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Behavioural Approach to Oil Price Dynamics

An Analysis of the Role of Behavioural Finance in Explaining the Oil Price Dynamics in the period 2003 – 2008

Tamila Fonshtain
Advisor - Finn Østrup
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EXECUTIVE SUMMARY

Crude oil has a significant position in society as a crucial input to global, national and individual production and consumption. Therefore, it is a strategic resource that attracts the interest and attention of nearly everyone on the planet.

The aim of this thesis is analyse the oil market in the period 2003 – October, 2008 with the purpose of explaining the recent oil price dynamics by supplementing the traditional theory of fundamentals with the theories from behavioural finance.

To achieve the goal, first a thorough analysis of the two theoretical frameworks was conducted. Present writer then proceeded to analyse the oil market, its supply and demand factors and the oil price development in order to obtain an understanding of the fundamental drivers of the oil market and factors that influence the oil price formation. A behavioural theories were then used to analyse the latter.

The main findings of the thesis showed that the oil market in the outlined period is not as efficient as predicted by the efficient market hypothesis. Furthermore, several market occurrences such as speculation, excessive trading and increasing price volatility indicated that the market exhibited the signs of a speculative bubble. The basic drivers of the observed behaviour was discussed by applying the insights of the behavioural theory. Not surprisingly, the explanatory power of these theories was substantial and contributed to the understanding of the reasons behind investor behaviour as well as the reason for prolonged state of mispricing.

The present writer found this topic to be inspiring and exuberant and therefore hopes that the reader finds it just as exiting.

Tamila Fonshtain

CHAPTER 1 – INTRODUCTION

Crude oil is a strategic resource and one of the most imperative commodities to affect the global economy and international trade. The price of crude oil[1] had been hitting new highs since the beginning of the twenty first century up until the beginning of its plunge in mid July 2008. The initial price surge was instigated by the U.S. led invasion of Iraq in March 2008 and since then the world has witnessed the breath-taking upswing of the oil price. At the time of the invasion a barrel of crude oil was trading at 32.51 U.S. dollars (USD)[2] per barrel (bbl[3]). Thereon, the oil price proceeded to rise to above 50 USD/bbl in 2004-2005, 75 USD/bbl by mid 2006 and 99.29 USD/bbl by the end of 2007. Throughout 2008, crude oil price had been extremely volatile. During the first half of 2008, the price regularly reached ultimate heights, with its all time peak of 147.02 USD/bbl on July 11th. From thereon the price assumed a downtrend and proceeded to plummet to below 70 USD/bbl by October 19th.

The dramatic increase in the oil price up until mid summer 2008 and then its dramatic plunge has been a major concern for economist, politicians, policy makers and the general public. This concern is easily justified by the fact that crude oil is an indispensable input to global, national and individual production and consumption as the vast majority of the segments of modern daily life are highly depended on oil-based products. The development of the oil price has raised yet another concern, one of an irrational bubble in the oil market, where the oil price is being driven by speculative behaviour rather than fundamental factors of supply and demand.

Bubbles have been analysed in academia by using two main disciplines; the traditional efficiency theory and behavioural finance theories. The efficiency theory is led by the Efficient Market Hypothesis (EMH) with the fundamental assumptions that agents are fully rational and markets are always efficient. Accordingly, bubbles are defined as extraordinary market occurrences that require implausible assumptions in order to be

[1] Throughout this thesis “oil” or “crude” will be used for “crude oil” unless otherwise specified. Moreover, even though there are several types of oil with their own prices, the oil price will be mentioned in singular throughout this thesis and will refer to the benchmark spread of WTI and Brent.
[2] Throughout the thesis all oil prices are quoted in U.S USD per barrel and will be redered to as USD from hereon.
[3] The abbreviation bbl will we used to indicate a measure of per barrel

explained within the paradigm and are therefore left unexplained. Behavioural finance on the other hand, acknowledges the presence and influence of human behaviour on financial markets and thus relaxes the assumption regarding individual rationality. This is a discipline that explains fluctuations in financial markets by applying evidence from psychology and sociology to economic problems. That is by presenting models of human behaviour that clarify investor's ability to process information, make decisions and form expectations. Accordingly, market participants are not always fully rational and therefore, markets are not always efficient as the EMH predicts.

Both disciplines have been researched and scrutinised and there exist extensive literature on the topic in academia. This research, has mostly been applied to explaining phenomena in the equity markets. Present writer assumes though that commodity investors are guided by similar rational/irrational principals as the equity investors therefore, behavioural finance theories and principals can be applicable to analysing the speculative bubble in the oil market as well.

1.1 PROBLEM FORMULATION

The oil price development from 2003 onwards drawn much attention to the oil market and the driving forces behind the price increases. Evidence from the oil market indicate that the oil price dynamics cannot solely be explained by the fundamental factors of supply and demand in the period since late 2002. On the contrary, the research[4] suggests that the oil market has been mainly driven by speculative behaviour. Behavioural finance theories have proved to be very useful in explaining market occurrences and anomalies that the efficiency theory and fundamentals had failed to rationalise. It is therefore, the focal aim of the thesis to gain a profound understanding of behavioural finance theories, the oil market development and to investigate the possible contribution of these theories to explaining the oil price development in the period of 2003 - October 2008. Thus the research objective of this thesis is to answer the following research question:

[4] Research by Merino and Ortiz, (2005) and Kristiansen (2008)

What are the main characteristics of the oil price dynamics in the period 2003 – 2008 and how can behavioural finance theories contribute to our understanding of these?

In order to accommodate the research objective, it is first essential to gain a profound understanding of the fundamental approaches and the underlying assumptions of both the traditional finance theory and the behavioural finance theory. It is also necessary to have a clear understanding of oil market, oil price dynamics and development. The thesis will therefore answer the following sub-questions:

I. *What are the main theoretical perspectives of price formation within mainstream economics?*
II. *What are the main factors to influence the oil price and how does the recent oil price development differs from previous shocks in the oil market?*
III. *To what extent can the theoretical approaches be used when analysing the oil price development in the period from 2003 - 2008 in particular?*

The above sub-questions are used as guiding milestones though out the thesis and are answered in the subsequent chapters.

1.2 METHODOLOGY

Gubrium and Holstein (1997) define methodology as a distinctive way of orienting perception, comprehension and representation to the world. Thus, methodology or method is the art of choosing a specific approach/approaches when conducting a research.

It is common to distinguish between the qualitative and quantitative methodological approaches. Van Maanen (1979) defines the characteristics of the qualitative method as an umbrella term covering an array of interpretive techniques, that seek to describe, translate, decode, and otherwise come to terms with the meaning, not the frequency, of certain more or less naturally occurring phenomena in the social world. The strength of the qualitative method is that it enables the researcher to construct hypotheses together with grounded theory until he/she reaches the desired understanding of the

method at hand and interpret the information gathered, in an understanding perspective.

Quantitative method on the other hand, involves analysis of numerical data. It begins with hypotheses and then reduces the data at hand with the purpose of creating explanations and generalizations. The main purpose of the quantitative method is to find the reason *why* various phenomena occur rather than *how* they occur (Gubrium and Holstein, 1997). Qualitative and quantitative methodology is not mutually exclusive. Differences between the two approaches are located in the overall form, focus, and emphasis of study (Van Maanen, 1979).

It is also common to distinguish between the inductive and deductive reasoning/methods. An inductive method is the process of reasoning in which the logic of an argument is believed to support the conclusion but does not ensure its truth (Outhwaite and Turner, 2007). In other words in makes generalisations on the basis of individual observations and instances. On the contrary, a deductive method is a process of reasoning in which conclusions are drawn from the statements based on deductive arguments (Outhwaite and Turner, 2007). Furthermore, qualitative methods are mostly inductive while quantitative methods are mostly deductive.

Present writer found it necessary to use a combination of qualitative and quantitative methods in order to reach a profound conclusion and answer the research question. In order to gain a thorough understanding of the traditional efficiency theory, the behavioural finance theory and the fundamental model of pricing oil, an inductive approach was undertaken. As the inductive approach enables an in-depth evaluation and analysis of the paradigms, their underlying assumptions, building blocks as well as their limitations and challenges. The theoretical research is based on primary and secondary literature in the fields of traditional finance, economics and behavioural finance. However, to gain an understanding of the oil market, oil price formation and its determinants a quantitative method was used. Deductive reasoning enabled present writer to identify and analyse various patterns in the oil market and draw conclusions from these patterns.

The reviewed literature for the theoretical analysis is to a large extent comprised of scientific articles published in recognised financial and economic journals[5] as well as "working papers" and books. The goal of the theoretical analysis is to gain an in depth understanding of the theoretical frameworks in order to be able to apply these theories to analysing the developments in the oil market. Furthermore, the majority of the research on EMH and behavioural finance theories has been conducted on financial security markets, where the fundamental value of the security refers to its intrinsic value. Therefore the concept of market efficiency and fundamental value had to be adjusted to represent the physical commodity market, where the fundamental value of the commodity is mainly determined by the present and future supply and demand factors of the commodity.

The oil price data and the factors contributing to its development have been gathered from various sources. The main sources of raw price data, exchange rates and crude oil inventory levels have been EcoWin as well as the Energy Information Administration (EIA), International Energy Agency (IEA), U.S. Commodity Futures Trading Commission (CFTC) and British Petroleum (BP) reports. Data regarding supply and demand of oil and the factors and their determinants have been gathered form the above mentioned sources as well as from several books on the topic of crude oil politics and economics. Furthermore numerous commodity journals, newspaper articles and published interviews have been reviewed in order to get alternative view points on the topics and use them either as supporting and illustrating arguments or as counter arguments in order to facilitate a broader exploration. These are mainly presented in the analysis of oil price developments and the analysis of oil price dynamics (chapters 3 & 4).

1.3 DELIMITATIONS

First and foremost present writer decided to take on a theoretic approach, with the main goal of researching the possible explanatory contribution of behavioural finance theories when used to analyse the oil price development. Statistical analysis of the

[5] such as the Journal of Finance, the Journal of Financial Economics ext.

applicability of these theories is therefore, outside the scope of the thesis. Moreover, as the oil bubble burst during the time the thesis was in the writing, statistical analysis would have been superficial and premature. Instead the thesis touches upon areas that could be of interest for future research; these are outlined and discussed in the concluding chapter. Furthermore, as this thesis has mostly relied on secondary published data regarding oil prices, exchange rates, inventory levels, the precision of these data must also be taken into consideration. Even though the data has been collected from reliable and reputable sources such as EcoWin, EIA, IEA, CFTC and BP, these can still be prone to human error.

1.4 STRUCTURE

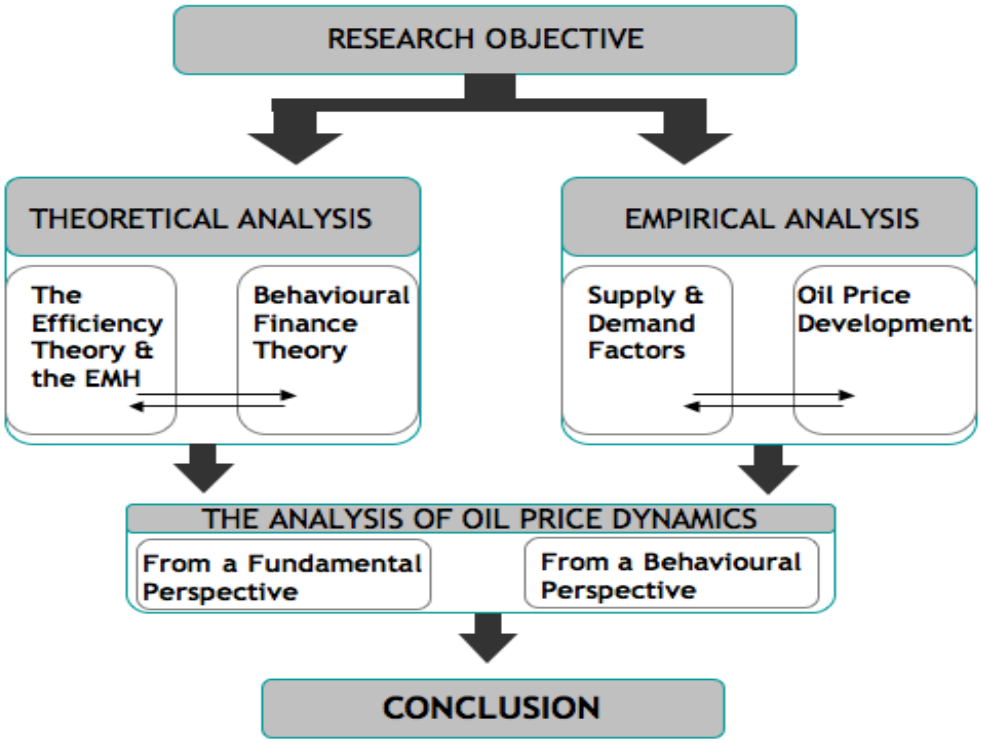
The exploratory nature speaks for the thesis layout. The body of the thesis is build of four chapters. The three sub-questions outlined above are used as guiding milestones in reaching the final conclusion and answering the research question. The first part of the thesis body, chapter 2, introduces the reader to two distinct theoretical perspectives within finance, namely the traditional efficiency theory that is based on the Efficient Market Hypothesis and the behavioural finance theories. By means of analysing and discussing the fundamental assumptions, approaches, empirical foundations, contributions, challenges and limitations of the two perspectives the present writer aims at gaining a profound understanding of the two paradigms with the intention of applying this knowledge to the oil price development in later chapters.

The second part of the thesis body, chapter 3, presents the analysis of the main factors that contribute to oil price formation. The chapter starts by analysing the basic characteristics of crude oil, its supply and demand factors and the price developments. Economic and geopolitical factors that affect the oil price development are also outlined as well as the change in these factors since 2003. Furthermore, a future outlook of the supply, demand and price as estimated by the EIA, is presented in this chapter. A thorough analysis of the oil price development and the factors that have a significant influence on the latter enable the classification and distinction of this period (2003- 2008) from other periods with high oil prices – the so called oil crises.

The third part of the thesis, chapter 4, presents the analysis and discussion of the oil price formation based on market fundamentals. The chapter then proceeds to discuss several market occurrences that challenge the efficiency of the oil market before proceeding to discuss behavioural finance theories that can contribute to explaining the price development in the period of 2003 – October 2008. This chapter starts by analysing the oil price development from the fundamental perspective, which is in line with the efficient market hypothesis, then it proceeds to analyse several of the market phenomena by using theories from the field of behavioural finance.

The fourth part of the thesis, chapter 5, is the concluding chapter, which puts forward the key findings pertaining to the overall research question. Additionally, the chapter presents subjects that were outside the scope of the thesis but could encourage new fields of possible future research. Figure 1.1 provides a graphical illustration of the thesis structure.

THESIS STRUCTURE Figure 1.1



Source: Self-made

CHAPTER 2 – THEORETICAL ANALYSIS

The aim of this chapter is to provide an in-depth overview and discussion of the fundamental assumptions and approaches of the traditional finance theory and behavioural finance theory. This chapter starts with discussing traditional finance and the efficiency theory, namely Efficient Market Hypothesis (EMH)[6], analysing the theoretical and empirical foundation, contribution, challenges and limitations of the theory. Thereafter, the chapter proceeds to the analysis and discussion of fundamental underlying theories and approaches of behavioural finance. Finally the contributions and the challenges of the behavioural approach are presented.

2.1 RATIONAL BEHAVIOUR & THE EFFICIENT MARKET HYPOTHESIS

One of the most fundamental assumptions of neoclassical economics and traditional financial theory is that agents are fully rational and motivated by self-interest. Furthermore, individuals are assumed to maximize their expected utility from a well-defined set of preferences while accumulating an optimal amount of information in a variety of markets (Jolls et al., 1998). Rational agents make rational decision. This entails choosing an action given one's preferences that will maximize one's expected utility. Furthermore, it is assumed that utility is a function[7] of total wealth and that investors are always risk-averse (Fisher and Statman, 1999). This implies that investors will always prefer a certain amount over a gamble when the expected value is the same.

The idea of efficient markets is very natural and thus most likely existed for centuries (Shiller, 2000:172). There have been countless studies and research in the field of efficient markets since the beginning of the 20th century. Louis Bachelier first expressed the EMH in his dissertation "The Theory of Speculation". Additionally, extensive work by Alfred Cowles in the 30s and 40s provided an early demonstration of the random walk in price movements by showing that professional investors were in general unable to outperform the market (Shleifer, 2000).

[6] Efficent Market Hypothesis – will be referred to as EMH from here on.
[7] A graphical illustration of the Standard Utility Function is available in Appendix 2

EMH as known today was developed by Eugene Fama at the University of Chicago Graduate School of Business in the beginning of 1960s. This was further supported by the works of Samuelson (1965) who stated that market prices are the best estimate of true value of equity, Jensen (1967) who presented the first study of actively managed mutual funds which documented the failure of investment professionals to outperform the market and Malkiel (1973) who popularized the notion of random walk[8].

2.1.1 The Theoretical basis of the EMH

The core building block of EMH is based on informational efficiency. The hypothesis defines an efficient financial market as one in which security prices always fully reflect all available information, furthermore when new information becomes available to the market it is immediately incorporated into the prices. When these two conditions are satisfied, market practitioners cannot earn economic profit on the basis of available information (Levich, 2001). This implies that all financial practitioners have access to immediate, costless and an equal amount of information, which establishes an equivalent playing field for investments to take place – a fair game process[9]. Therefore, security prices will incorporate all available information and thus reflect fundamentals (Shleifer, 2000).

The basic theoretical case for the EMH rests on three arguments (Shleifer, 2000:2):

- Investors are assumed to be rational, therefore able to transform available information into rational decisions and value securities rationally.
- Some investors are irrational, however their trades are random and therefore cancel each other without affecting the prices.
- Some investors are systematically irrational, but they are met in the market by a majority of rational arbitrageurs who will eliminate their influence on the prices.

[8] The notion of random walk asserts the unpredictable nature of future prices and is discussed in greater detail in section 2.1.2

[9] According to the fair-game process market is efficient when: 1. On average, errors is formulation of expectations about prices or returns are zero. 2. These errors follow no pattern that could be exploited for profit purposes (Levich, 2001).

