Caputil2	Caputil3	Refine	Nymex	Price
t-Statistic	-4.86**	-8.06**	-9.34**	-9.50**	-1.56	-3.20	2.46
p-Value	0.0001	0.0000	0.0000	0.0000	0.4992	0.0234	1.0000
ADF Test in difference							
	Δ(1) Days	Δ(1) Caputil	Δ(1) Caputil2	Δ(1) Caputil3	Δ(2) Refine	Δ(1) Nymex	Δ(1) Price
t-Statistic	-8.86**	-7.50**	-10.08**	-11.35**	-7.35**	-8.46**	-12.23**
p-Value	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001

** H_0 (series has a unit root) can be rejected at the 1% confidence level.

Serial correlation in the error correction term of equation (1) indicates a dynamic structure which has not been captured by the model yet. To test for serial correlation we save the residuals from the OLS estimation of equation (1) and apply the Breusch-Godfrey test on the series. The effectively zero probability of the test statistic strongly indicates serial correlation in the residuals.

Table 2: Breusch-Godfrey test results of equation (1)

Breusch-Godfrey Serial Correlation LM Test:		
	Test statistic	Probability value
Obs*R-squared	73.48825	0.0000

This implies that there is a richer structure in the dependent variable and more information from the sample can be used to explain this structure. We include leads and lags to account for serial correlation as specified in equation (2). Based on the SIC, the AIC and the significance of the regression coefficients, we select an optimal length of four leads and lags for our model. The regression results are summarized in table 3.

Table 3: OLS estimation results of equation (2)

Dependent variable: Price

Number of observations: 83

	Point estimates						
	C	Days	Caputil	Caputil2	Caputil3	Refine	Nymex
Our results	1202.63**	-7.01**	4.69**	-1.25E-01*	4.95E-04+	-6.68**	13.47**
Results Kaufmann (2008)	382.80**	-2.06**	2.46**	-1.01E-01**	7.84E-04**	-2.09**	3.25**

** significant at the 1% level, *significant at the 5% level, +significant at the 10% level

We test for collinearity between the variables. In particular for the three variables of Caputil, $Caputil^2$ and $Caputil^3$ we could expect high correlation. In case of high correlation between variables, the system is unable to identify the effects of the variables separately. We check for low individual t-statistics combined with a high overall F-statistic as an indication of collinearity.[29] The t-statistics are relatively high and the F-statistic is effectively zero.

We follow the two-step Engle and Granger procedure to test for cointegration. First, we test for stationarity on the data series. Unit root tests indicate I(1) for all variables, except Days and Caputil, which are I(0). However, even in the case where we have a mix of I(0) and I(1) variables, a cointegration relationship might well exist.[30] In step two, we estimate equation (2) via OLS and perform an ADF test on the error correction term. We can reject the null that the error correction term has a unit root. The residuals are stationary. Hence, we can assume a cointegrating relationship between the variables.

[29] Kawakatsu, H. (1998). “A computer handbook using EViews to accompany Econometric models and econometric forecasts, fourth edition, Pindyck and Rubinfeld.” Irwin/McGraw/Hill: p. 34.

[30] Asteriou, D. (2006). "Applied Econometrics: A modern approach using EViews and Microfit." Palgrave Macmillan: p. 344.

We also test for cointegration using the multivariate cointegration model developed by Johansen (1988). This approach may be preferred when there are more than two variables in the model, since more than one cointegration relationship may exist. In a first step, we estimate the VAR to identify the optimal lag length for our model. We select a VAR with two lags in the levels. In a second step, we apply the Pantula Principle to specify the cointegration equation. We allow for an intercept for the cointegration equation, but no intercept in the VAR. In a third step, we test for cointegration. Both, the trace statistic and the Max eigenvalue test statistic, indicate two cointegration relationships. The existence of cointegrating relationships undermines the findings from the Engle and Granger test. The large number of variables in our model, however, makes it difficult to identify the two cointegrating relationships using the full information maximum likelihood estimator.

