Charles University in Prague
Faculty of Social Sciences

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THESIS

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ANALYSIS OF CRUDE OIL PRICE

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Declaration

Hereby I declare that the thesis has been compiled independently and only literature in reference has been used

In Prague on August 31th, 2005

Abstract

The main goal of this work is to test the hypothesis that the technical analysis and its speculative consequences influence widely the crude oil price. This study describes the main features of the crude oil market, its specifics and the historical price development and it takes closer look at the underlying price making forces. Some of them are evident; some of them need more detailed explanation. This work searches for the speculative forces that might influence the price. This work examines the effects that the technical analysis might have in the hands of price predictors and some of its psychological aspects. The validity of the predictions generated by the tools of the technical analysis is being tested. The second part focuses on the fundamental analysis. In order to better understand the channels, first the impacts of crude oil price movements on the economy are described. Then, main channels which influence the crude oil price are explained. The end of the study concentrates on the backwardation phenomenon and compiles existing studies of given topics to provide a complex view on the crude oil price backwardation issue and possible speculative implications. Throughout the work, the sample data set is used to test the validity of the hypothesis of this study. This study does not provide scope for the complex investigation to determine the extent in which the crude oil price is influenced. It suffices to state that certain channels exist and further research with larger data sample would be needed to bring a detailed explanation for the magnitude of given price-making forces.

Acknowledgements

Throughout the preparation of my diploma thesis, I received helpful suggestions from many people. In this regard, I am particularly grateful to RNDr. Alexis Dervitz, CSc. for his kind recommendations and patience. The technical analysis tools have been discussed with Mr. Rob Booker and the external consultants from the oil industry were ing. Václav Loula, ing. Hynek and ing. Marek. Mr. Marek Bednár from Colosseum gave me usefull suggestions about the crude oil markets.

Special thanks belongs to Mr. Igor Muller representing Bloomberg for providing me with the important dataset of crude oil, futures and stock prices.

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LIST OF FIGURES AND TABLES

1. Units and basic definitions

Crude oil is measured in barrels[1]. One barrel equals 42 gallons, or 159 liters.

The following abbreviations are used in the work:

MBD	million barrels per day
MMB	million barrels
t	metric ton (1000kg)
EUR	EURO currency
USD	US dollar
WTI	West Texas Intermediate crude oil
CL(n)	Future contract on NYMEX where n is the number of months till delivery
RDA	Royal Dutch Petroleum Company
XOM	Exxon/Mobile company
BP	British petroleum
NYMEX	New York Mercantile Exchange
IPE	International Petroleum Exchange in London
OECD	Organization for Economic Cooperation and Development
CPI	Consumer price index

This conversion table is presented for a better understanding of the units used with regard to the crude oil.

Table 1
Unit conversion table

	Tones (metric)	Kilolitres	Barrels	US gallons
1 Tones (metric)	1	1.165	7.33	307.86
1 Kilolitre	0.8581	1	6.2898	264.17
1 Barrel	0.1364	0.159	1	42
1 US gallons	0.00325	0.0038	0.0238	1

Source:www.theIPE.com

2. Data used in the study

The data provided by Bloomberg[2] have been used in the thesis. A data set containing intraday and interday prices have been obtained. The interday data contained the period from January 1st, 1990 until June 30th, 2005. The intraday data contain a tick values for two months from May until July, 2005. Unfortunately, longer span of the intraday data was not available as older data are not being stored.

The interday and intraday prices were obtained for WTI oil spot prices and WTI future contracts for 1, 2, 3, 4, 8 and 12 months delivery. Together with the oil prices, the interday and intraday stock prices of British Petroleum, Royal Dutch Petroleum Company[3] and Exxon were used. The selection of these three companies as representatives of the oil industry comes from the availability of the data and the global importance of these companies. Similar results as presented in the study can be expected from a broader sample of oil industry companies. A strong correlation between the stock prices among these companies (on average 0.92) was found.

Besides these stock and commodity prices, the US GDP deflator (quarterly values) for the period 1990-2005 was used to adjust prices for inflation. The EUR/USD exchange rate from 1999 was used to recalculate the prices from USD to EUR to measure the development of crude oil prices in both currencies.

For all prices, the opening and closing as well as the high and low price for given period was obtained. For the interday prices, volume value of the

trades and the ticks per day value was also available. Other commodity data was obtained from the United Nations' statistical yearbook.