Arbitrageurs are defined as investors who form fully rational expectations about security returns, and are also called “smart money” or “rational speculators”(Shleifer and Summers, 1990). Accordingly, markets are supposedly *efficient*, enabling *perfect competition*, due to the rational behaviour of the majority of the investors (Fama, 1970). The above arguments rest on progressively weaker assumptions. The first assumption seems to be rather theoretical as it ignores the heterogeneous nature of investors. The second argument of EMH accounts for the nature of investors, arguing that the irrationality of some of its participants does not mean that markets are inefficient as the trades of the irrational investors are unsystematic and therefore cancel each other out (Shleifer, 2000). The counter contention to the second argument is that irrational investors often act systematically rather than randomly and therefore reacting similarly to particular new information/non information (Barberis and Thaler, 2003). Nonetheless, according to the third argument of EMH, markets are still efficient, despite the correlated trades of its irrational participants due to the rational arbitrageurs.

The third argument of EMH is based on the concept of the *No Arbitrage Theorem* (also known as the Fundamental Theorem of Arbitrage-Free Pricing), which was introduced by Milton Friedman in 1963. Arbitrage is defined as ‘ the simultaneous purchase and sale of the same or essentially similar security in two different markets at advantageously different price’ (Shleifer, 2000:3). Thus, arbitrage assumes the existence of similar securities in the market in terms of cash flows in all states of the world and therefore similar risk characteristics. Hence, arbitrageurs are able to trade among these substitutes and earn profits by going short on expensive stocks and long on the similar, but cheaper, ones (Shleifer, 2000). However, according to EMH and rational expectations, arbitrage is quick and effective, thus the price of a security will never deviate profoundly from the fundamentals and never for a long time period, thus mispricing will essentially be eliminated.

Therefore, due to the process of arbitrage, the rational arbitrageurs will bring security prices in line with their fundamental values as long as securities have close substitutes. Furthermore, irrational investors, who buy overpriced securities while

selling under priced ones, earn lower returns than both passive investors[10] and arbitrageurs and will therefore, lose money in comparison to their rational peers and as a result, eventually disappear from the market (Shleifer, 2000).

2.1.2 The Empirical basis of the EMH

There has been an overwhelming amount of empirical evidence for the EMH, and the hypothesis has been confirmed by an impressive number of findings (Brealey et al., 2006). There are two empirical predictions of the EMH. First, when new information becomes publicly available, it will be 'quickly' and 'correctly' incorporated into the prices[11]. Second, as security prices must reflect fundamental value, prices should only react to news regarding the value of the security and not news regarding the supply or demand of the security. This results in the hypothesis that stale information is of no value to investors, as they cannot profit from it (Fama, 1970). It is common to distinguish among three forms of market efficiency, namely the *weak*, the *semi-strong* and the *strong* form of efficiency. These differ by the degree of stale information that is reflected in security prices (Brealey et al., 2006).

The *weak form of market efficiency* – prices reflect all the information contained in the record of past prices. Accordingly it is impossible to make a superior risk adjusted profit on the basis of knowledge of past prices and returns. The *semi-strong form of market efficiency* requires that prices reflect not only the past prices but also all other published information (annual earnings announcements, stock issue/splits, M&A announcements). Thus investors are not able to profit by using any publicly available information, because as soon as information becomes public, it is immediately incorporated into prices. Finally the *strong form of market efficiency* states that it is impossible to earn superior profit by using unpublished (insider) information, as the insiders' information rapidly leaks out, becomes public and is immediately incorporated into the prices. In such a market, there can be lucky and unlucky investors, but there

[10] Passive investors are investors that hold the market portfolio.
[11] In this context quickly means that no one should be able to profit from this information, while correctly means that the adjustment of prices to the new information should be accurate on average (not over-/under reacting to the news) (Fama, 1970).

will never be a superior investment manager who consistently outperforms the market (Brealey et al., 2006).

The majority of empirical tests have focused on the weak and the semi-strong forms of market efficiency, and their findings have broadly supported the EMH. Fama (1965) found that security prices followed a random walk, concluding that the best predicament of tomorrow's prices are today's' prices. The random walk (RW) hypothesis states that future prices cannot be predicted by extrapolation of past prices, thus future prices move randomly and are independent of each other. Therefore, it is impossible for anyone to outperform the market for a substantial period of time without assuming additional risk (Fama, 1965). This supports the weak form of market efficiency. Fama (1969) have also pioneered event studies that measured the effect of important corporate news events[12] on share prices, these tests proved to be consistent with the semi-strong form of market efficiency. According to one of the studies, targets' share prices reacted to important corporate news, for example takeover announcements, by gradually rising prior to the announcement of the bid, then leaping on the day of the bid announcement. However, the leap in share prices was not followed by further increase/decrease in the prices, indicating that prices of takeover targets instantaneously incorporate news of the bid (Fama, 1970).

Scholes's (1972) substitution hypothesis addressed the other implication of EMH, namely the non-reaction of security prices to non-information, otherwise known as noise. According to the substitution hypothesis, all securities have close substitutes with very similar risk characteristics, this enables arbitrage as it allows for various ways of obtaining a given pattern of cash flows in different states of the world. Scholes's argument is that investors are indifferent as to which stock, with the same risk characteristics, to hold and therefore, sales of large blocks of shares should not have a considerable impact on share prices, as these do not convey news regarding a change in the fundamental value of the security. Consequently in line with the arbitrage argument, when sales of large share blocks occur, investors will gladly substitute the

[12] In Fama's (1969) research important corporate news included among others: earnings, dividends and takeover announcements, changes in management compensation, share issues and repurchases (Fama, 1970).

expensive stock with a cheaper one. This is supportive of the semi-strong form of market efficiency (Shleifer, 2000).

The tests of the strong form of market efficiency are concerned with testing whether or not it is possible to earn superior profits by having monopolistic access to some information. Fama (1970), acknowledges that some investor have access to monopolistic information that enables them to earn monopolistic profits at times, however he focuses primarily on whether it is profitable for investors to expend resources obtaining this information and who these people are in the investment community that have access to the insider information. The majority of research[13] on the subject have focused on the management of open-end mutual funds, moreover, for his test of the strong form of efficiency, Fama (1970) focuses on the researches by Jensen (1968 and 1969). Jensen's study of 115 mutual funds over the period of 1955-1964 aims at uncovering whether or not mutual fund managements have special information (monopolistic information) that enables them to earn extraordinary returns. According to the research, Jensen found that on average consumers' wealth after ten years of holding mutual funds was approximately 15% lower than that of consumers that held corresponding portfolios along the market line. While these results do not suggest that the strong form of market efficiency hold for all investors all the time, it does provide a strong evidence in the support of that hypothesis (Fama, 1970: 413). Fama (1979:388) argues, "There is no important evidence against the efficient market hypothesis in the weak and the semi strong form tests, and only limited evidence against the hypothesis in the strong form tests".

Both theoretical and empirical findings seem to constitute a strong case for the assumption of efficient markets, therefore it is no surprise that the EMH has dominated the finance literature during the last century.

[13] Majority of the research on the subject have been mainly done by Sharpe (1965, 1966), Treynor (1965) and Jensen (1968, 1969) (Fama, 1970)

2.2 CHALLENGING THE EFFICIENT MARKET HYPOTHESIS

It is said, that once individuals form a belief or an opinion, they are reluctant to search for evidence that contradicts this belief, and even if such evidence is presented to them, they treat it with undue scepticism. This could be the reasoning why the EMH has dominated financial markets for decades without being challenged (Barberis and Thaler, 2002). In the last thirty years, however, the EMH has been progressively challenged both on theoretical and empirical grounds. The following part will present an overview of the challenges and the criticisms that the EMH faces.

2.2.1 Theoretical Challenges to the EMH

The theoretical bases for EMH rests on tree assumptions that were laid out earlier in this paper[14]. These are being challenged by various arguments. The first and the foremost is the criticism addressing the issue of investor rationality. It is impractical to assume that people in general and investors in particular are fully rational all the time (Shleifer, 2000). On the contrary, theories from psychology describe investor rationality as bounded[15] and find their decision-making to be influenced by cognitive biases[16]. These will be discussed in depth in the following section.

The second assumption of the EMH is being challenged by the fact that investor deviations from rationality prove to be rather systematic. Irrational investors seem to behave socially and follow each other's mistakes by believing rumours or/and imitating their peers (Shleifer, 2000). The third assumption of the EMH is being challenged by the fact that sometime arbitrage opportunities are risky and costly and therefore unattractive. Hence disabling the rational arbitrageurs from immediately correcting the mispricing created by the irrational investors. This refers to the theory of limited arbitrage and will be discussed in depth in section 2.3.1.

2.2.2 Empirical challenges to the EMH

The EMH has been challenged on empirical bases as well, due to the trouble it had in explaining certain market occurrences. These occurrences are difficult to rationalize or

[14] See section 2.1.1
[15] Bounded rationality is defined in section2.2
[16] Cognitive biases are discussed in section 2.2.2.2

they require implausible assumptions in order to be explained within the paradigm – they are termed *anomalies* (De Bondt and Thaler, 1989). Empirical research present a number of such anomalies, some of these are presented here.

2.2.2.1 The Equity premium Puzzle

Empirical studies show that, on average, the risk premium[17] over the last one hundred years have been approximately 6% (Siegel and Thaler, 1997). Due to the fact that stocks are riskier than bonds, investors require a higher risk premium for bearing the extra risk, however, a study by Mehra and Prescot (1985) have shown that the risk premium is too high to be explained by standard economic model - they have termed this anomaly *the equity premium puzzle* (Siegel and Thaler, 1997).

Different explanations to the puzzle have been proposed. One explanation suggests that the reason for the high equity premium is the large differential in the cost of trading stocks and bonds. This suggests that trading stocks entails higher transaction costs than trading bonds, therefore equity premium is partly compensating for these transaction costs (Kocherlakota, 1996). Another explanation is that investors are so risk averse that they need an extremely high-risk premium in order to choose stocks rather than bonds (Siegel and Thaler, 1997). Nonetheless, research shows that *the equity premium puzzle* is real and remains unexplained, however there is reason to believe that the equity premium in the 21st century will be somewhat lower than the equity premium in the 20th century (Dimson et al, 2000).

2.2.2.2 Short-Term Momentum and Long-Term Mean Reversion

Poterba and Summers (1988) found that stock prices exhibit mean reversion at long horizons and momentum effect at horizons shorter than one year. Mean reversion is defined as negative serial correlation of returns. This means that a price increase will be followed by a subsequent price drop. Momentum effect, on the other hand, is defined as positive serial correlation of returns, which means that a price increase will be followed by a subsequent increase in the price (Poterba and Summers, 1988). Both

[17] Risk premium is defined as the difference between the return on risky assets (stocks) and the return on risk-free assets (bonds) (Siegel and Thaler, 1997).

phenomena show that a certain degree of predictability does exist in financial markets and therefore challenge one of the basic assumptions of the EMH, namely – the random walk hypothesis.

2.2.2.3 Small vs. Large Caps and Value vs. Growth Stocks

Research has shown that smaller company stocks (small caps) systematically generated larger returns than large company stocks (large caps) over the last century (Risager, 2008). In fact, Keim (1983) found that since 1926, small caps in the U.S have on average outperformed large caps by one percent. These findings were further supported by the findings of Fama and French (1992) and Chou et al (2004). Additionally, research has shown that a portfolio comprised of value stocks have yielded superior returns in the long run compared to a portfolio comprised of growth (glamour) stocks (Lakonishok et al., 1994). Value stocks are defined as stocks with low price earnings, price dividend and price book ratios but with a high book to market ratio, while growth stocks comprise the opposite.

Fama and French (1996) have argued that the reason for the higher return of the small caps and value stocks is higher risk, however evidence suggests the contrary. According to Lakonishok et al, (1994) while value stocks perform equally well during market booms, they seem to outperform the glamour stocks during market recessions. Furthermore, it seems that the returns of glamour stocks have higher volatility at times of earning announcements than the returns of value stocks. The important implication of these anomalies however is that they create a predictable pattern that will enable investors to generate excess risk adjusted returns and therefore challenges the EMH.

2.2.2.4 Excessive Trading and Overreaction of Financial Markets

One of the main predictions of the rational models of investing is that there should be very little trading (Barberis and Thaler, 2002). This is mainly due to the assumption that in efficient markets prices reflect all available information, therefore any attempt to initiate a trade will unveil the bidder's private knowledge of the asset, which in turn should quickly be incorporated into the prices before the actual trade can take place (De Bondt and Thaler, 1995).

In reality however, the trading volume is much higher than can be justified by rational behaviour and it yields lower returns (Barberis and Thaler, 2002). Barber and Odean (2000) examined the trading activity from 1991 to 1996 and found that, after accounting for trading costs, the average return of investors in their sample was below the standard benchmark. Furthermore, in his prior study, Odean (1999) found that the average return on stocks bought is lower over the year after their purchase and the average return on the stocks sold is higher over the year after the sell. One explanation for this behaviour is overconfidence, it will be discussed in section 2.3.2.2.

Overtrading can have an effect on price volatility and overreaction of financial markets. This is expressed in the excessive volatility of stock and commodity prices (De Bondt and Thaler, 1990). Research of the 1987 and 1989 stock market crashes emphasise that investors followed each other rather than basing their investment decisions on fundamental factors (De Bondt, 1991). Another evidence of overreaction in financial markets, is the price reaction to non-information such as inclusion of stocks in important indexes such as Standard and Poor's 500 (S&P 500), this is discussed in section 2.3.1.

2.3 BEHAVIOURAL FINANCE – A NEW PARADIGM

Behavioural Finance is a new paradigm that has emerged within the last thirty years as a response to the difficulties faced by the traditional framework of efficient markets. According to the behavioural theories, financial markets are influenced by human behaviour, and some financial phenomena can be better explained by relaxing the assumptions underlying individual rationality (Barberis and Thaler, 2002).

The notion of human intervention in economics has existed for many years, essentially, since Adam Smith in his work *An Inquiry into the Nature and Causes of the Wealth of Nations* in the 18th century had introduced the 'invisible hand'. However, it was not until the late-1980s that Behavioural finance theories started to become more acceptable within academic fields, primarily due to occurrences of phenomena that could not be fully explained by the EMH (Malkiel, 2003). Behavioural finance is a discipline that

explains fluctuations in financial markets by applying evidence from psychology and sociology to economic problems. This is by presenting models of human behaviour that clarify investor's ability to process information, make decisions and form expectations. The behavioural discipline is built on the notion of "bounded rationality" and is focused on observed behaviour.

Under the notion of bounded rationality, people are not able to contemplate the full range of possible future actions, instead the decision-making process is influenced by a person's attention span, memory, time, social influence, habit, emotion and task complexity. (De Bondt, 2003). Therefore, it is possible that some investors at some point in time will trade not only on the basis of information, but also on the basis of noise. These are noise traders, - investors that are subject to systematic biases and therefore not always rational (Shleifer and Summers, 1990). Behavioural finance rests on two building blocks, specifically; limits of arbitrage and investor sentiment, also known as investor psychology (Shleifer and Summers, 1990). The two building blocks together imply that changes in investor psychology are not fully accounted for by arbitrageurs and therefore affect returns and prices. These are discussed below.

2.3.1 Limits of Arbitrage

Literature on limits of arbitrage is considered one of the biggest successes of behavioural finance. It shows that in an economy where rational and irrational investors interact, irrationality can have a substantial and long lasting impact on security prices (Barberis and Thaler, 2002). The prediction of EMH is that when mispricing occurs and prices deviate from their fundamental values due to the irrationality of noise traders[18], the rational investor will be able to correct it by means of arbitrage. According to EMH, arbitrage requires no capital and involves no risk, however, research has shown that strategies designed to correct mispricing can be both risky and costly, making them unattractive and therefore leaving mispricing unchallenged (Shleifer and Vishny, 1997 Shleifer and Summers, 1990, Barberis and Thaler, 2002).

[18] Noise traders are investors that are subject to systematic biases and therefore not always rational (Shleifer and Summers, 1990).

Shleifer and Summers (1990) define two types of risk that limit arbitrage namely, fundamental risk and noise trader risk. Moreover, they identify implementation costs as an additional obstacle that can limit arbitrage.

Fundamental risk

In order to take advantage of the arbitrage opportunity, the arbitrageur needs to sell short the overpriced security while buying a perfect or close substitute to hedge against the fundamental risk. However, the existence of perfect or close substitutes is highly unlikely, making it impossible to completely remove the fundamental risk. The remaining risk limits the arbitrageur's original position and keeps him from short selling the overpriced security, allowing mispricing to continue (Barberis and Thaler, 2002).

Noise Trader Risk

Noise trader risk is a risk of the mispricing worsening in the short run, causing losses to the arbitrageur. De Long et al. (1990), who introduced the idea, argue that there is a risk that the investor pessimism/optimism that initially caused the security to be under/overvalued will persist and push the price of the security further down/up (De Long et al., 1990). Moreover, as arbitrageurs are assumed to have short investment horizon, they bear the risk that they will be forced to liquidate their positions prematurely and lose money (Shleifer and Summers, 1990). The assumption of short-term investment horizon is due to the fact that the majority of arbitrageurs are professional portfolio-managers that are evaluated by their investors on a yearly or even quarterly basis, this determines the extent of their investment horizon. Therefore, if future mispricing is more extreme than the one at the time when arbitrage takes place, the arbitrageur stands to lose on his position. The fear of this loss, limits his initial position, preventing him from correcting the mispricing (Shleifer and Summers, 1990).

Implementation costs

Transaction costs such as commissions, bid-ask spreads, price impacts fees of borrowing securities and legal constraints[19], make it less attractive to exploit mispricing (Barberis and Thaler, 2002). Furthermore, there are also costs of learning about the mispricing and the costs of the resources needed to exploit it.

Extensive research have uncovered that at times, arbitrage can be both risky and costly, making it less attractive for arbitrageurs. De Long et al. (1990) show that noise trader risk on its own is very powerful because, even when disregarding fundamental risk (due to the existence of perfect substitutes) and implementation costs, it can sometimes limit arbitrage (Barberis and Thaler, 2002). There is also a substantial number of empirical evidence that supports limited arbitrage[20]. Such evidence is the researches by Harris and Gurel (1986) and Shleifer (1986) that examined stock price reactions to the inclusion of new stocks into the S&P 500 stock index (Shleifer and Summers, 1990). It was found that announcements of inclusion into the index are accompanied by a permanent increase in share prices of 2-3%. The criteria when choosing which stocks to add to the S&P index is their representativness of the US economy and not their performance potential. Therefore, the price increase is a clear evidence of mispricing, as announcements of inclusion do not convey any information regarding the shares' fundamental value (Shleifer and Summers, 1990). This type of mispricing is nonetheless, present in the market and have not been "corrected" yet.