The cointegration results suggest that the variables are integrated. Thus, we may apply OLS to estimate the long-run equilibrium relationship. The results are summarized in table 3. All coefficients are highly significant and the signs are in line with Kaufmann (2008). The sign of Days is negative. When stocks increase, the oil price decreases, because the reliance on current production decreases. Capacity utilization is modeled in a nonlinear fashion. The idea behind is that producers prefer to stay within a specific production range. Below this range, contribution margins may be not enough to cover fixed costs. Above this range, high utilization may interfere with maintenance services to ensure the viability of the site. The signs of Caputil and $Caputil^3$ are positive, while $Caputil^2$ has a negative sign. Those results imply that refiners are reluctant to increase production outside the range. The oil price increases. Inside the range, increasing production utilization reduces the oil price because supply increases. The coefficient on NYMEX is positive. NYMEX is the difference between the four-month and the near-month futures contract for WTI. Markets are in backwardation, when near-month futures prices are below far-month futures prices. The positive coefficient for NYMEX indicates that backwardation has a positive effect on crude spot prices, while contango has a negative effect. This is in line with our expectation. Backwardation is our proxy for abnormal markets, in which market participants may react more sensitive to changes in supply and demand. The significance of the regression coefficient supports the hypothesis that there is a time-varying effect in crude oil prices, based on the state of the market. The coefficient associated with refinery utilization rates is negative. This implies a negative relationship between the WTI, which is the U.S. benchmark for light crude oil, and refining utilization rates. Kaufmann (2008) argues in his paper, that the negative effect is associated with a change in the crude oil product mix and a change in the price spread between light and heavy crude oil. This argument may explain the negative relationship between refining utilization and average crude prices, which are sensitive to relative changes in the product mix and the spread between heavy and light crudes. However, it cannot explain the negative relationship for a single-product light crude oil price, such as the WTI. We are bound to offer an alternative explanation, which we refer to as the crack spread model. The hypothesis has already been discussed in the methodology part. The findings related to the crack spread model will be summarized in the latter part of this section.

To check for the short-run relationship between the variables, we apply an ECM and estimate the adjustment rate. The adjustment rate is negative, but insignificant. The statistical significance of the adjustment rate indicates that prices are affected by disequilibrium between the oil price and the right hand side variables. We eliminate the last 8 observations in our data to test the effect of the economic crisis. We find that applying the same ECM, we obtain a negative adjustment rate, which is significant at the 10% confidence level. We account for seasonality and the economic crisis, and carry out the ECM using the full time span until Q4 2008. We obtain an adjustment rate that has the expected negative sign with significance at the 10% confidence level. The point estimate indicates that 24 percent of the difference between the equilibrium and observed price for crude oil is eliminated within one quarter.

Table 4: Test results of the ECM

Dependent variable: Δprice

Number of observations: 83

	C	e(-1)	Q1	Q2	Q3	Crisis
Point Estimates	1.52	-0.24	-2.89	-0.38	-0.68	9.27
p-Value	0.1354	0.0815	0.0447	0.7830	0.6343	0.0003

Further we check for robustness of the model by applying diagnostic tests on serial correlation and heteroskedasticity. We perform the Breusch-Godfrey serial correlation test. The results are contradictory. The F-test statistic is not significantly different from zero. The null of no serial correlation cannot be rejected. The chi-square test statistic is significantly different from zero at the 1% level. This indicates the presence of serial correlation. We carry out a Durbin Watson test. As a rough guide, values of the DW statistic of less than 1.3 may indicate autocorrelation.[31] The DW test result does not suggest serial correlation. Heteroskedasticity deals with the fact that the variance of the error terms may vary over

[31] Griffith (1930), Mathematical introduction to economics, New York: McGraw-Hill: p. 183.

time.[32] First, we apply the Breusch-Pagan test on the residuals. We cannot reject the null that the error terms are constant over time. We also perform the White test, which confirms the findings from the first test.

Table 5: Test results on serial correlation and heteroskedasticity

Breusch-Godfrey Serial Correlation LM Test:		
	Test statistic	Probability value
F-statistic	1.53	0.241538
Obs*R-squared	11.00	0.004102

Durbin-Watson Test:		
Durbin-Watson statistic	1.45	

Heteroskedasticity Test: Breusch-Pagan-Godfrey:		
	Test statistic	Probability value
F-statistic	0.51	0.9803
Obs*R-squared	48.14	0.8646

Heteroskedasticity Test: White:		
	Test statistic	Probability value
F-statistic	0.58	0.9509
Obs*R-squared	48.59	0.8061

The Crack Spread Model

The crack spread model may serve as an explanation for the negative relationship between crude oil prices and refining utilization rates. The crack spread model consists of three interlinked hypotheses. To test the strength the theoretical hypotheses, we statistically

[32] Griffith (1930), Mathematical introduction to economics, New York: McGraw-Hill: p. 147.

examine equations (3), (4) and (5). We use the second data set, which includes annual observations from 1986 to 2008 and estimate the linear form of the equations via OLS. We correct for stationarity by taking the differenced data. The test results are summarized in this section.