3. Methods used in the study

Even though the computation does not reflect an exact picture (for more detailed computations, the data set would need to involve longer time span and larger sample of future contract as well as higher variety of crude oil types), it is sufficient enough to give a basic idea about the influences that are being sought. To compute the regressions, a standard ordinary least square method was used as this method with its simplicity provides the best unbiased estimates.

The modeling in the chapter concerning the technical analysis was done with the help of software designed to capture the searched patterns. Even though visual recognition of these patterns was possible because the dataset obtained from Bloomberg covered only a short time period, the software to enable further research if needed for much larger data sample has been programmed.

4. Commodity and market specifics

The crude oil as any other commodity is traded worldwide. Unlike other commodities, crude oil is far less homogenous than other commodities. Each oil field has different characteristics and thus the crude oil can not be freely taken as homogenous commodity (unlike gold for instance which has one

quality only). The many types of crude oil are imperfect substitutes. The major crude oil characteristics is the sulfur content, high sulfur content is called sweet crude oil, low sulfur content is called sour crude oil. Based on the content of other admixtures the crude is either light or heavy. Crude oil varies in how much gasoline, fuel oil and other petroleum products they yield when being refined. When collecting the evidence of the crude oil types approximately 200 crude types which can be further divided into many subtypes were came across. Nevertheless, in the world there are four basic types of crude oil which are considered to be the benchmark types. These are Brent (produced in the North Sea), West Texas Intermediate (produced in Texas in the USA), Oman (drilled in Oman) and Dubai (drilled in the United Arab Emirates). Each of these four crude oil types count as a price benchmark for a given part of the world. For the whole Europe the benchmark is Brent and for the USA it is WTI crude. Brent being the major crude produced in Europe gives the opportunity to other crude producers and importers to set their prices so that the whole market in Europe uses Brent as the only price variable. The same is valid for the other three indicative crude oils.

Unlike financial markets and unlike many other commodity markets, the crude oil spot market is very shallow. The major producing companies supply the crude oil to the refineries. The supplies are in their majority contracted long before the actual delivery. This condition is based on the physical need for the refineries to have long-term supplies of crude oil. Such contracts

usually involve a formula which calculates the crude oil price at the moment of the delivery. In Europe this formula consists of the reference quote issued by Platt's (PQ) (more on Platt's in the next paragraph) for given commodity (it can be crude oil as well as refined products) plus certain inland premium (ip):

Contract price=PQ + ip, where PQ is defined as the average Platt's quotes for the past week. In cases where transactions are settled in other currencies, the exchange rate is also calculated as the average exchange rate for the previous week. The inland premium rises with the distance and transaction cost needed to import crude oil from the Rotterdam oil base. The inland premium is close to zero for deliveries in Rotterdam. By this formula both sides of the transaction get a just approximation of the market conditions.

4.1. The Platt's

When certain commodity is being quoted, it is always a matter of the demand and supply. The demand and supply usually meet at agreed market building (or the market is run by computer network). In the case of the spot crude oil contracts, the market participants do not meet publicly, rather they contract their deliveries on a bilateral basis. More than 80 per cent of crude oil traded worldwide is not traded at a spot price or under a contract with a price tied to the spot price (Razavi (1989)). For the spot price there is no actual marketplace any real-time reporting of prices. Rather there are many

independent trades that take place at different locations between well-informed traders.

Platt's historically developed into the most respected quoting company offering market information and quotes all around the world. When quoting certain commodity, Platt's contacts the private companies and gathers the information about signed contracts. At the end of each day, the quote for certain crude oil type is set in accordance to the daily trades. During the day, no market participant has a full knowledge about the deals being executed by other oil producers. This creates an imperfect information intraday market conditions.

The market for the spot crude oil covers a very low number of market participants (in comparison to any other commodities or financial instruments). Each oil producer when having an excessive production searches for the demand among other firms without offering the production to the open market. The whole spot crude oil market could be described as very individualistic and influenced by the peer-to-peer negotiations.

There are other similar companies like Platt's operating on the market (Argus for instance[4]) but the European oil industry relies only on the Platt's quotations.

4.2. Crude oil futures

The Brent crude oil futures are being traded on the International Petroleum Exchange (IPE) in London and on the New York Mercantile Exchange

(NYMEX) in New York. The NYMEX futures cover 30 consecutive months based on a quarterly listing schedule plus long-dated June futures initially listed out three years, and long-dated December futures initially listed out three to seven years.