Additional evidence of price reaction to non-information comes from Ritter's (1988) research on the "*January effect*". January effect is named after the fact that small stocks have been significantly outperforming the market each January for the last five decades. According to the research, individual investors usually sell small stocks in December in order to realize capital losses and then re-buy back in January (Ritter, 1988). The January effect can only exist when arbitrage is limited and therefore ineffective (Shleifer and Summers, 1990).

[19] Many pension fund and mutual fund managers are not allow to short-sell securities (Barberis and Thaler, 2002).
[20] In general any evidence of persistent mis-pricing is an evidence of limited arbitrage (Barberis and Thaler, 2002).

2.3.2 Investor Sentiment

Shifts in investor demand for securities are completely rational at times (Shleifer and Summers, 1990) and these shifts reflect information such as public announcements, news conveyed through the trading process and more. However not all demand changes appear to be rational but more as a response to a shift in expectations or a sentiment. The theory of limited arbitrage suggests that rational traders are often powerless in the situations where irrational traders cause security prices to deviate from their fundamental value (Barberis and Thaler, 2002). Irrational investors, that cause the demand shifts are assumed to have a specific form of irrationality that can be explained by systematic biases that arise when people form preferences and beliefs (Barberis and Thaler, 2002).

2.3.2.1 Understanding Investor Preferences – The Prospect Theory

Preference is the essential ingredient in understanding trading behaviour. Preferences determine how investors evaluate risk and uncertainty. The majority of models on investor preferences assume that investors evaluate gambles according to the Expected Utility Framework (EU)[21]. However, empirical evidence have shown that people steadily violate the EU theorem when choosing among risky gambles. Subsequently much research have been conducted on the non- EU theories, one of those theories is the *prospect theory* (Barberis and Thaler, 2002).

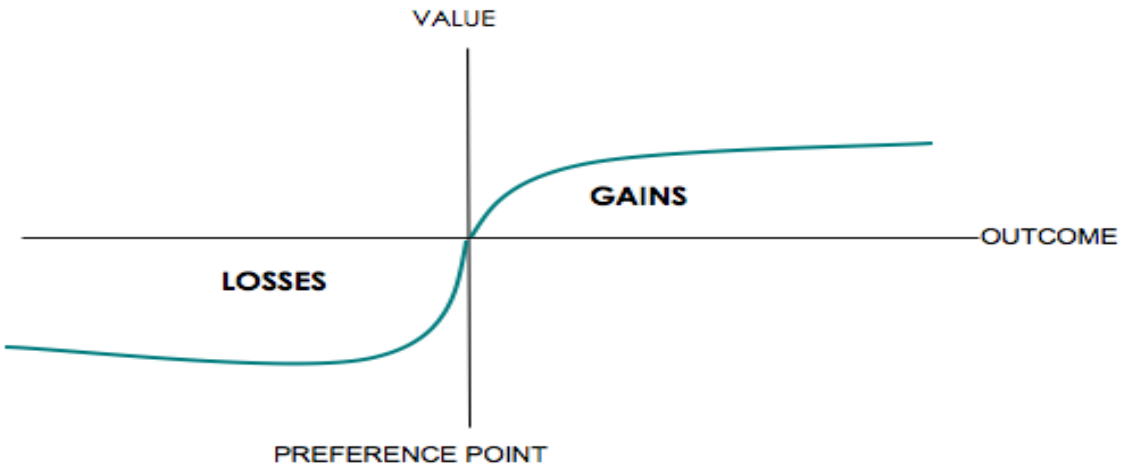
Prospect theory, developed by Daniel Kahneman and Amos Tversky in 1979, is a non-normative theory that captures people's attitude towards risky gambles and is said to be the most successful in explaining the empirical evidence. There are several formulation differences between the EU and the prospect theory. First, utility is a function of gains and losses rather than total wealth, as is the case with the EU. Second, Kahneman and Tversky (1979) found the value function to be concave in the 'gains' domain and convex in the 'looses' domain. In their experiments, the authors demonstrated that the majority of subjects prefer a certain outcome over a probable one in the gain domain, i.e. the subject prefers a small certain gain over a large

[21] Expected Utility will be referred to as EU from here on. The expected utility function is available is appendix 2

possible one, whilst in the loss domain prefer a probable outcome over a certain one. This suggests that people are risk averse over gains but risk seeking over losses.

Furthermore, Kahneman and Tversky (1979), found that the 'loss' part of the function is steeper than the 'gain' part, indicating greater sensitivity to losses, also known as *loss aversion* (Kahneman and Tversky, 1979). Accordingly, subjects are willing to bare the risk in order to have a possibility of avoiding losses. This behaviour can be observed in the market when investors are reluctant to sell looser stocks in the hopes of them bouncing back, however in many cases the value of these stock plummets even further inflicting higher losses on investors. Finally, prospect theory argues for the non-linear probability transformation, indicating that people are more sensitive to differences in probabilities at higher probability levels. This means that a twenty percent increase in probability from 0.8 to 1.0 is perceived as more significant than a twenty percent increase from 0.2 to 0.25. The utility function as described by the prospect theory is S shaped and is known as prospect function. Figure 2.1 is a graphical illustration of the prospect function.

PROSPECT FUNCTION Figure 2.1



Source: Fisher and Statman (1999).

2.3.2.2 Understanding Investor Beliefs & Expectation Formation

From the previous discussion it is obvious that people in general and investors in particular are not always perfectly rational as assumed by the traditional economics and finance theories. Due to bounded rationality, investors do not always perfectly process new information, but rather often rely on frames and heuristics, which are mostly useful as they identify patterns in data and save computation time. However, these usually lead to systematic and predictable errors/biases in decision-making (Shleifer, 2000). One such error has been presented by the prospect theory with regards to the asymmetric way investors value risk and uncertainty. Other typical errors occur when forming beliefs and expectations – these are known as cognitive biases (Lewicki et al., 2006).

Framing

A frame is a subjective mechanism by means of which people make sense and evaluate complex situations, this leads them to pursue or avoid subsequent actions (Liwicki et al., 2006). A frame defines how the problem is formulated and how actions and outcomes are experienced. Frames are individual and unique but they are also affected by exogenous factors such as education, family, environment, advertising and therefore can be socially shared (De Bondt, 1985).

The way how facts are presented to individuals can have a big impact on their decision-making. Therefore information can be framed in different ways to influence the decisions of investors. For example, when choosing between investments, investors allocate more of their wealth to stocks rather than bonds when they see an impressive long-term history of stock returns relative to the returns on bonds, however the stock market would have looked less promising if a volatile short-term history of stock returns was observed instead (Shleifer, 2000).

Anchoring and Adjustment

Cognitive biases in anchoring and adjustment are related to the effect of a benchmark/anchor against which investors make subsequent adjustments when forming expectations or beliefs. The choice of an anchor might be arbitrary and therefore misleading, however, once an anchor is determined it is being perceived as a valid benchmark against which new information is being evaluated (Lewicki et al., 2006). The Anchoring bias is evident in security markets where security analysts do not revise their earnings estimates quickly enough after the earning announcements. This is one of the reasons why surprises about positive earnings tend to be followed by additional positive earnings (Shleifer, 2000).

Overconfidence

Behavioural research has shown that people are overconfident in their judgements (De Bondt and Thaler, 1995). Overconfidence is defined as a characteristic that makes agents perceive themselves as more skilled and proficient than they really are, more specifically it is defined as an "information-processing bias" (Daniel et al., 2001).

Overconfidence is manifested in different ways (Barberis and Thaler, 2002). First, people tend to overestimate the accuracy of their knowledge or information. Second, people are poorly calibrated when estimating probabilities and overweigh own forecasts relative to those of others. It seems that events that they estimate to occur with certainty actually only occur eighty percent of the time, while events that they deem impossible, occur approximately twenty percent of the time (Barberis and Thaler, 2002). Furthermore, people tend to be overconfident in answering questions of moderate to extreme difficulty. The existence of overconfidence in financial markets can be viewed in the high trading volumes (Odean, 1998).

Optimism and Wishful Thinking

People tend to overestimate their own abilities and perceive themselves more favourably than others view them, typically people perceive to be above average in such domains as driving skills, sense of humour and ability to get along with others (Barberis and Thaler, 2002). People also tend to overestimate their own contribution to

positive past outcomes while underestimating it with regards to negative past outcomes. This is expressed when people recall information related to their success more easily than information related to their failures (Odean, 1998). Furthermore, they seem to display a systematic planning fallacy; by predicting that's certain tasks will be completed much sooner than they actually are (Barberis and Thaler, 2002).

Representativeness

Kahneman and Tversky (1974) show that when people try to determine the probability that an object A belongs to class B, they often use *representativeness heuristic* (Barberis and Thaler, 2002). The authors show that it is a natural human tendency to draw analogies by evaluating the degree to which A reflects the essential characteristic of B. Relying on representativeness can cause several biases such as the base rate neglect and sample size neglect (Barberis and Thaler, 2002).

Base rate neglect also known as stereotyping, is a distortion by generalization. It is a bias that occurs when individuals identify certain attributes of object A to be in line with these of object/class B and therefore categorise A with B, disregarding the base rate of A (Lewicki et al., 2006). This tendency is evident in financial markets, when investors label two stock/companies as very similar (perhaps substitutes), when the actual resemblance is only superficial. *Sample size neglect* refers to the tendency of people to draw conclusions based on small sample sizes, this is also known as *the law of small numbers* (Lewicki et al., 2006). In financial markets, the law of small numbers applies to the way investors learn and extrapolate based on their own experience, which can be limited in time or scope. Moreover, at times investors try to predict future uncertain events by applying a short history of data to a broader chain of events. When doing so, investors disregard the possibility that a recent history could be generated by chance instead of a 'model' they are trying to build and justify (Shleifer, 2000).

Conservatism

Conservatism occurs in situations when the base rates are over-emphasized relative to sample evidence. It could be viewed as the opposite of representativeness. According

to Barberis and Thaler (2002), when handling a data sample that is representative of an underlying model, people tend to over-emphasize the data, however, when the data is not representative of any silent model, people underweight the data and rely too much on extrapolation.

Belief Perseverance

Research has shown that once people form an opinion, they hang on to it and are reluctant to change it (Barberis and Thaler, 2002). First, people are disinclined to search for evidence that will contradict their beliefs. Second, even when such evidence is presented to them, it will most likely be treated with scepticism. Furthermore some tend to misinterpret contradictory evidence as supportive evidence instead – this is termed confirmation bias (Barberis and Thaler, 2002).

Availability Bias

When judging the probability of an event, individuals often focus on things they have seen or experienced themselves, by searching their memories for relevant information. However by doing so individuals might arrive at a biased judgement since not all memories are equally available and more recent and salient events will have a stronger influence. (Barberis and Thaler, 2002).

Herding

People tend to overestimate the reliability of their knowledge, which is significantly manifested in the herding behaviour (Sornette, 2003). Herding behaviour describes how individuals can act together without a planned direction, and mimic the actions of others in the flock. Through the development of behavioural finance, herding has been linked to many financial activities such as investment recommendations, behaviour of underwriters, analysis of IPOs[22] and most importantly earnings forecasting. And while imitation might be optimal when one is in lack of information, historically herding created bubbles. Furthermore, reconsideration from an optimistic to a pessimistic outlook can be amplified by herding; a mechanism that could intensify losses and may lead to brutal drops and crashes (Loewenstein and Thaler, 1989).

[22] IPO stands for Initial Public Offering

2.3.3 The Contributions and Challenges of Behavioural Finance

Behavioural finance, as any other theoretic framework has its important contributions and challenges. The main contribution of behavioural finance is the underlying assumptions regarding investor rationality and the behaviour of market participants. These assumptions are based on empirically validated data, and present a more realistic view of financial market. Another main contribution of the behavioural approach is the theory of limited arbitrage. By proving that arbitrage can be risky and costly at times, it presents an explanation for the times when arbitrage is useless as a market clearing mechanism. Additionally, the behavioural approach imposes more discipline on economic theorizing, in the sense that additional assumptions cannot be imported into the model in order to achieve a predictive fit. Furthermore, the predictions of the behavioural models are testable and have been confirmed in real life.

One of the main challenges of the behavioural approach is the complexity of its models. It is undeniably easier to build models of rational, unemotional agents that strive for profit maximization rather than models of quasi-rational humans that rely on heuristics in their decision making processes (Barberis and Thaler, 2002). Supplementary challenge of the behavioural theory is the complexity of testing human behaviour, as majority of humans are not aware of these biases. Despite the fact that the presence of these behaviours have been tested by psychologist and are proven to exist, it is very challenging for economist to examine the presence of particular cognitive biases in specific markets at specific times. Therefore, one must either except or reject the notion that these biases exist in all markets at all times and have an effect on at least some of the investors.

Additionally the notion of bounded rationality could be challenged by the possibility that investors are not necessarily irrational (or have bounded rationality) but rather are constrained by the institutional environment and framework. Therefore, instead of maximizing utility on the overall level as predicted by the efficiency theory, they maximise utility within the framework provided by the their institutional environment. This issue however, is outside the scope of this thesis but could provide an interesting topic for future investigation.

2.4 DISCUSSION

Extensive research on theory of efficient markets exits in academia. The theoretical basis of the EMH is very strong, therefore, regardless of how the argument of investor rationality is approached, markets are considered efficient as they are able to promptly react to new information, incorporate it into the prices and if deviation from the fundamental values should occur, they are quickly eliminated by arbitrage. Empirically, the EMH has also generally been supported by the data. Therefore, it is not surprising that the theory has dominated financial markets for many decades. However in the last thirty years empirical evidence arose that presented challenges to the EMH. These are market occurrences required implausible assumptions in order to be rationalised by the efficient models and ware therefore termed anomalies. These are *the equity premium puzzle*, occurrences of *momentum in the short run versus mean reversion in the long run*, *excessive trading* and *over reaction of financial markets*, as well as the *systematic over-performance of value over growth stocks and small over large caps*. The existence of such anomalies suggests that additional forces have been active in financial markets and that perhaps the EMH could not fully explain financial markets and thus gave rise to a new paradigm, namely behavioural finance.

In contrast to the EMH, behavioural finance theories acknowledge the influence of human behaviour on financial markets, and hence, argue that some financial phenomena can be better explained by relaxing the assumptions underlying individual rationality. The theory rests on two building blocks; the limits to arbitrage and investor sentiment. The theory on *limits to arbitrage* puts forward the notion that arbitrage is not always effective as a market clearing mechanism. This is due to the fact that sometimes due to the lack of close substitutes it becomes risk and costly and therefore, unattractive to investors. The theory on *investor sentiment* addresses the issues regarding investor preferences and the way beliefs and expectations are formed.

CHAPTER 3 – THE OIL MAREKT & PRICE DEVELOPMENT ANALYSIS

This chapter introduces and analyses the basic characteristics of crude oil, its supply and demand factors as well as the historical price developments. Furthermore, a future outlook of the supply, demand and price as estimated by the Energy Information Administration (EIA) are presented. The chapter starts by briefly introducing various types of oil and their distinguishing characteristics. The chapter then proceeds to analyse the supply and demand of oil, followed by an outline of the influencing economic and geopolitical factors. Moreover, the development and the change in these factors since 2003 are discussed. A future outlook of the oil supply and demand as outlined by the EIA is presented as it is essential in understanding the future of oil and how it affects present prices.

The chapter then moves to depict oil price development from 1981 until October 2008. This part is divided into two sections, historical oil price developments and recent oil price development. The separation of the two periods enables a clearer view and understanding of the recent development and emphasizes that the development in the oil prices since 2003, like non other in history, is considerably distinctive.

3.1 THE BASICS OF CRUDE OIL

This part will commence by defining crude oil, its basic characteristics and types. Thereon, the quality of oil, which is crucial for determining the oil price, is discussed. These factors are essential for the future discussion of the oil price development and the supply and demand factors as some oil types are more demanded and scarce that others. Furthermore, these happen to be concentrated in specific geographic areas, which at times adds pressure on the oil price.

Crude oil, also known as liquid petroleum, is an exhaustible, natural resource that consists mainly of pentanes and heavier hydrocarbons[23] and a mixture of widely varying constituents and proportions (Encyclopaedia Britannica, 2008). According to the Noreng (2002), there are about 161 different internationally traded oils, these vary widely with respect to quality, geographic location and availability. The quality of oil is determined by its density measure, also known as the API[24] gravity that distinguishes between light and heavy oil. Heavy oil is less attractive as it requires a longer and more complicated refining process, whereas, light oil produces a higher yield of gasoline. The quality of oil is also determined by its acidity. The acidity measure refers to the percentage of sulphur in the oil and distinguishes between sweet and sour classes. Oil is considered sweet if it contains low percentage of sulphur and sour if it contains substantial amount of sulphur. Sweet oil is more desirable as it is better in complying with the environmental standards and requires less refining in order to meet sulphur standards that are imposed on fuel (Noreng, 2002).

The price of oil is based on a spread to one of the benchmark oil prices namely West Texas Intermediate (WTI), North Sea Brent Blend (Brent), Dubai, Tapis and the OPEC[25] Basket. These benchmark prices distinguish between the oils that flow from different geographic locations. *WTI* is the benchmark price for light, sweet oil that is extracted and refined in the United States (U.S) and the Gulf Coast of Mexico. It is traded on the New York Mercantile Exchange (NYMEX) and is used as a vehicle for hedging and speculation[26] (Milonas and Henker, 2001).

Brent is a benchmark price used for pricing oils from the North Sea fields that supply North West Europe where it is usually refined. It is traded on the Intercontinental Exchange (ICE) in London[27]. Brent is usually referred to as the world benchmark, because it is used for pricing two thirds of the internationally traded oil that flow west

[23] Sometimes oil also contains natural gas, water and other minerals.
[24] API stands for American Petroleum Institute
[25] OPEC stands for Organisation of Petroleum Exporting Countries and is introduced later on in the chapter.
[26] The distinction between hedging and speculation is discussed in further detail in chapter 4 and is defined in Appendix 1.
[27] Prior to 2005 Brent was traded on the International Petroleum Exchange (IPE). But after the acquisition of IPE by ICE trading was changed and made electronic.

from Europe, Africa and the Middle East. Both WTI and Brent are of very high quality, namely they are both light and sweet oils, however the price of WTI is somewhat higher than the price of Brent as the former results in slightly more gasoline and slightly less heating oil than Brent (Milonas and Henker, 2001).

The *OPEC basket* is a benchmark price based on the prices of seven different oils extracted and refined by OPEC members. It is of a slightly inferior quality to WTI and Brent as it is heavier and more sour. *Dubai* is a benchmark price for Middle Eastern oil that flows towards Asia, while *Tapis* is used as a marker for light sweet oil from the Asian region.