Our first hypothesis states a positive relationship between crude oil prices and refined product prices. Further, we expect the relationship to be less than unity, where a one-unit change in crude prices leads to a less than one-unit change in product prices. This would imply that crack spreads decrease when crude prices increase, and crack spreads increase when crude prices decrease. In other words, the incentive for refiners to ramp up utilization increases when crude prices decrease, because of higher expected gross margins (crack spreads). We estimate equation (3). The results are highly significant and confirm our hypothesis. If the WTI increases by one, gasoline increase by only 0.71. Hence, the crack spread decreases when the WTI increase. If the WTI decrease by one, gasoline prices decrease by only 0.71. The crack spread increases, when the WTI decreases. Stability tests confirm stationarity in the residuals. We cannot find any evidence of serial correlation and heteroskedasticity.

Table 6: Test results on hypothesis 1 of the Crack Spread Model

Dependent Variable: Gasoline

Number of Observations: 22

	C	WTI	GDP	R
Point Estimates	-9.20**	0.71**	2.06E-05**	1.78
p-Value	0.0049	0.0000	0.0039	0.2307

** significant at the 1% level, *significant at the 5% level, +significant at the 10% level

We find strong empirical evidence in favour for our first hypothesis. An increase in the crack spread, which is the gross margin for refiners, may be an incentive for refiners to ramp up utilization. We test this argument with our second hypothesis, which states a positive link between crack spreads and refining utilization rates. It is expected that increasing crack spreads serve as an incentive for refiners to ramp up utilization. We estimate equation (4). The sign of the coefficient is positive and correct. The p-value, however, is statistically insignificant.

Table 7: Test results on hypothesis 2 of the Crack Spread Model

Dependent Variable: Refine
Number of Observations: 21

	C	Spread
Point Estimates	-0.17	0.02
p-Value	0.7268	0.5949

Since we cannot find a significant direct link between the crack spread and refining utilization rates, we test an indirect link between crack spreads and profitability. Our third hypothesis states a positive link between crack spreads and profitability. We want to know whether crack spreads feed directly through to profits in the industry. A positive link between crack spreads and profits would suggest an incentive to ramp up utilization when crack spreads increase. We estimate equation (5). The test results are significant and confirm a positive link between crack spreads and profits. We apply stability tests on the equation. The residuals are stationary based on the one percent confidence level. We cannot find any evidence for serial correlation and heteroskedasticity.

Table 8: Test results on hypothesis 3 of the Crack Spread Model

Dependent Variable: Profit
Number of Observations: 22

	C	Spread
Point Estimates	-1654.97	1428.28+
p-Value	0.7348	0.0893

** significant at the 1% level, *significant at the 5% level, +significant at the 10% level

In this section, we set up a model to explain the negative relationship between crude prices and refining utilization rates. We call it the crack spread model. The model is sub-divided into three hypotheses, which are interlinked. We collect data and set up three equations to test our hypothesis. The test results are significant and correct for hypothesis 1 and for hypothesis 3. We can argue that crack spreads increase when the WTI decreases and they decrease, when the WTI increases. We cannot find a significant direct link between the crack spread and refining utilization rates. This may be work for future research. Nevertheless, we provide an indirect link. We can find a significant relationship between crack spreads and profitability in the oil industry. We can argue that crack spreads feed directly through to absolute profits in the oil industry. The top players in the refining industry in the U.S. are integrated players, i.e. active in oil production as well as refining and marketing. Higher profits may serve as an incentive for those players to ramp up utilization. If we combine hypothesis 1 and hypothesis 3, we can argue that crack spreads and profits increase when the WTI decreases, which may serve as an incentive to ramp up utilization.

CONCLUSION

(in progress!)

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