This thesis will proceed to analyse the price developments of WTI and Brent as these are the most commonly traded oils. The next part will discuss the issues regarding the current and future supply and demand of oil.

3.2 THE SUPPLY & DEMAND OF CRUDE OIL

Oil is an exhaustible resource, consequently each extracted barrel will take millions of years to replace. According to experts the oil production (supply) is stretched almost to the limit (EIA Outlook, 2008). The demand for oil, on the other hand, has been increasing over the last five years, especially in the developing countries, such as India and China. This creates uncertainty with regards to how much oil there is left and for how long it is going to last. Therefore, the current and future expected supply and demand factors represent oil fundamentals and have a significant effect on the oil price.

3.2.1 Demand for Crude Oil

The demand for oil is a composite of actual demand, inventory building and speculative movements (Noreng, 2002). Since WWII the demand for oil has been constantly increasing (EIA Outlook, 2008). This is mainly a result of increased economic activity worldwide, universal industrial development and improved social welfare standards. Furthermore, due to the globalisation effect of the 20th century the

demand for transportation of goods and the mobility of people has dramatically increased (Mitchell et al., 2001). Energy is a major driver of industrialised economies therefore, when economic activity, as captured by the Gross Domestic Product (GDP) is increasing, the demand for energy and transportation is also increasing. Furthermore, the demand for energy and transportation is expected to increase as the emerging market economies are growing and catching up with the Western economies (Banks, 1980).

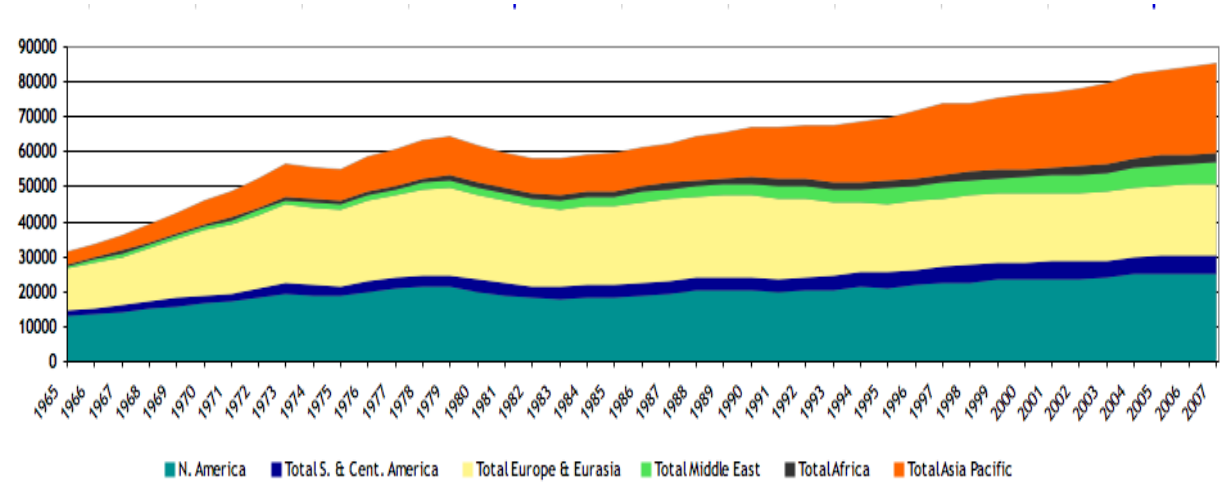
In recent years the key driver of oil demand has been the robust global economic growth, averaging at about 5 percent per year since 2004, marking the strongest performance in two decades (CFTC, 2008). The economic growth is particularly strong in the emerging market economies such as China, India and the Middle East. The increase in global economic growth has been followed by an increase in oil consumption, in particular in these countries. Since 2003, the average oil consumption growth has been 1.8 percent per year, and the above-mentioned emerging economies alone account for two-thirds of that growth (CFTC, 2008). Additional stimulate of oil consumption in these countries is the use of subsidies and other administrative measures to control domestic fuel prices - these artificially boost demand by reducing the domestic oil price compared to the market price (CFTC, 2008).

The short run demand for oil in the recent years has also been relatively price inelastic, meaning that the demand for oil is somewhat insensitive to changes in the oil price. Therefore, only large price increases will dramatically reduce the amount of oil demanded in the short run. Accordingly, the demand for oil has continued to increase despite the extraordinary high prices. The recent economic developments of 2008 however, have partially reduced the demand for oil where the global recession and the credit crunch have been major factors in the reduction of oil consumption, especially in the U.S. and Europe. However the consumption growth seems to be uninterrupted in China, in fact, Chinese imports of oil in September have been the highest in history (MarketBeat, 2008).

Figure 3.1 illustrates the world consumption patterns divided into geographical areas.

It is evident that the general demand for oil has dramatically increased, in fact the worldwide consumption increased from 76,340 million barrels per year in 2000 to 85,220 million barrels per year in 2007. However it is interesting to see the consumption increase in the Asia pacific region which is mainly driven by the increasing demand from China. The consumption level of the latter, today matches the consumption levels in North America and Europe and Eurasia.

WORLD OIL CONSUMPTION DEVIDED BY REGION (in millions of barrels) Figure 3.1



Source: Self-made. Data source BP Review (2008)

Despite the economic developments of the last year, the EIA Outlook (2008) still estimates that the world oil consumption will increase by 29 million barrels per day (MMBPD)[28] from 2005 to 2030, in the reference case[29]. This will mainly be attributed to the increases among emerging economies of the world where strong economic growth is projected to continue in the future.

3.2.2 Supply of Crude Oil

The supply of oil is determined by the proved oil reserves, their growth rate and the estimates of the undiscovered/non conventional reserves (Banks, 1980). The proved oil reserves indicate how much oil there is, that is profitable to extract. The growth rate of proved reserves is indicative of the improvements in the recovery processes of the discovered oil. The growth rate is driven and determined by technological advances

[28] The term MMBPD will be used from hereon.
[29] The EIA uses three possible scenarios; high, reference and low case, when estimating the development of the future oil prices based on the development of supply and demand– for further elaboration see Appendix 3

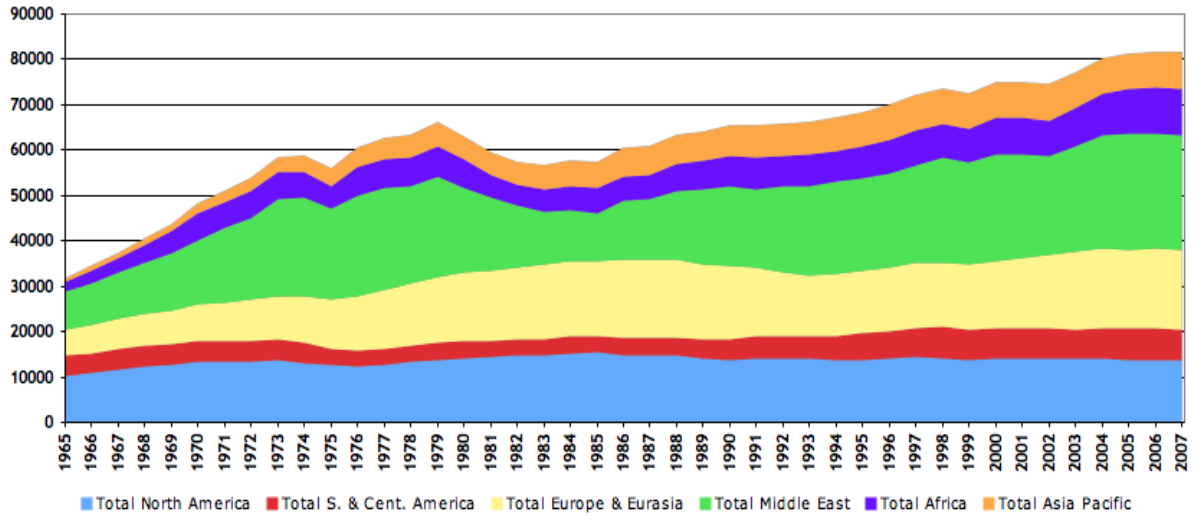
that improve oil recovery and helps maximise the amount of oil extracted from each field. Moreover, estimates of undiscovered/unconventional oil reserves are also used in determining the supply side of oil. The undiscovered reserves are estimates of the amount of oil that is yet to be discovered while unconventional reserves refer to oil that requires production technologies different from the mainstream ones, for example sand oil, bitumen and heavy oils. The unconventional reserves are expected to become conventional in the near future with the help of technological advances (Mitchell et al.,2001).

According to BP review (2008) the current estimates of oil reserves show that there is enough oil to accommodate the current world demand for the next 40 years[30]. These estimates have remained unchanged since the early 1980's (BP review, 2008). However, the high price and restricted supply in the recent years have increased the concerns of economists, politicians and the public with regards to the declining supply and the peak of oil production.

Peak oil is defined as a point in time when oil production reaches its peak. The theory of peak oil, also known as the Hubbert Peak theory, was created and applied by M. King Hubbert in 1956 in order to estimate the peak of the U.S oil production. Accordingly, oil is viewed as a finite resource that will eventually be depleted, therefore, at a certain point in time oil production will reach its peak after which the rate of production will enter terminal decline. In line with these assumptions the production rate is set to follow a roughly symmetrical bell shaped curve based on the limits of exploitability and market pressures. Experts estimate that reserves in effect peaked[31] in 1980, and are now in the declining stage. This is also known as the pessimistic view (Mitchell et al., 2001). Figure 3.2 depicts production developments in different geographic regions over the years 1965 until 2007.

[30] These estimates are based on present production levels while excluding the possibility of finding new reserves.
[31] The peak of the reserve was characterised by production surpassing new discoveries.

DEVELOPMENT OF PRODUCTION BY REGION (in millions of barrels) Figure 3.2



Source: self-made. Data source BP Review (2008)

According to the CFTC's Interim Report (2008), the oil production growth has been stagnant since 2003 and while the global demand has remained strong, the non-OPEC production growth has been well below its growth rates prior to 2003. However, considering that the estimates of the oil reserve future capacity have not changed in the last two decades, one must consider the influence of politics on the supply factors.

Political influence on the supply of oil is derived from the fact that concentration of proved oil reserves is not equally distributed between all the producing countries[32]. As stated by BR review (2008), the Middle East is the region with the highest concentration of oil reserves, totalling 61 percent of the world oil reserves, 21.3 percent of these are located in Saudi Arabia alone. Due to the large concentration of the oil reserves, the Middle East or rather OPEC is responsible for the largest portion of world production. Furthermore, the majority of the spare production capacity is also located in the Middle East. Therefore, the reliance on OPEC production and inventories to fill the gap has dramatically increased, which in turn has significantly tightened the world oil market balance. Additionally, high concentration of production, inventories and access capacity within one region make the supply vulnerable to economic and

[32] The distribution of proved oil reserves and present production are available in appendix 4

geopolitical developments in that region. This is particularly important as the region at hand is the Middle East, which is historically known for being a politically turbulent region.

The EIA Outlook (2008), estimate that in the reference case, the world oil production will increase by 28 MMBPD from 2005 to 2030 to meet the projected growth in demand. Moreover, 47 percent of production increase is expected to come from OPEC member countries.

3.3 OIL PRICE DEVELOPMENT

This part presents an analysis of oil price development in two periods, the historical and the recent periods. This is by first depicting historical oil price developments since it's beginning in 1861 until 2002, with a main focus on the post World War II (WWII) price developments. The time focus was chosen due to the increased use and dependence on crude oil after WWII, furthermore, it was mainly from that period on that the crude oil began to play a major role in the world's economic and political areas. The section then proceeds to depict and analyse the recent oil price development starting from 2003 until October 16th, 2008. The recent development since 2003 is analysed separately due to the distinctive upwards characteristic of the price development and high return volatility during this period. The separation is helpful in keeping a clear line between developments that could imply a speculative bubble and historical occurrences that are seen as inline with the fundamental factors.

Due to the variations in the availability of benchmark prices, Energy Information Administration (EIA) has constructed an overview of historical spot prices by combining various benchmarks. For the period from 1861 to 1944 period the EIA used the U.S average oil prices and from 1945 to 1985 the Arabian Light posted at Ras Tanura has been used, whereas from 1986 onwards the Brent Spot has been used (EIA, 2008).

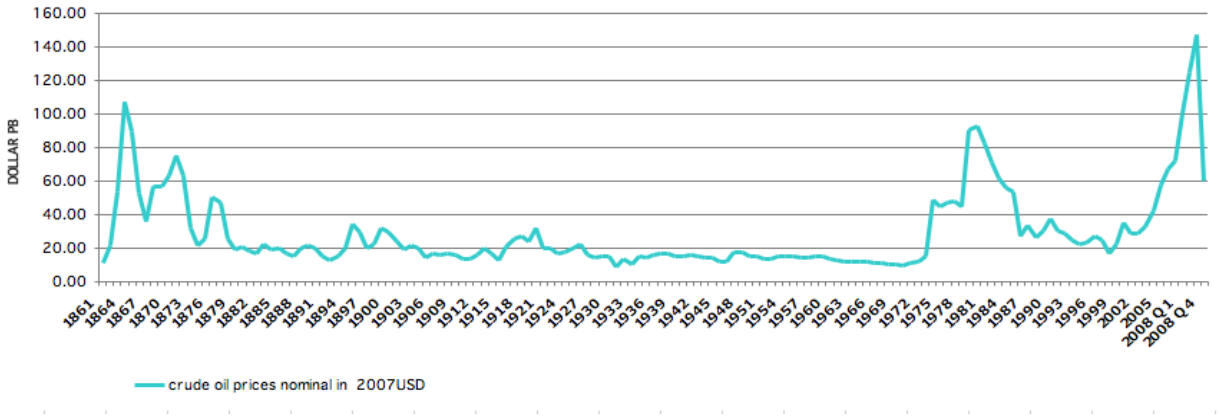
3.3.1 Historical Oil Price Development 1861-2002

The first commercial oil in the United States (U.S.) was extracted in 1859 in Titusville, Pennsylvania, and the first oil price, available in 1861 was quoted at 49 cents/bbl, which corresponds to 11.36 USD in 2007 prices. Figure 3.1 presents the oil price development from 1861 until October 2008 in 2007/8 USD[33]. In the 1860's the price of oil fluctuated substantially, reaching as high as 107.38 USD/bbl, and the sharp price increase could be attributed to the initial large investments made by the oil producing companies. The high prices of the time attracted many new players who tried to get their share of the booming new market (Noreng, 2002). Nonetheless, during the 1870's

[33] For consistent presentation of the price development, all the prices mentioned from hereon, unless otherwise specified, are real prices in 2007/08 USD.

the price gradually fell to approximately 20 USD/bbl, which was most likely caused by oversupply.

OIL PRICE DEVELOPMENT 1861 – 2008 (REAL PRICES IN 2007/8 USD) Figure 3.1



Source: Self-made. Data source EIA (2008). The figure presents the oil price development since 1861 – 2008. The prices are real price adjusted for inflation fro 2007 and 2008.

From the 1870's the price of oil had stabilised and the stability lasted almost a century where the average price of a barrel of oil was 18 USD. During this period, only a few shocks resulted in positive price movements, mainly due to shortage in oil supply. The first was during the very harsh winter of 1919-20, which caused a scarcity of oil supply, followed by the Wall Street crash of 1929, and finally the post war consumption boom in 1947 all causing the supply to fall sharply behind the demand, and therefore resulting in an increase in the price of oil (Mitchell et al., 2001).

In general, the worldwide demand for oil had increased after World War II (WWII), however past the initial price shock of 1947 the prices remained stable, for the next 25 years, with an average price of 14 USD/bbl. The reason behind the stable prices was the constant increase in the supply of oil as the production nearly doubled after the WWII. In the post WWII period, several economic and political events had occurred that changed the world market for crude oil. First, the Organisation of Petroleum Exporting Countries (OPEC) was formed in the1960 by five founding members Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela and by the end of 1971 six other members had joined, Qatar, Indonesia, Libya, United Arab Emirates, Algeria and Nigeria. This created a power union that in later years would be responsible for more than fifty percent of the

world's proven oil reserves. In 1971, The Texas Railroad Commission[34] set the proration at 100 percent, in other words, the commission had lifted the output limits of the U.S. oil producers. The underlying reason for the decision was that U.S. producers had no more spare capacity and therefore no tool of putting upper limit on the prices. This symbolised a major shift in the power to control oil prices, from the U.S. to OPEC. (EIA market chronology, 2007).

The first major oil crisis occurred in 1973/4, when a price of a barrel of oil quadrupled[35] from 15.48 USD/bbl in 1973 to 48.92 USD/bbl in 1974. The crisis was a result of an embargo imposed by OPEC on the western countries as a retribution for their support of Israel in the Yom Kipur War. During the embargo period the supply of oil shrank by 4 million barrels per day (MMBPD). This represented seven percent of the free world production at the time. In March 1974, OPEC decided to lift the embargo against the United States, but persisted with the embargo on the Netherlands, Portugal, South Africa and Rhodesia until June that year.

The aggregated effect of the Arab embargo on oil prices was substantial as the price never diverted back to the pre-embargo level. Furthermore, it showed the world the extent of OPEC's power to influence oil prices. Several projects and funds were established in order to cope with the post crisis situation. One such project was "Project Independence", proposed by the U.S. government, which intended to make the U.S. energy self-sufficient. Another example is the "Oil Facility" fund, established by the International Monetary Fund (IMF) providing loans to nations, who's balance of payment had been severely affected by the crisis.

The International Energy Agency (IEA) was founded by the Organisation for Economic Co-operation and Development (OECD) in 1974, with a main purpose of preventing disruptions in the supply of oil, as well as acting as an information source on statistics about the international oil market and other energy sectors. In addition, the U.S.

[34] The Railroad Commission of Texas established by the Texas Legislature in 1891, is a state agency that regulates the oil and gas industry, as well as surface coal and uranium mining.
[35] The nominal price had quadrupled from 3.29 USD/bbl in 1973 to 11.58 USD/bbl in 1974.

government imposed price controls on domestically produced oil in an attempt to minimise the impact of high 1973/4 oil prices. As a result, U.S. oil consumers got much cheaper oil than the rest of the world, while the U.S. oil producers received less than the world market price. The price controls helped moderate the U.S. recession in the short term, however, it had some long-term effects on future capacity of exploration and production. It is believed that in the absence of price controls, the U.S. exploration and production would have been significantly greater. Furthermore, it is said that the high petroleum prices would have resulted in lower consumption rates and in the development of more fuel-efficient cars and home heating devises as well as improvements in the industrial energy efficiency.

The second major oil crisis struck in January 1979, during which the world oil price skyrocketed up to 93 USD/bbl. The price increase was due to a dramatic drop in the supply of oil caused by a political unrest between Iran and Iraq. First, the Iranian revolution in 1979 resulted in a loss of 2.5 MMBPD. However according to experts at WTRG Economics (2008), the impact of the revolution on the price could have been limited and short lived had it not been for the Iraqi invasion of Iran in September 1980. As a result of the Iraqi invasion, the combined production of both countries was drastically reduced by 6.5 MMBPD. Consequently, the world crude oil production had dropped by ten percent compared to the previous year. The effect of the second oil crisis on the world economy was devastating. The price of a barrel of oil had risen with 211 percent in a period of two years from 1978 until 1980. The rise in the price of oil benefited the OPEC members, other than Iran and Iraq. This was a large transfer of fortune from the Western World to OPEC member countries who made astronomical profits.

The main result of the crises on the U.S. was the beginning of the deregulation of oil prices and the abandonment of price controls. In order to cope with the high price, odd-even gas rationing[36] was imposed in several states such as Pennsylvania, New Jersey and Texas. Furthermore, energy saving became a major public issue and attention

[36] Odd-even rationing meant that only people with an odd-numbered license plate could purchase gas on an odd-numbered day and visa versa.

was directed towards other sources of energy such as solar and gas power. In 1980, the U.S. Government established the Synthetic Fuels Corporation as an alternative to imported fossil fuels. In addition, the U.S. president Jimmy Carter issued a doctrine, which declared that any interference with the U.S. oil interests in the Persian Gulf would be considered an attack on the vital interests of the country.

The European reaction to the crises was somewhat similar, energy saving was a major issue. New houses were built with better isolation, while the old houses got additional isolation. Car manufacturers both in Europe and in the U.S. were working towards more fuel-efficient cars; this is where Japanese imports were also building inroads. Furthermore, non-OPEC producing countries began exploration and extraction of oil in Alaska, Mexico and the North Sea. From 1980 to 1986 the non-OPEC production increased by 10 MMBPD (EIA market chronology, 2007).

The effect of the crisis on Iran and Iraq was also permanently damaging. Iran's production capacity has never recovered from the 1979 crisis, and today, the production level still only reaches two thirds of the pre-revolution production. Iraq's production had a better recovery, however, is still lagging 1.5 MMBPD behind its peak before the Iraq-Iran war. The high oil prices combined with the global recession gradually reduced the demand for oil, which in turn led to a downtrend in the oil prices. During a period of six years the price of a barrel of oil had dropped from 93 USD in 1980 to 27.33 USD in 1986. OPEC attempted to control the prices by setting low production quotas, however this had very limited success as several of its members produced beyond their quotas during that period. It was also said that OPEC's main enforcement mechanism was the Saudi Arabian spare capacity, however when the latter in 1985 decided to link their oil price to the spot market for crude oil and increase production by 3MMBPD[37], the price took a plunge to 27 USD and stayed relatively stable for the rest of the 1980's (EIA market chronology, 2007).

[37] This move by Saudi Arabia was done in order to avoid loosing more market share and revenue. Despite the lower prices, Saudi Arabian revenue remained stable, as the high volumes compensated for the low price.

In 1990, oil prices experienced another up-trend as a result of a political unrest caused by the Iraqi invasion of Kuwait, ensuing the Gulf War. Saddam Hussein's declaration regarding the intention of damaging the oil fields added to the instability of the prices. As the coalition of forces moved to liberate Kuwait, oil prices entered a period of steady decline. The downtrend of the oil prices were very moderate and short lived as the price cycle assumed an up-trend, mainly due to the strong U.S economy and the booming Asian Pacific region. During these years the world oil consumption increased by 6.2 MMBPD, where the Asian consumption accounted for 5.9 MMBPD. Another factor that that may have influenced the price trend was the declining Russian production. Nevertheless, the price increase abruptly ended in 1997-8 as the Asian economic crisis hit. At the same time OPEC approved an increase in the production quota by 2.5 MMBPD (a 10 percent increase) (Mitchell et al., 2001). The combination of reduced Asian consumption and increased OPEC's production caused the oil price to plummet to 16.60 USD/bbl, the lowest real price since 1973. Though by 1999, the prices recovered to approximately 25 USD/bbl, as OPEC drastically reduced production by 3MMBPD. Throughout the year 2000, the prices continued to rise due to the growing U.S and world economy. However this trend was abruptly interrupted by the increased production coming from Russia and the political and economic effect of terrorist attack on the World Trade Centre on September 11, 2001. These events put a heavy down pressure on the oil prices, resulting in 35 percent decrease in the spot price for WTI (WGTR Economics, 2008).

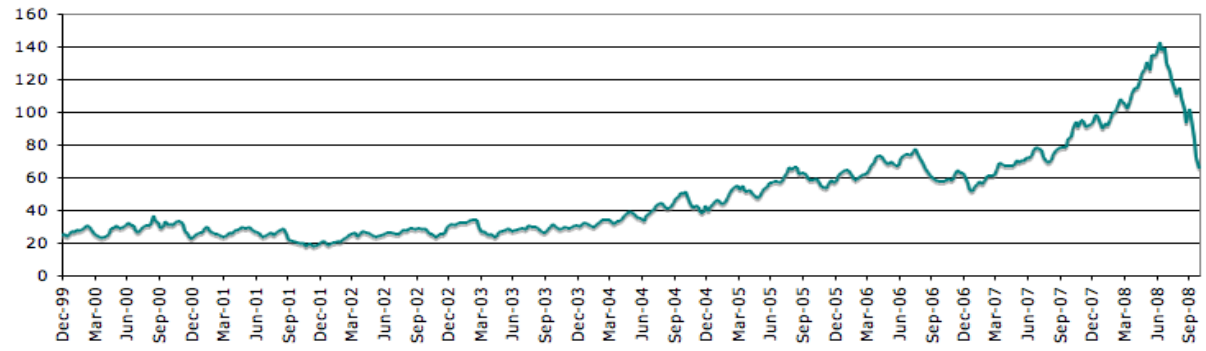
In 2002 several events kept the oil price at nearly 30 USD/bbl, giving ground to the subsequent price spike in 2003. First, in early January, OPEC decided to cut production quotas by 1.5 MMBPD, this agreement was maid in coordination with the Russian and Mexican oil producers. In February, Iraq refused United Nations arms inspectors to return to Iraq. This combined with the production cuts by OPEC and non OPEC producers puts a slight pressure on the price. By mid-autumn the price rose again as the EIA released data showing that crude oil stocks fell to their lowest levels in twenty years. In mid December the price of WTI on NYMEX was traded at nearly 32 USD/bbl mainly due to the general strike in Venezuela and the geopolitical situation in the Middle East (EIA market chronology, 2007).

3.3.2 Recent Oil Price Development 2003 - 2008

The crude oil price assumed yet another uptrend in the very late - 2002, and since then prices had reached record levels. First, the price rose to 32.5 USD/bbl in late December 2002 – early January 2003, and then during 2004 price rose above 40 USD/bbl, settling at 57.90 USD/bbl in the early 2005. A series of events led the price to exceed 60 USD by August 2005, and then briefly exceed 75 USD in the middle of 2006. The price then dropped back to 60 USD/bbl by the early 2007 before rising steeply again to as high as 99.29 USD/bbl by the end of the year. Throughout 2008, crude oil price had been extremely volatile. During the first half of 2008, the price regularly reached ultimate heights, reaching its all time peak of 147.02 USD/bbl on July 11th. From thereon the price assumed a downtrend and proceeded to plummet to below 70 USD/bbl by October 19th.

Figure 3.2 depicts the recent development of the oil price since December 1999 until October 2008 on weekly bases. The prices are denoted by real prices, adjusted for inflation for 2008.

MONTHLY DEVELOPMENT OF WTI 2003 - 2008 (REAL PRICES IN 2008 USD) Figure 3.2



Source: Self-made. Data source EcoWin (2008)

The initial price increase in 2003 was triggered by the political instabilities in the OPEC member countries. First, Venezuela experienced challenges in production as a result strikes and political unrest in mid-January. Then, the constant threat of the U.S. invasion of Iraq also put an upper pressure on the prices, due to the dependence on the Iraqi large oil reserves. At the time of the U.S. invasion, in March, the Iraqi production decreased abruptly and the price rose to 31 USD/bbl, a 19 percent increase

from the average 2002 price. Nigeria also experienced political unrest at about the same time, as violence broke between several ethnic groups in the Niger Delta area. This caused the three major oil producers to shut down their operations and resulted in a 40 percent loss of the total Nigerian oil production.

At the same time, the economic situation worldwide was improving and the demand for oil was constantly increasing, especially from Asia Pacific. The U.S. domestic consumption had also increased due to the long and cold winter that year. The loss of production capacity in Iraq, Venezuela and Nigeria combined with the increasing demand worldwide contributed greatly to the price spike in 2003. Political unrest in Saudi Arabia, world's largest oil producer, in the spring that year had also greatly contributed to the price increase. On April 21st, Saudi militants attacked governmental targets using a car bomb in the centre of Riyadh, killing four civilians and wounding hundreds. Then, only 40 days later, a complex, housing foreign workers in Khobar was attacked. These attacks created a panic among the foreign firms and their representatives in Saudi Arabia, causing them to reconsider their presence in the country. This tension was evident in the price behaviour as late May price on NYMEX was quoted at 42.33 USD/bbl, the highest price in nearly two decades.

In an effort to moderate high crude oil prices, OPEC decided to increase the production. This however, had a trivial effect on the price, as several incidents during the summer had lowered the non-OPEC production. In July the Russian government decided to freeze all the assets and the bank accounts of Yukos, one of Russia's largest oil producers, disrupting the company's exports to the world. However, in September disruptions, inflicted by Hurricane Ivan hitting the Gulf of Mexico, resulted in 61 percent production loss in the region. Moreover, due to the whether conditions caused by the hurricane, Venezuelan oil tankers, carrying oil to the U.S. were considerably delayed. The effect of Hurricane Ivan on the oil production in the Gulf of Mexico was substantial, causing a loss of approximately 7 percent of the total yearly production in the region. Therefore resulting in a substantial price increase of the WTI.

In the early 2005, the oil price experienced a mild downtrend that could have been a result of the Nigeria resuming its production after a yearlong dispute in the Niger Delta area. Furthermore, British Petroleum (BP) launched their first commercial crude oil production from the Central Azeri field in the Caspian Sea. The downtrend, however, was short lived as already in March 2005 the price began to rise again and reached 58.28 USD/bbl by mid-April. The price increase was mainly driven by the concern of a prolonged weak dollar, and in June the price broke the sixty-dollar barrier.

In the summer months of July and August 2005 the price continued to rise sharply mainly due to disruptions in production caused by the natural disasters in the Gulf of Mexico. The Gulf region suffered serious damages to their production facilities caused by tropical storm Cindy on July 5th, Hurricane Dennis on July 11th, Hurricane Emily on July 19th and finally Hurricane Katrina on August 28th. The damages of Hurricane Katrina alone were extensive and devastating[38]. During the height of the storm 95 percent of the oil production and 88 percent of the gas production in the Gulf region were shut down. The hurricane also had a substantial impact of the oil refineries in the region, shutting down some 2.2 MMBPD of refining capacity. Substantial production and refinery loss drove the price of crude oil as high as 65.67 USD/bbl in the first week of September.

As a response to the hurricanes, in an attempt to ease the pressure on the supply of oil, the U.S government releases 30 million barrels of crude from the SRP. This was accompanied by the release of additional 30 million barrels from the commercial stock of the IEA. Shortly after, before the oil companies had the chance to recover from the damages caused by Katrina, Hurricane Rita made a landfall along the U.S. Golf coast, disrupting production and refinery yet again. The effects of the Atlantic hurricane season continued to linger and affect the price of crude oil all the way into 2006.

[38] The devastating damages mentioned in the thesis refer only to the oil production, refinery and storage. The damages to the economy, infrastructure and most importantly, human life was even more devastating and long lasting however the thesis does not touch upon them.

At the same time, European production experienced difficulties due to worker strikes in France's largest oil refinery. Labour disputes also affected production in the Netherlands and Nigeria, while political instability lingered again over the Middle East. All the above had put additional upper pressure on the price. A combination of a rising global demand and weakened supply, due to natural disasters and geopolitical instability, contributed to the high oil price in 2006[39]. Furthermore, during the first half of 2006 OPEC maintained its production levels, attributing the high oil prices to the lack of global surplus refining capacity, not on the lack of production by its members.

During the first half of 2007 the oil price was relatively stable, circling at around 60 USD/bbl, however, it was not long lived and by mid-May the price rose to 73.93 USD/bbl. Thereon, in mid-October WTI traded at 90.02 USD/bbl, the highest price in over a century which surpassed the high prices of the early seventies and the eighties. The price increase was mainly attributed to the combination of the political unrest in Nigeria and Turkey as well as a disruption of six pipelines by leftist groups in Mexico and an accidental disruption of a pipeline in the North Sea. During the rest of the year, the oil price kept pushing the limit and breaking new records.

In 2008 the oil price reached new heights and broke all time record. On January 2nd, trading opened at a price above 100 USD/bbl, mainly due to political tensions on New Year day in Nigeria, furthermore, pessimistic domestic outlook of rising unemployment had a minor negative impact on the price. In mid-March the price reached as high as 110.20 USD/bbl, this rise represented the sixth record in seven trading days. During the rest of March the price fluctuated within a band of 99 - 111 USD/bbl, breaking new records yet again by mid-April when rising to 119 USD/bbl. The increase was mainly attributed to the political tension between the U.S. and Iran, when the news about the U.S. Military Sealift Command firing at an Iranian boat had reached the market.

From thereon, the price continued to rise aggressively, passing the mark of 130 – 135 USD/bbl in less than 24 hours[40]. On June 6th, the price increased 11 USD in a single

[39] In the early 2006, 18 percent of the Gulf Coast supplies were still disabled.
[40] May 21st, crude oil traded at 130 USD/bbl, less than 24 hours later on may 22nd crude oil traded at 135 USD/bbl

day, making it the largest one day increase in history and by the end of the month it was as high as 141.71 USD. The main driver behind the price increase was most likely the political instability in the Middle East, namely the possibility of Israel's attack on Iran.

The ultimate record to this day was reached both on NYMEX and on ICE during the month of July. On July 11th the London Brent Crude was trading at 147.02 USD/bbl –the highest price for a barrel of oil to this date. The price spike was following the tension between the U.S and Iran, OPEC's second largest producer, created fears among traders that OPEC could retaliate by blocking the Strait of Hormuz, the passage responsible for the passing of 40 percent of world's tankers.

Since its peak on July 11th, the oil price has been experiencing a downtrend. Indications of significant demand reductions as a result of the high prices that were predicted by the chairman of the Federal Reserve, Ben Bernanke, contributed to this development. The credit crisis and the fears of its reach as well as the relaxation of the tension between the U.S. and Iran have also contributed to the price decline.

By the end of July the price dropped to 128 USD/bbl, by middle of August it was 113 USD/bbl and by the end of the summer the price fluctuated around 100 USD/bbl. In the early September Hurricane Ike hit the Gulf of Mexico, the heart of the U.S oil refineries, however the oil price preceded to decline, closing at about 100 USD/bbl. In mid-September the price rose again to 120.92 USD/bbl, making a record one-day gain of 16.37 USD and causing the electronic trading to be briefly suspended on NYMEX[41]. The price increase could be attributed to growing optimism in the market with regard to the success of the U.S. governmental bailout to help ease the pressure of the credit crisis on the U.S. economy. In late September however, the oil price fell below 100 USD/bbl after the U.S. Congress failed to pass the 700 billion dollar bailout program. Then the price proceeded to fall to 92 USD/bbl in the aftermath of the Lehman Brothers bankruptcy, the largest bankruptcy in the U.S history.

[41] NYMEX has a daily price rise limit of $10 (EIA, Annual Oil market Chronology, 2007).

On October 10th a barrel of oil traded at 78 USD and by October 16th it fell below 70 USD/bbl. This price drop represented a 53 percent plunge from the ultimate price peak just 3 month earlier (on July 11th). The concern over the effectiveness of the U.S. bank rescue program to restore demand and OPEC production cuts were among the factors that influenced the price. Furthermore, a stronger US dollar and a likely decline in European demand have also contributed to the price decline (The National, October 19th, 2008).

3.4 DISCUSSION

Over the last forty years the demand for oil has been increasing dramatically. This increase is mainly attributed to the robust economic growth, industrialisation and globalisation effects of the 20th century. In the recent years the increased demand came especially from the emerging market economies such as China and India. This demand increase is projected to continue in the future, perhaps at a more moderate rate (EIA outlook, 2008). The supply of oil, during that period has also increased but at a somewhat lower magnitude. Additionally, one must consider the distribution and concentration oil reserves and production. The fact that a large portion of oil supply is concentrated in the Middle East provides OPEC with market power to influence prices by simply adjusting volumes. This makes the supply market for oil an oligopoly, dominated by few sellers.

These combined factors create a tight market for oil, which is characterised by imperfect competition and supplier concentration. As the oil price is sensitive to changes in the supply and demand, which are in turn influenced by the economic and geopolitical factors in the producing as well as consuming countries, these put an upward pressure on the oil price. The tight oil market and the high oil price brought the discussion of the peak oil theory to the centre of attention. Nonetheless, despite the fact that earth's finite oil supply means that peak oil is inevitable, technological innovations in discovery and exploration of oil have at times changed the understanding of the total oil supply.

Throughout the history of oil price development four major events had a substantial impact on the oil price. First was the oil crisis of 1973, which was a result of the Arab oil embargo on the Western counties as a retribution for their support of Israel in the Yom Kipur War. Then was the oil crisis of 1979/80, which was instigated by Iraqi invasion of Iran in 1979 and resulted in a sharp plunge in production in the two countries. The third major event was the Gulf war in 1990 when Iraq invaded its neighbouring Kuwait resulting in a sharp decrease in production from the region and a substantial price increase. The fourth and the most recent major event was the anticipated U.S invasion of Iraq in 2003. Since then the price surged to record levels for a consecutive period of five years, until July 2008.

The impact of the four shocks on the oil price was substantial. During these times the price rose dramatically for continuous periods of time, furthermore, it seems that the price did not deviated back to its original level in the aftermath of the crisis/shock at least not in the case of the first three events. However the most recent event is of a rather different characteristics as the price increase during the last five years has been continuous and gradual compared to immediate and abrupt price increases during the three other crises. Furthermore, the demand for oil during the recent years continued to increase despite the high prices, this was not the case in the former shocks. Additionally, the analysis of price development shows the volatility over the last five years had sharply increased reaching it peak in 2008 where the oil price hit 147 USD/bbl in July, a 63 percent increase from December 2007. Then by October 2008 it dropped to below 70 USD/bbl representing a 53 percent plunge from its peak just three month earlier. Therefore, one must wonder whether the price increase can be solely attributed to the fundamental changes in the supply and demand and the political and economical factors that influenced them. Or whether there were other factors that contributed to this substantial price increase, this will be elaborated on in the following chapter.

The recent high oil prices can have a positive impact on the investments in new technologies to increase exploration and refining efficiency as well as promote discoveries of new conventional and non-conventional oil reserves. The investments are necessary in order to amend the course of production and guarantee a continuous

supply of in the long-term. However this is a cyclical matter as high prices encourage investment in such projects, which then create periods of supply surplus this in turn put a down pressure on the oil price in the long term. The factors that can alter the demand for oil are the alternative energy sources and transportation means, and while these already exist, their accessibility, affordability and efficiency are not yet fully developed.

CHAPTER 4 – THE DISCUSSION OF OIL PRICE DYNAMICS

The development of the oil price over the last 5 years has been receiving increasing attention from economist, politicians, policy makers and the public. It has become a key concern for consumers and businesses around the globe. The unusually high price of oil up until mid summer 2008 and then its dramatic plunge raise the concern of a bubble in the oil market, where the oil price has been driven by speculative behaviour rather than fundamental factors of supply and demand.

A great amount of resources has been allocated to analysing and explaining the recent oil price development. This chapter first presents a discussion of the oil price formation based on market fundamentals as assumed by the *efficiency theory*. In efficient markets, when oil price is said to reflect fundamentals, the price development is explained by the changes in the current and future supply and demand factors. The chapter then proceeds to analyse the oil price development from a behavioural perspective. Firstly, the oil market anomalies in the period 2003 – 2008 that challenge the efficiency of the crude oil market are discussed as these indicate a possibility of a speculative bubble. These are among others, speculation, excessive trading and market overreaction. When oil price is said to exhibit a bubble, the price development is no longer solely influenced by the supply and demand factors, but is also influenced by the behaviour and the activity in the oil futures market. The chapter then proceeds to discuss *how* behavioural finance theories can contribute to explaining the various market occurrences and the oil price development.

4.1 OIL PRICE DYNAMICS BASED ON MARKET FUNDAMENTALS

"*Ever since Eugene Fama published his paper in 1970, the issue of market efficiency in capital and commodity markets has long been an interesting subject of study and debate*" (Milonas and Henker, 2001: 25).

As discussed in chapter two, the efficient market hypothesis argues that observed market prices fully reflect all available information. With respect to future commodity markets this hypothesis entails that future oil prices fully incorporate all available

information that affects future spot prices. The general determinant of the oil price in an efficient market is therefore, the present and future supply and demand factors as well as their potential changes – this is also known as the *fundamental approach* (Ye et al., 2002). A traditional method of modelling the oil price, based on the fundamental factors, is the *inventory model approach*. Accordingly, oil inventories capture and reflect the interaction between the supply and demand forces and therefore contribute to explaining the oil prices (Merino and Ortiz, 2005). Petroleum inventory levels are considered to be a measure of balance or imbalance between the production (supply) and demand sides thus, they reflect changing market pressure on the oil price and provide a good market barometer of the oil price changes in the short run (Ye et al., 2002). Additionally, research has shown that the oil price seem to be more responsive to changes in inventory levels than changes in production (Ye et al., 2002).

4.1.1 The Inventory Model

Pindyck (1994) developed an inventory model that aimed at capturing supply and demand shocks and their effect on commodity prices. The model was initially used for copper, heating oil and lumber but later Pindyck (2001) applied the model to crude oil, heating oil and gasoline. The fluctuating demand conditions in commodity markets create the need for inventories as these enable the producers to reduce costs of adjusting production to sudden demand changes as well as reducing marketing costs and avoiding stockouts (Pindyck, 1994). Thus producers can reduce costs by selling out inventories during high demand periods and replenish inventories during low demand periods. Industrial consumers that use crude oil as a production input also hold inventories for the same reason (Pindyck, 2001). When inventory holdings are flexible, production need not necessarily equal consumption, instead inventories can be used as a buffer. Therefore, according to the inventory model the market-clearing price is determined by production, consumption and change in inventory levels (Pindyck, 1994).

The spot price is estimated by using relative inventory variables (Ye et al., 2002). Relative inventory (RIN_t) is defined as the actual inventory levels less the optimal inventory level. Actual inventory levels (IN_t) are the reported inventory levels either by

the U.S. government, the OECD or commercial oil companies. The optimal inventory levels (IN_t*), on the other hand, are calculated by de-trending and de-seasonalising[42] the observed inventory (Ye et al., 2002). This relationship is expressed in equation 4.1:

(4.1) $$RIN_t = IN_t - IN_t^*$$

The key assumption of the inventory model is that price changes are driven by abnormal supply and demand balance, accounting for any possible trend or seasonality. Therefore, any quantitative difference between the actual and the target inventory level will result in either upward or downward pressure on the oil price (Kristiansen, 2008). The relationship between the oil price and relative inventory level is expressed in the following equation:

(4.2) $$\text{Price of Oil}_{(t)} = \alpha + \sum b_i RIN_{t-1} + \varepsilon_t$$

The ε_t is an error term that incorporates all factors other than fundamentals that can influence the oil price (Pindyck, 2001). Merino and Ortiz (2005) have later termed ε_t price premium.

The price of oil is determined by equilibrium in two interconnected markets namely, the cash market for spot trading of the commodity and the storage market (Pindyck, 2001). In the *cash market*, due to the flexible nature of inventories the spot price does not equate production and consumption but rather the net demand, which is defined as the difference between production and consumption. Market-clearance price in the cash market is therefore defined by the relationship between the spot price and the change in inventory levels (Pindyck, 2001). In the *storage market*, the equilibrium price implies a relationship between marginal convenience yield and the demand for storage (Pindyck, 2001). Marginal convenience yield (ψ) is defined as a flow of benefits from holding an inventory, or simply the price of storage (Pindyck and Rotemberg, 1988). The convenience yield is comprised of physical cost of storage and the opportunity

[42] Oil prices follow seasonal trends due to seasonal trends in supply and demand. In the wintertime the higher demand for oil is resulting in a higher price, the opposite trend is seen during the summertime. In order to get an overview on yearly bases the supply, demand and inventory factors need to be de-trended and de-seasonalised.

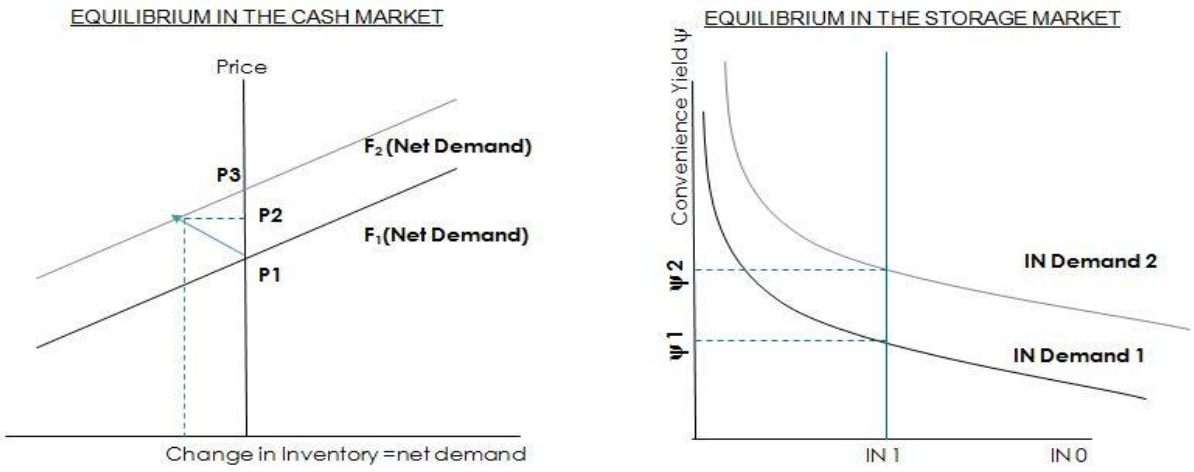
cost of capital of investing in oil. For commodities with actively traded future contracts[43], convenience yield can be measured as a function of future prices (Pindyck, 1994).

The supply of storage is the total inventories held by all the parties (producers/consumers/third parties). The demand for storage however, is a function of the convenience yield, current and expected consumption rates and most importantly price volatility. Both the cash market and the market for storage are highly sensitive to price volatility. One of the main causes of price volatility is supply and demand fluctuations and rigidities, furthermore, price fluctuations themselves cause supply and demand to fluctuate (Pindyck, 1994). Whenever, the price volatility increases it positively effects the demand for storage as it makes scheduling and stockouts more costly (Pindyck, 2001).

The equilibrium in the cash and storage markets are illustrated in figure 4.1. The figure presents the market-clearing price in the two markets. *In the cash market*, when the demand for oil increases it shifts the net demand function upwards from F1 to F2. The change in price ultimately depends on what happens to the inventories: in case the production adjusts to the demand, the net demand stays the same and the price will rise to P3. Whereas, in case production stays the same and inventories are used as a smoothing mechanism, the price will only rise to P2. In the *storage market* on the other hand, the demand for storage (IN Demand) is sensitive to changes in spot price volatility. Therefore, when price volatility increase it increases the uncertainty and the need for higher inventory levels, this pushes the IN demand curve upwards. The change in the convenience yield will depend on the change in inventory levels: in case the inventory levels remain unchanged then the convenience yield will rise to $\psi 2$, in case the inventory levels increase due to increased demand for storage the convenience yield will increase and will be somewhere between $\psi 1$ and $\psi 2$. According to Pindyck (2001) it is most likely that when the demand for storage increases the inventory levels increase with it.

[43] Future contracts are contracts in which parties agree to deliver a specified quantity at a specified future price at some date in the future. For an elaborate definition please see Appendix 8.1

EQUILIBRIUM IN CASH AND STORAGE MARKETS Figure 4.2



Source: Pindyck (2001). The figure presents a market clearing price in the Cash and the Storage markets.

4.1.2 Applying the Inventory Model

When applying the inventory model on a set of data on crude oil, heating oil and gasoline in the period of 1984 and 2001, Pindyck (2001) examined the price dynamics and tested the reaction of the fundamental factors to temporary[44] and permanent[45] exogenous shocks. In cases where the demand shock was *temporary*, inventories were used as a buffer and production stayed unchanged, the spot price rose to P2 and the convenience yield rose to $\psi 2$. However, once the shock had passed and demand for oil returned to normal, the net demand curve shifted back, the spot price fell but initially not to its original level as production needed to exceed consumption for inventories to be replenished. When the inventories were re-accumulated the convenience yield fell back to $\psi 1$ and the spot price returned to its original level of P1 (Pindyck, 2001).

[44] Temporary shocks refer to seasonal shocks such as extremely cold winter or minor supply interruptions that are expected to be resolved within a matter of days or weeks.
[45] According to Pindyck 2001, it is difficult to find changes that occurred in real world commodity markets that were expected to persist indefinitely – therefore permanent shocks refer to sustained shocks that are expected to influence the supply and demand factors for a long period of time.

In the case where the demand shock was sustainable and was expected to proceed for a significant period of time the oil price reacted differently. The net demand curve shifted upwards from F1 to F2, this in turn increased the demand for storage and shifted the IN demand curve upwards as well. As a result the convenience yield rose to $\psi 2$ and the spot price increased to P2. As the initial demand change was expected to proceed for a continuous period of time, production had to adjust and inventory levels grew. As inventory levels increased convenience yield gradually fell but not to its original level, the same was expected of the spot price. Therefore, when a demand shock was expected to persist for a long period of time the market had a new equilibrium in which the spot price, the convenience yield and inventory levels were all higher than in the pre-shock market (Pindyck, 2001).

In his study, Pindyck (2001) addressed yet another important relationship, the one between the spot price, future prices and inventory levels. Future oil prices can be used in the calculation of convenience yield. Convenience yield equals the difference between the future and the risk adjusted spot price plus the physical price of storage (Pindyck, 1994). Moreover, future prices can be greater or less than spot prices depending on the magnitude of net convenience yield[46]. When the marginal convenience yield is large, the spot price will exceed the future price and the futures market will exhibit a *strong backwardation*. When the net marginal convenience yield is positive but not large, the spot price will be less than the future price but greater than the discounted future price and the futures market is said to exhibit a *weak backwardation*. When marginal convenience yield is zero the spot price will be equal to the discounted future price and the market will experience zero backwardation. In cases when the market is characterised by zero or weak backwardation the future market is said to be in *contango*[47] (Pindyck, 2001). Furthermore, his research showed that much of the time future markets exhibit weak backwardation nonetheless, frequent and extended periods of strong backwardation were also present in future markets. Additionally, positive correlation between the convenience yield and crude oil spot price was found.

[46] Net marginal convenience yield = (convenience yield – physical price of storage)
[47] For an elaborate definition of strong and weak backwardation please see Appendix 1

The inventory model provides an explanation of short run oil price movements based on rational shifts in supply and demand in each of the two markets, however according to the author it is not unorthodox to expect that some portions of commodity price variations are not solely based on fundamentals but are rather also influenced by speculation, noise trading and herd behaviour, these are incorporated in the model in the 'error term' ε_t (Pindyck, 2001).

The work of Ye et al. (2002) supports and elaborates on the findings of Pindyck (1994) and (2001) in that the inventory model is a simple model that enables a dynamic forecast of crude oil spot price[48]. Ye et al. (2002) also found that the OECD inventory data provided better forecasts than domestic inventory data as it represents a larger portion of world's inventories. Furthermore, it was found that a combination of governmental and commercial inventories provided a better forecast than each of these individually.

4.2 OIL PRICE DYNAMICS FROM A BEHAVIOURAL PERSPECTIVE

In line with the efficient market hypothesis oil price should be determined by the fundamental supply and demand factors. These factors should reflect all available information with regards to the present and future supply and demand of oil. Furthermore, in accordance with the EMH, changes in fundamentals should precede the changes in the price and influence it accordingly. Nonetheless, market occurrences since late 2002 challenge the efficiency theory.

4.2.1 Challenging the Efficiency of the Crude Oil Market

The oil futures market has been studied extensively and has generally been considered efficient by scholars[49]. Nevertheless, the developments of the oil price since 2003, have attracted significant attention and gave rise to the idea that the oil

[48] Ye et al. (2002) tested the inventory model on the data from 1992 to 2001. They have used the OECD inventory levels to forecast the price of WTI.
[49] Studies of Dominguez (1989), Ma (1989) and Bozorg (1990) are among the scholars who found the oil futures market to be efficient in the tested period.

price might exhibit inefficiency or a speculative bubble. A bubble is a spike in the commodity price that is usually caused by exaggerated expectations of future growth, price appreciation, or other events that could cause an increase of its value (Investopedia, 2008). To categorise the recent developments in the oil market as a speculative bubble, significant evidence on the presence of speculation in oil price formation must be presented, furthermore, the above-mentioned phenomena should also be evident in the market. These phenomena, also termed anomalies, as previously defined in chapter two, cannot be fully explained by the rational models, as they require implausible assumption. These are discussed below.

4.2.1.1 Speculation in the Oil Market

Recent works by Merino and Ortiz (2005) and Kristiansen (2008) provided evidence on the high presence of speculative behaviour in the oil market by utilising the findings of Pindyck (2001) and Ye et al. (2002) and applying the inventory model, using OECD inventory levels, to a more recent set of data. However first, it is appropriate to define speculation and draw a clear distinction between speculation and hedging. CFTC Interim report (2008) defines *hedgers* as these traders that have a commercial interest or a physical exposure to the commodity; these are for example energy and oil companies that hedge their physical position. *Speculators*, on the other hand, are non-commercial traders that enter future contracts with an intention of reversing their positions before the physical delivery date, these are for example investment banks, pension and mutual funds (CFTC Interim report, 2008).

With an aim of explaining the oil price developments since 2003, Merino and Ortiz (2005) applied the inventory model to data from 1992 to 2004, which showed that oil prices were highly correlated with the OECD inventory levels up until 2003 and that this relationship had been considerably weaker ever since. Furthermore, the difference between the market spot price and the price predicted by the model, also termed the *price premium* (ε_t), was found to be persistently high[50]. By estimating the size of the

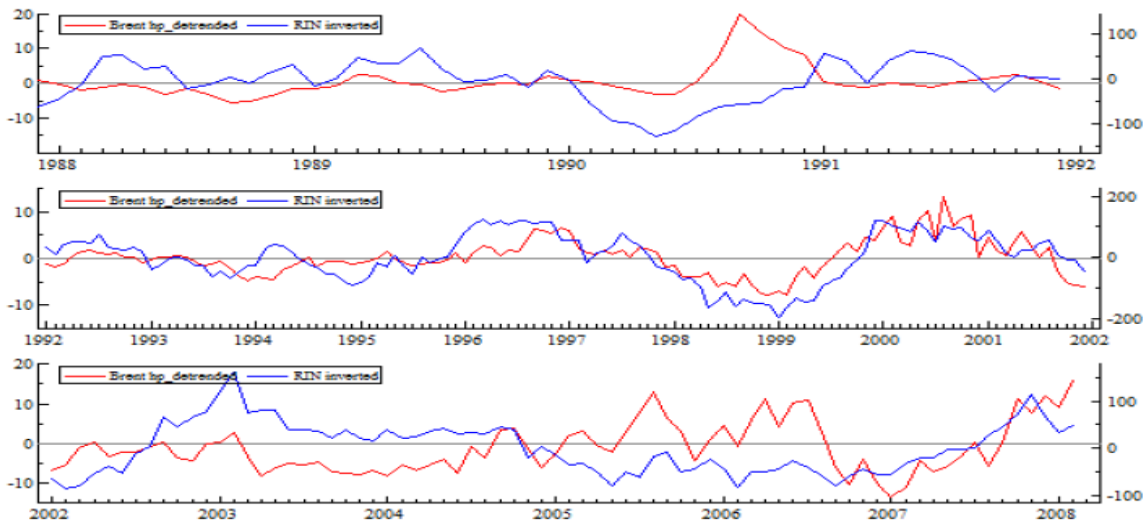
[50] The assumption of the Inventory Model is that when price fully reflect all available information with regards to fundamental factors of supply and demand the price predicted by the model should be very similar to the spot price observed in the market.

price premium and the possible systematic variables that could explain it, it was found that speculative activity had the highest impact on the price premium for the entire sample period. Speculative activity was measured by the number of long positions held by non-commercial traders on NYMEX. When the inventory model was adjusted to account for the speculative activity, it dramatically improved the accuracy of its price predictions. Moreover, Merino and Ortiz (2005) tested the relationship between the oil price and the USD/EURO exchange rate fluctuations, the authors found only a week relationship between the two variables.

Kristiansen (2008) sought to find the significant long-term drivers that could quantitatively explain the recent price movements. Additionally, the hypothesis that market speculation can potentially explain the price premium (ε_t) was tested. The inventory model was applied to a data set dating from 1987 to 2008. The relative inventory was calculated by using OECD inventory data; this was in turn modelled against the price development of Brent crude oil[51] (Kristiansen, 2008). Kristiansen (2008) found that common trends between the relative inventories and the Brent price development have strong presence in the data, however during some of the periods they are less than perfectly in sync. The time series was therefore divided into three sub-periods based on the correlation measure between the inventory levels and price developments. These are illustrated in figure 4.2.

[51] Previously, majority of studies focused on modelling relative inventory against WTI oil benchmark, however due to 0.994 correlation between the Brent and the WTI the conclusions of this research are applicable to both types of oil.

BRENT AND INVENTORIES AS TIME-SERIES PLOTS Figure 4.3



Source: Kristiansen (2008)

Statistical analysis showed that there is a fit between the inventory model and the actual price development as depicted by coefficient of determination (R^2)[52], in the first and the second sub-periods. And while the fit is not particularly strong in the first sub-period, it is very strong in the second sub period (Kristiansen, 2008). This is in line with previous studies by Pindyck (1994, 2001), Ye et al. (2002) and Merino and Ortiz (2005). In the third sub-period however, from late 2002 until 2008 the inventory model fails to explain the oil price development[53]. Based on these results, Kristiansen (2008) named the first sub-period (1988-1992) an *immature market* where neither the fundamentals nor speculation have significant presence and the prices are instead driven by the liquid and mature U.S stock market. The second sub-period (1992-2002) was named the *fundamental market*, where oil prices were driven by fundamentals of supply and demand as well as business cycle components and where no evidence of speculation was found. The third sub-period (2002-2008) however was found to be mainly driven by speculation and was therefore termed *speculative market* (Kristiansen, 2008). Additionally, Kristiansen (2008) showed that it is the speculative

[52] Coefficient of determination - R^2 - is a statistical measure of the portion of variation described by the model. It is defined as the ratio of the sum of squares explained by a regression model and the "total" sum of squares around the mean (Pindyck and Rubinfeld, 1997).

[53] The coefficient of determination in the second sub-period was found to be R^2=0.562, while in the third sub-period it was almost insignificant R^2=0.0499. A detailed table of the results of the relative inventory model as tested by Kristiansen 2008 is available in Appendix 5

activity in the future market that impacted the oil price and contributed to its increase and not visa versa.

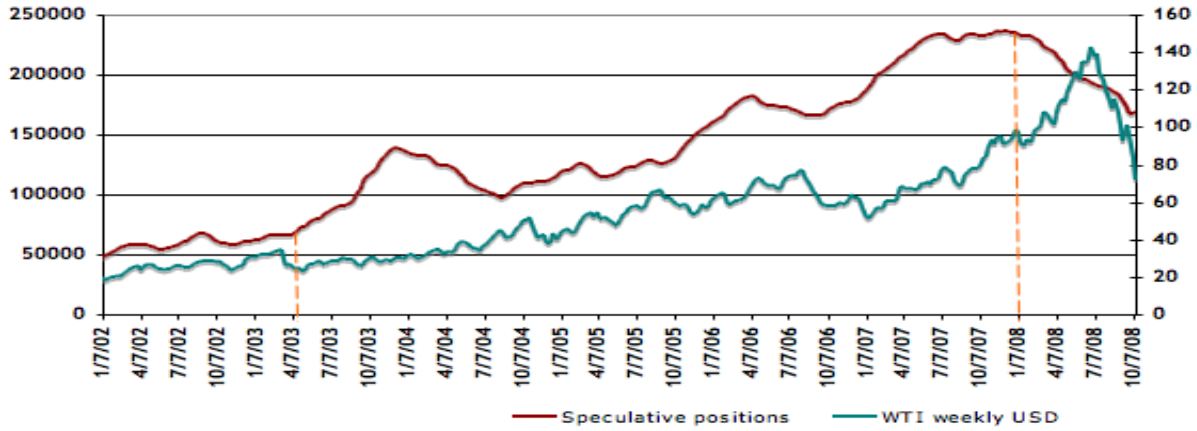
4.2.1.2 Excessive Trading and Market Overreaction

One of the focal predictions of the efficient market hypothesis is that prices reflect all available information therefore, there should be very little trading as any attempt to initiate a trade will unveil the bidder's private information, which would quickly be incorporated into the prices before the actual trade can take place. In reality however, evidence is to the contrary. According to the CFTC Commitment of Trader Reports (2008), the aggregate trading activity on NYMEX had dramatically increased during this time period from 418,682 long-term contacts in January 2003 to 1,173,028 long-term contracts in July 2007 (factor of 2.8) before subsequently dropping to 738,076 in October 2008 (factor of 0.6). Furthermore, speculative activity on NYMEX, which is measured by the non-commercial long positions[54], was also found to have increased considerably. In fact the speculative activity had increase by a factor of 3.8 from 69,202 to 267,721 weekly position holdings in the period from January 2003 to May 2008, prior to declining by a factor of 0.6 to 164,118 weekly position holdings by the end of October 2008. Moreover, the speculative trading activity was found to precede the price changes and is found to be the main driver behind the price increases.

The large increase in the speculative trading activity, in the period of 2003 – 2008, can be interpreted as excessive trading and it appears to have a noteworthy affect on the oil price. This is illustrated in figure 4.3 below. The weekly development of the WTI price is plotted against the weekly development of the non-commercial trading activity (speculative activity) on NYMEX. The data is thereafter filtered using a six months moving average technique in order to reduce the significance of isolated explosive observations in the data on the overall explanation of the oil price development. The data on weekly WTI prices and non-commercial positions on NYMEX as well as the applied filter are available in appendix 6.

[54] The definition of speculative behaviour is used from Merino and Ortiz (2005).

TRENDS OF WTI PRICES AND NON-COMMERCIAL TRADING ACTIVITY (SMOOTHENED) Figure 4.3



Source: Self-made. Data source: The WTI Weekly price from EcoWin. The long positions of non-commercial traders on NYMEX is from the CFTC Trader Commitment report.

The above figure depicts the close relationship between the price development of WTI and the development of the speculative trading activity. Furthermore, the figure indicates that an increase in the non-commercial trading activity in late 2002 was followed by a subsequent price increase. Similarly, a decrease in non-commercial trading activity in October 2007, was followed by a price decrease in the following year. One explanation to high trading volumes is overconfidence; this is discussed in section 4.3.

4.2.1.3 Oil Price Volatility

Excessive trading that is discussed in the previous section, might also have an effect on price volatility, causing the market to overreact (De Bondt and Thaler, 1990). An analysis of price volatility had been computed on a sample of the daily WTI prices in the time period from May 1987 to late October 2008. First, relative price changes, otherwise known as price returns, are calculated on a continuous compounding basis with the price return computed as the natural logarithm of the price spread between time (t) and (t-1). This relationship is depicted by equation 4.3. LN denotes the natural logarithm, $P_{(t)}$ denotes WTI price at time (t) whereas $P_{(t-1)}$ stands for WTI price on the previous day[55].

(4.3) Price Return (R) = Relative Price Change = $LN [P_{(t)} / P_{(t-1)}]$

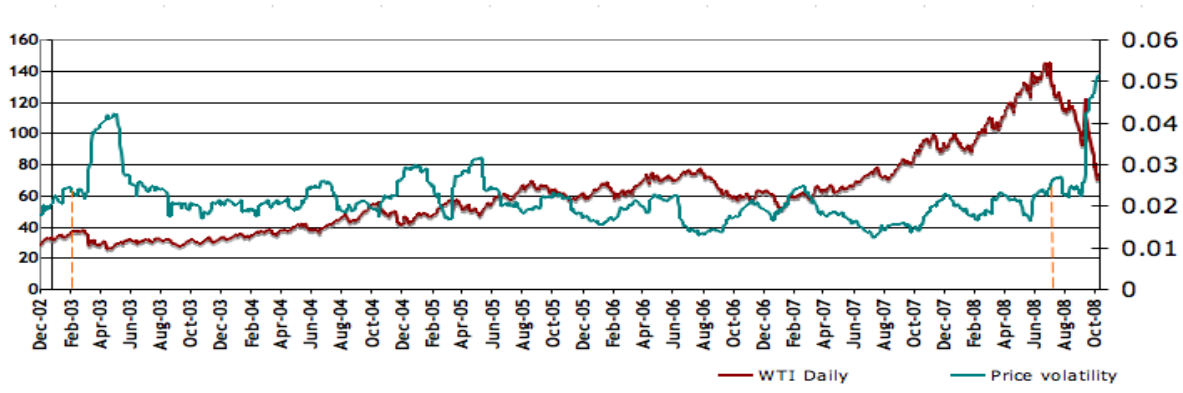
[55] The figure of daily returns on WTI prices is depicted in the following section (section 2.2.4).

The volatility of the WTI price is then computed on basis of historical volatility[56] also known as the moving average volatility and is expressed in equation 4.4 below.

(4.4) $$\text{Volatility } (\sigma_t^2) = (1/N)\sum_{i=1}^{N} R_{t-i}^2$$

N denotes the time period of the moving average. For the purpose of the experiment, the moving average, or fixed window is set for 60 business days. Thus enabling the model to portray a more realistic picture of volatility in the market while reducing the significance of secluded extreme observations in the data. The moving average approach has been criticised because it places the same weight on all observations within the moving window while ignoring the fact that more recent observations might contain more information than older observations (Jorion, 2007). Furthermore, changes in volatility might occur when extraordinary observations fall out of the moving window, this creates plateaus when volatility is plotted against time[57]. However historic volatility serves well the purpose of this analysis, as it enables the reader to understand the general volatility trends in the oil market and which factors might affect it. Though it is important for the reader to be aware of the limitations of this approach. The results of the volatility analysis are illustrated in figure 4.4 below.

OIL PRICE VOLATILITY (Daily WTI prices) Figure 4.4



Source: Self-made. Price data source EcoWin (2008)

The figure shows that price volatility seem to follow the change in the WTI price quite closely. The two spikes marked by the yellow lines two represent the start of the

[56] The methodology of calculating historical volatility was adapted from Jorion (2007).
[57] These plateaus are evident in figure 4.4 and have a width of 60 days.

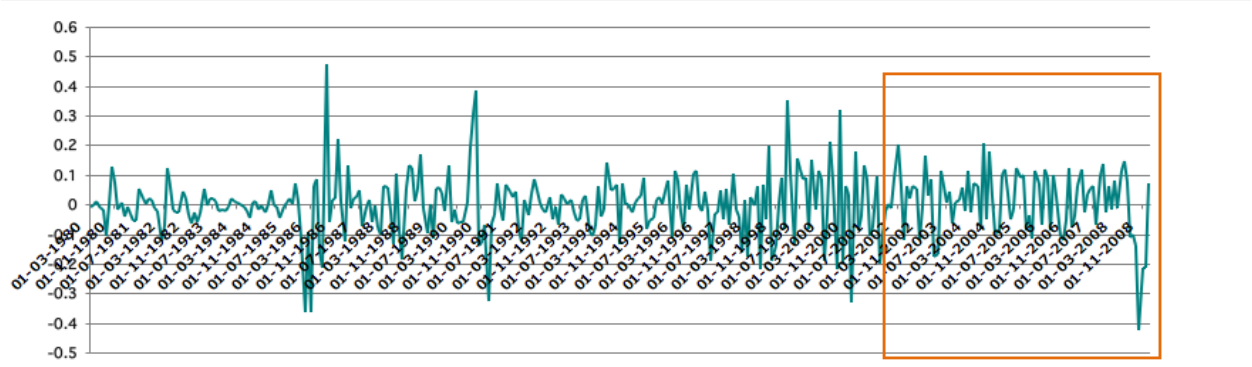
bubble and the beginning of its end. The first spike in volatility around March 2003 corresponds to the oil price increase during the anticipated U.S invasion of Iraq. The second spike in price volatility in summer 2008 relates to the plunge in the oil price after its peak in July that year. These two spikes could be viewed as points of market overreaction. The first point was characterised by optimism in the market with regards to the oil price, thus investors rush to take long positions in the market. Whereas the second point could be characterised by pessimism and fear where investors try to sell out all their positions. In any case neither of these occurrences portray an efficient market where investors act rationally.

4.2.1.4 Short-Term Momentum and Long-Term Mean Reversion

In efficient markets prices should follow a random walk. Accordingly future prices cannot be forecasted and the best predicament of tomorrow's prices are today's' prices. Nevertheless, oil prices seem to follow a negative serial correlation, also termed mean reversion. Consequently, price increase will be followed by a subsequent price drop and visa versa. The intuition behind the mean reversion in the oil market is that when the price of oil increases above a long-term mean price level, the supply of the commodity will increase as new producers enter the market which in turn intensifies competition and puts a down pressure on the price. On the other hand, when the price of oil decreases below the mean price level, supply of oil declines which forces many producers to leave the market, this in turn puts an upward pressure on the price. However as this mechanism might extend over a period of time, temporary momentum effects are present in the market. Momentum as defined earlier is a positive serial correlation meaning that a price increase/decrease is followed by a further price increase/decrease. The momentum period in the oil market is characterised by periods when the demand for oil is inelastic to changes in the oil prices. Mean reversion has presence in the data of the logarithmic daily returns on the WTI prices[58]. This is illustrated below.

[58] These were computed on the basis of equation (4.3) as a prerequisite for the purpose of volatility analysis.

DISTRIBUTION OF LOGARITHMIC RETURNS ON DAILY WTI PRICES Figure4.5



Source: Self-made. Price data source EcoWin (2008)

The figure shows the tendency of the oil price returns to exhibit mean reversion in the long run, with short-lived momentum periods. The implication of this observation is that it introduced a certain degree of predictability to the oil market. This stands in contrast to the efficient market hypothesis where prices should follow a random walk.

4.2.2 Explaining the Anomalies

The works of Merino and Ortiz, (2005) and Kristiansen (2008) show that the oil market and oil price dynamics in particular present a challenge to the EMH, as these cannot solely be explained by the fundamental factors of supply and demand. On the contrary, the above analysis suggests that the oil market has been mainly driven by speculative behaviour. Furthermore, the existence of the anomalies such as excessive trading and negative serial correlation raise the question regarding the efficiency of the market. Based on the excessive presence of speculation in the oil market coupled with the presence of the above-analysed anomalies, there is a reason to believe that the oil market exhibited a bubble in the time period 2003-2008. Consequently, the presence of human behaviour in the oil market and its influence on the oil price indicate that behavioural finance theories could greatly contribute to analysing and explaining these anomalies by relaxing the assumptions underlying individual rationality. This section starts by outlining how theories regarding investor sentiment can contribute to

explaining these market anomalies, thereafter this section proceeds to address the theory of limited arbitrage in the oil market.

4.2.2.1 Investor Sentiment

As it is impractical to assume that investors are fully rational all the time, investor rationality and behaviour is better explained by behavioural finance theories, which describe the rationality as bounded. As a result of bounded rationality, investors in general and oil investors in particular are not always able to perfectly process new information; thus they rather often rely on frames and heuristics. These could be very helpful in identifying and understanding patterns in the data however these usually lead to systematic and predictable biases. These biases were defined in chapter two as cognitive biases. Consequently, oil investors are prone to cognitive biases such as framing, overconfidence, optimism and wishful thinking and belief perseverance, which cause them to behave socially and follow each other's mistakes by believing rumours or/and imitating their peers (herd). This type of behaviour might be the reason behind the anomalies observed in the oil market.

Cognitive biases have previously been found to give rise to phenomena such as excessive trading and speculation (chapter 2). Empirical research on the existence of these biases in equity markets has been reviewed and analyses in the theoretical analysis. However testing the presence of these biases in the behaviour of oil investors during the period 2003-2008 is outside the scope of this thesis. Therefore, the present writer takes on the assumption that oil investors like equity investors are subjected and prone to these biases, thus, these biases must exist in the behaviour of at least some of the oil traders during the outlined time period.

The existence of overconfidence in the oil market can be viewed in the high trading volumes in the futures market. As previously portrayed by figure 4.3, the overall trading activity on NYMEX had dramatically increased in the period since with speculators tripling the number of their positions. Additionally overconfidence of market participants can be inferred from the reviews and statements by respected organisations such as the CFTC, claiming that the oil price development is based solely on the fundamental

factors of supply and demand, as should be expected in efficient markets (CFTC:ITF Interim report on crude oil, July 2008).

The reason behind investor overconfidence could be the reliance of investors on frames and heuristics which in turn might lead to cognitive biases such as the *availability bias*, *belief perseverance*, *representativeness* and *conservatism*. Therefore, when trying to predict future uncertain events, investors could apply a short history of data to a broader chain of events, therefore, disregarding the *law of small numbers*.

4.2.2.2 Limits to Arbitrage

One of the main predictions of the EMH is that when mispricing occurs and prices deviate from their fundamental values due to irrationality of some investors, the rational investors will correct this by means of arbitrage. Behavioural theory on limited arbitrage on the other hand shows that arbitrage can be both risky and costly, making it unattractive and thus allows mispricing to continue (Shleifer and Vishny, 1997). According to the theory, three risks create limits to arbitrage, namely the fundamental risk, the noise trader risk and implementation costs. These have been previously discussed in the theoretical analysis and while noise trader risk and implementations costs[59] might be similar in both equity and commodity markets, the fundamental risk faced by oil investors varies substantially.

The fundamental risk evolves around the availability of perfect/close substitutes as arbitrageurs needs to short the overpriced commodity while buying a substitute to hedge against the fundamental risk. However in the case of crude oil close substitutes are not yet available. Substitutes of crude oil are unconventional oils that are heavier and more sour oils as well as the bitumen and tar sands. However these require significantly different refinement processes, which are more expensive and are therefore unattractive. Additionally, technological advances enable the production of synthetic liquid petroleum from coal and natural gas, however these are also

[59] For a definition and discussion of noise trader risk and implementation costs please refer to chapter 2 – the theoretical analysis.

expensive and thus not lucrative alternatives. Hence, until technological advances enable a cost efficient refinement of non-conventional oils and other energy commodities into liquid petroleum, fundamental risk envolved in arbitrage cannot be removed.

Noise trader risk considered during the period of time from 2003 to 2008 has also been substantially large as the mispricing continued for a consecutive period of five years. Arbitrageurs who would have bet against the market in 2003 would have suffered considerable losses for the five following years. Thus the fear of that alone is a valid reason to discourage arbitrage. Additionally, it is important to consider the implementation costs that are evolved when trading a commodity like crude oil. These are among other distribution and transportation costs, storage costs and the usual commissions and bid-ask spreads.

All the above mentioned risks and costs reduce the attractiveness of arbitrage and allow mispricing to continue. These could also partially be the reason for the prolonged period of mispricing in the oil market and thus can contribute to the understanding of the oil price developments.

4.3 DISCUSSION

The oil market is said to be efficient when oil price development is explained by the changes in the current and future supply and demand factors. This is known as the *fundamental approach*, consequently, future oil prices fully incorporate all available information that affects future spot prices. A traditional method of modelling the oil price, based on the fundamental factors is the *inventory model approach*. Petroleum inventory levels are considered to be a measure of balance or imbalance between the supply and demand sides thus, they reflect changing market pressure on the oil price and contribute to explaining the oil price changes in the short run. The relationship between the oil price and relative inventories is complex and dynamic and while the relative inventory captures the affect of fundamentals on the oil price, before any speculation evidence is considered, the price premium (ε_t) captures and explains the residual impact of factors such as speculation that might affect the oil price.

The inventory model has been applied numerous times on various data sets. Strong support for the inventory model was found in the data prior to 2002, however since then, the findings show that price development is best explained by the price premium (ε_t), which in turn was found to be mainly driven by speculation. Thus, in the period from 2003 to 2008, the explanatory power of the fundamental factors had weakened and the oil price was found to be mainly driven by speculative behaviour in the market. Additionally, the presence of market occurrences such as excessive trading, high volatility and market overreaction have challenged the efficiency of the oil market. Also, the pattern of short-term momentum effects and long term mean reversion introduced certain degree of predictability into the market.

Behavioural finance theories when applied to the oil market, contributed substantially to the understanding of these anomalies and enabled to shed light on possible causes of these. The theoretical frameworks on the topic of investor sentiment provided an explanation and rationalisation for different behaviours observed in the market at the time, while theory on limited arbitrage provided the reason for the long lasting effect of the mispricing and market inefficiency.

CHAPTER 5 - CONCLUSION

Crude oil is undoubtedly an important strategic and political resource that plays a significant role in the modern society. Due to its importance as a crucial input to global, national and individual production and consumption, it has attracted the interests of politicians, policy makers, economists and the general public. The development of the oil price over the last 5 years has become a key concern for consumers and businesses around the globe. The unusually high price up until mid summer 2008 and then its dramatic plunge raised the concern of a bubble in the oil market, where the oil price has been driven by speculative behaviour rather than by the fundamental factors.

The aim of this thesis was to analyse the main characteristics of the oil market and its price dynamics in the period from 2003 to October 2008 by supplementing the classical efficiency theory of market fundaments with the theories from behavioural finance. The classical efficiency theory with the underlying assumption of information efficiency, investor rationality and utility maximisation, predicts that markets are always efficient, prices are determined by the fundamental factors and therefore always reflect all available information. Behavioural theories, on the other hand, acknowledge the presence of human behaviour in financial markets, and thus, assert that some financial phenomena can better be explained by relinquishing the assumptions of individual rationality. Accordingly, investors are not always fully rational and consequently markets are not always efficient as predicted by the efficient market hypothesis. These theoretical paradigms provided the basis for the investigation of the oil market and the analysis of the price development in the defined time period. When discussing commodities such as crude oil, the price is said to reflect fundamentals when it incorporates all available information regarding the current and future supply and demand factors of oil. This constitutes an efficient commodity market.

The analysis of the oil market found several supply and demand characteristics that influence the oil price formation. The demand for oil has been steadily increasing since WWII due to the robust economic growth, industrialisation and globalisation effects of

the 20th century. This is mainly attributed to the increasing demand for energy and transportation. In the recent years however, the increase in the demand was particularly large, especially from the emerging market economies such as China, India and the Middle East. The increase in demand is expected to continue in the future, perhaps at a more moderate rate.

The supply of oil has been constantly increasing in order to accommodate the demand. However, since the mid 1980's the balance changed as demand surpassed supply and since, the production has been constantly trying to catch up with the consumption. Therefore, supply continues to increase but at a somewhat lower magnitude. Additionally, one must consider the distribution and concentration oil reserves and production. A large portion of oil supply is concentrated in the Middle East, this provides OPEC with market power to influence prices by simply adjusting volumes and control the flow of oil to the west. Thus making the supply market for oil an oligopoly, dominated by few sellers.

These combined factors create a considerably tight market for oil, which is characterised by imperfect competition and supplier concentration. The economic and geopolitical factors in both producing and consuming countries influence the supply and demand of oil, which in turn puts an upward pressure on the price. And indeed, the pressure that the supply and demand factors have on the price is evident in the fluctuation of the oil price. The analysis of price development has shown that the oil prices have been volatile throughout the entire history, however price fluctuations over the last five years were exceptional and record breaking reaching the peak in 2008, when the oil price hit 147 USD/bbl in July, a 63 percent increase from December 2007. Then by October 2008 it dropped to below 70 USD/bbl representing a 53 percent plunge from its peak just three month earlier. Therefore, one must wonder whether the price increase can be solely attributed to the fundamental changes in the supply and demand and the political and economical factors that influenced them. Or whether there were other factors had contributed to this substantial price increase.

The analysis of the oil price dynamics showed that the explanatory power of the fundamental factors had weakened in the defined time period and the oil price was found to be mainly driven by speculative behaviour in the market. The characteristics of a speculative bubble such as high trading volumes, a situation when buyers outnumber sellers as the wave of optimistic expectations spread in the market pushing prices beyond what an objective analysis of fundamentals would suggest, were observed in the market during the last five years. These are the anomalies that challenge the efficiency of the oil market. Excessive trading activity in general and excessive speculative activity in particular was observed over the last five years. This could lead to an increase in price volatility and cause market overreaction. Indeed the volatility of the oil price increased during the initial price surge in 2003 as well as during the price plunge in 2008. Furthermore, it was found that the oil price follows mean reversion, introducing certain predictability to the oil market.

Behavioural finance theories have a substantial explanatory power when applied to the oil price dynamics as these are able to explain the reason behind market anomalies discussed above. The theory on investor sentiment provided an explanation and rationalisation for different behaviours observed in the market at the time by addressing the issues regarding investor preferences and the way beliefs and expectations are formed. Additionally, the theory on limited arbitrage provided the reason for the long lasting effect of the mispricing and market inefficiency. Accordingly, strategies that are designed to correct mispricing (arbitrage) could be risky and costly and therefore unattractive to investors, thus allowing mispricing to prevail for a continuous period of time.

5.1 AREAS FOR FUTURE RESEARCH

In the process of writing the thesis, present writer came across several interesting issues, which were outside the scope of this thesis. These, however, could be a source of inspiration for future research.

A statistical analysis of the applicability of the behavioural theories can provide valuable insights and a further explanation to the oil bubble. Furthermore, testing the

influence and the magnitude of each of the cognitive biases could perhaps help investors learn from their past mistakes. Additionally, analysing the oil price development by applying the theories from institutional economics can provide additional insight of the oil market as the players in the oil market are large institutions such as Exxon Mobile, Shell and British Petroleum.

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Appendixes

APPENDIX 1 – DEFINITION OF TERMS

Spot price - the current price at which a particular commodity can be bought or sold at a specified time and place. (Investorpedia.com, 2008)

Forward Contract – is an agreement to deliver a specified quantity of a commodity at a specified future date, at a price (forward price) to be paid at the time of the delivery. In a forward contact there are two parties: the buyer (long position party), who will receive the commodity and pay the forward price and the seller (short position party), who will deliver the commodity. Forward contract are usually traded directly among producers and industrial consumers. (Pyndick, 2001).

Future contract – is also an agreement to deliver a specified quantity of a commodity at a specified future date at a specified price (future price) to be paid at the time of the delivery. Future contacts are usually traded on organized exchanges such as NYMEX or ICE and are therefore considered to be more liquid. Furthermore, future contracts are marked to market, which means that there is a settlement and corresponding transfer of funds at the end of each trading day. Future contacts have a lower default risk as the payment is based on daily settlements. The future price are therefore slightly higher than the forward prices, however for most commoddities the differences between the future and forward contract are neglegeble (Pyndick, 2001).

Marked to Market – M2M is an accounting methodology of assigning a value to a position held in a financial instrument based on the current market price for that instrument. (Brealey et al., 2006)

Strong Backwardation -

Weak Backwardation –

Contango – Contango is a term that describes an upward sloping forward curve price curve in the futures markets.

Call option – the option to buy a given stock (or stock index or commodity future) at a given price before a given date

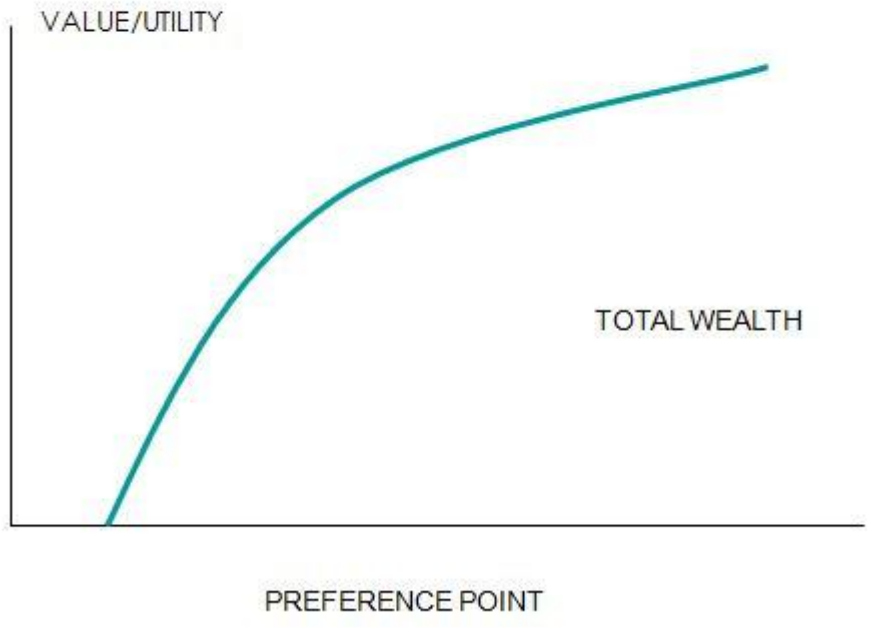
Coefficient of Determination - R^2 – is a statistical measure of the portion of variation described by the model. It is defined as the ratio of the sum of squares explained by a regression model and the "total" sum of squares around the mean (Pyndick and Rubinfeld, 1997).

Hedgers – are traders that have a commercial interest in or have an exposure to the physical commodity; these are for example oil companies that hedge their physical position

Speculators – are non-commercial traders that enter future contracts with an intention of reversing their positions before the physical delivery date, these are for example investment banks, pension and mutual funds.

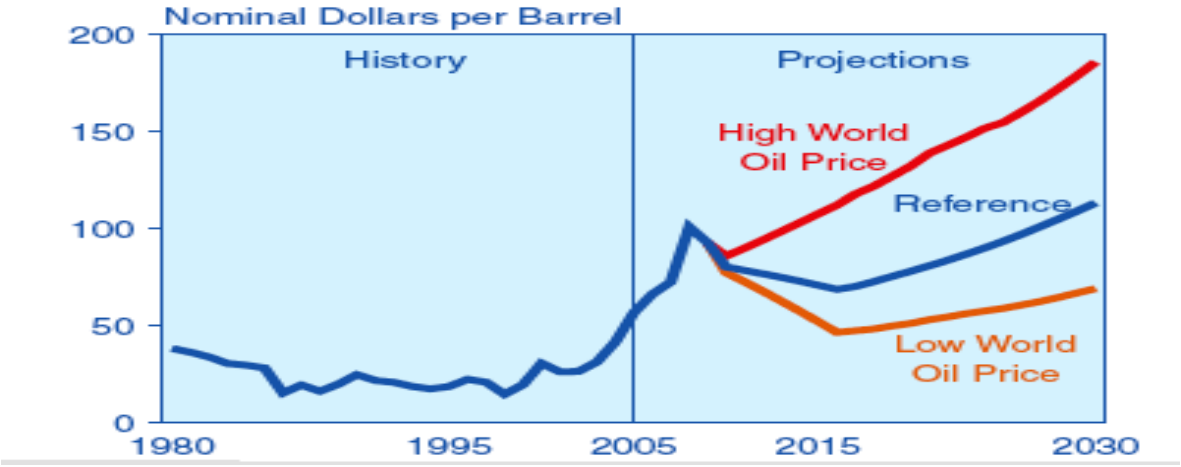
APPENDIX 2 – THE STANDARD UTILITY FUNCTION

The Standard Utility Function assumes that utility is a function of total wealth and that investors are always risk averse.



SOURCE: Fisher and Statman (1999)

APPENDIX 3 – EIA 3 SCENARIOS OF WORLD OIL PRICES 1980 – 2030



SOURCE: EIA OUTLOOK 2008

The EIA considers 3 alternative scenarios for the development of the oil prices in the time period of 1980 – 2030.
The High World Oil Price case assumes that the oil prices will stay at the 2008 price level and rather aggressively continue to increase to around 186 USD/bbl.

The Low World Oil Price case, on the other hand, assumes that the oil price will decline over the years to approximately 46 USD/bbl in 2016 and then increase slowly to 69 USD/bbl in 2030.

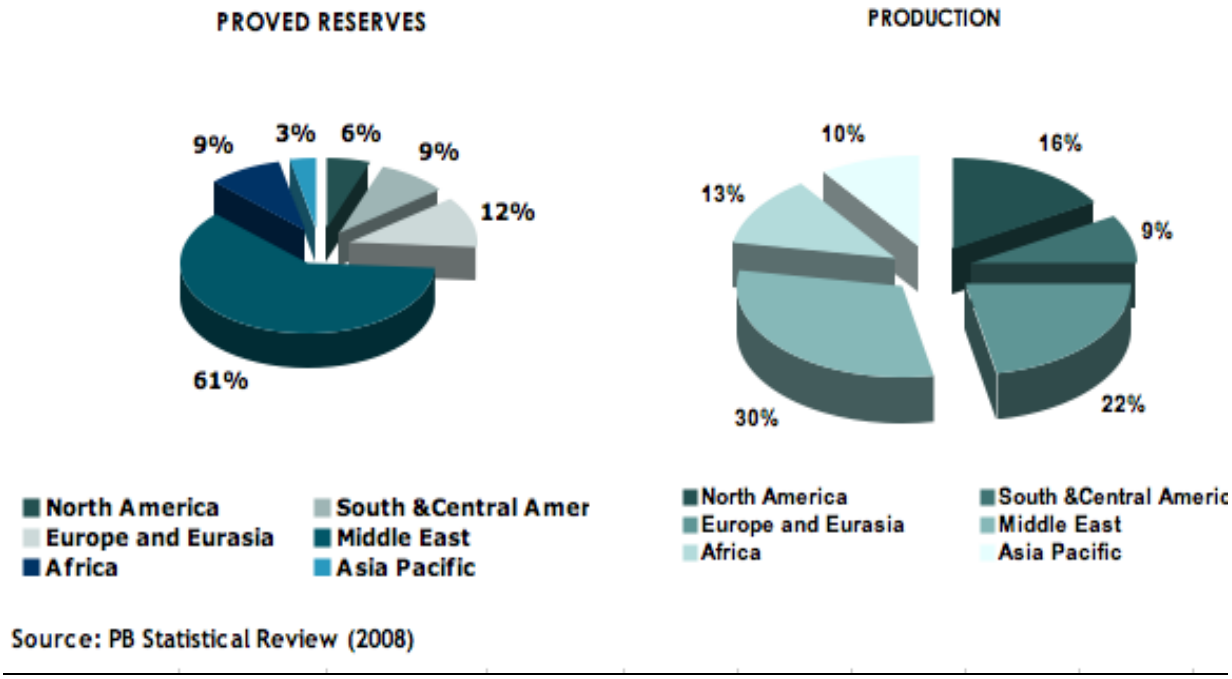
The Reference case, as is also considered the most likely by the EIA, the oil price will slowly decrease to approximately 60 USD/bbl in 2016 and then steadily rise to 113 USD/bbl by 2030.

The EIA sees economic growth as one of the most influential factors on the development of oil prices.

APPENDIX 4 – DISTRIBUTION OF OIL RESERVES & PRODUCTION

The figure illustrates the distribution of oil reserves world wide side by side with the distribution of the oil production worldwide.

DISTRIBUTION OF PROVED OIL RESERVES AND PRODUCTION (BY REGION) Figure 3.3



Source: PB Statistical Review (2008)

APPENDIX 5 – RELATIVE INVETORY MODEL APPLIED TO DATA 1988 – 2008

The following table presents the results of the relative inventory model as applied by Kristiansen (2008) to the a data series from 1988 to 2008.

Endogenous variable Brent HP_detrended	All observations	Sub-period 1	Sub-period 2	Sub-period 3
RIN inverted	0.0261	0.00261	0.0279	0.0194
	(0.0116)**	(0.0224)	(0.00913)***	(0.031)
RIN inverted$_{t-1}$	0.0123	0.00647	0.00617	0.0273
	(0.0155)	(0.0284)	(0.0125)	(0.0397)
RIN inverted$_{t-2}$	-0.00827	-0.0161	0.00292	-0.0337
	(0.0152)	(0.0275)	(0.0124)	(0.0392)
RIN inverted$_{t-3}$	-0.00227	0.00172	-0.000388	-0.00467
	(0.0156)	(0.0285)	(0.0125)	(0.0399)
RIN inverted$_{t-4}$	-0.00516	-0.0517	0.00222	-0.0133
	(0.0116)	(0.0211)**	(0.00917)	(0.0318)
Observations	239	45	120	74
R^2	0.126	0.364	0.562	0.0499
Joint significance	[0,000]***	[0,003]***	[0,000]***	[0,615]

Source: Kristiansen (2008)