The IPE future maturities cover 30 consecutive months plus January futures listed out 3 to 8 years. The underlying asset is 1000 barrels of crude oil. Besides Brent crude oil, NYMEX trades West Texas Intermediate, Low Sweet Mix, New Mexican Sweet, North Texas Sweet, Oklahoma Sweet, and South Texas Sweet. IPE trades the Brent blend type only. The futures can have a physical or cash settlement. The futures are in most cases used to hedge against price movements. There are also other hedging instruments available like crack spread option and inventory option which help the oil companies to diminish risk associated with strategic petroleum reserves changes and changes in the crack spread.

4.3. Strategic Petroleum Reserve

The strategic petroleum reserves are the governmental inventory of petroleum (either crude oil or refined products) which acts as a security inventory for any external supply disruptions. The strategic reserves act also as a strong market participant because the volume of these reserves in comparison to the daily production is overwhelming. Any decision to change the reserves' volume sends a strong signal to other market participants.

The reserves in the USA have been created after the 1973-1974 Arab oil embargo when the International Energy agency has been founded to counter the influence of OPEC. The reserves in other countries are currently of a similar or lower size as those in the USA covering up to 90 days of imported crude oil volume. The reserves main goal is "...to diminish the vulnerability of the given economy to the harmful effects of petroleum supply disruptions..." The capacity of the US petroleum reserves is 700MMB and currently contains 589MMB covering 59 days of import. Together with the private sector inventory, the USA have approximately 150 days worth of emergency supply. The oil delivered to the reserves is usually "royalty –in –kind" oil – royalties owed to the government by operators who acquire permissions to drill the crude oil.

4.4. OPEC

The Organization of the Petroleum Exporting Countries (OPEC) was formed in September 14, 1960 at the Baghdad Conference with five founding members Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. By the end of 1971 six other nations had joined the group: Qatar, Indonesia, Libya, United Arab Emirates, Algeria and Nigeria. Through coordinated regulation of the member production, OPEC seeks to manage oil prices. OPEC members hold approximately 66 percent of the world's oil reserves. Unlike many other cartels, OPEC has been successful in increasing the price of oil for extended periods of time. Much of OPEC's success can be attributed to Saudi-Arabia's

flexibility. As Saudi-Arabia is the only member with spare capacity to increase supply, if needed.

OPEC with its strong market share (currently at approximately 35 percent) has a unique opportunity to influence the crude oil price by increasing or decreasing the production of the crude oil and thus creating a supply shock followed by an adequate price movement.

Table 2 summarizes the actual oil production of the OPEC members.

Table 2

Current crude oil production of OPEC members and the major crude oil types

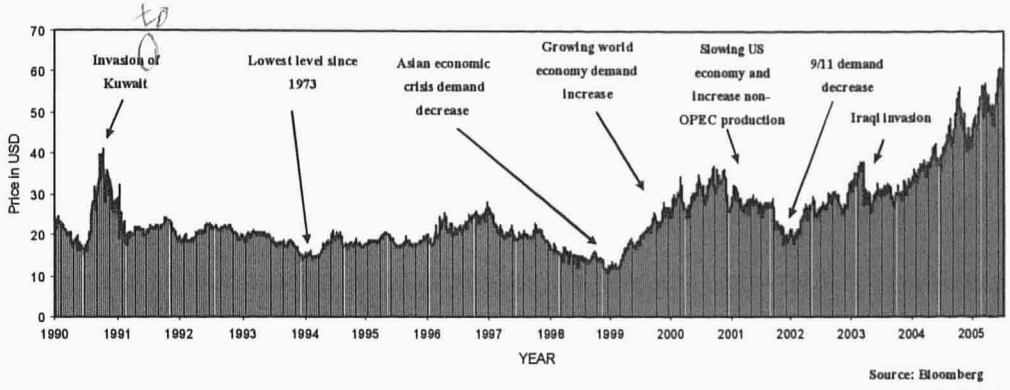
Algeria	894 000	Saharan Blend
Indonesia	1 451 000	Minas
Iran	4 110 000	Iran Heavy
Kuwait	2 247 000	Kuwait Export
Libya	1 500 000	Es Sider
Nigeria	2 306 000	Bonny Light
Qatar	726 000	Qatar Marine
Saudi Arabia	9 099 000	Arab Light
UAE	2 444 000	Murban
Venezuela	3 223 000	BCF 17
Iraq	0	Basra Light
Total	**28 000 000**	

Source:OPEC

5. Crude oil prices

To provide a broader context, this section reviews the prices of petroleum and other primary commodities since the beginning of the last century. The comparison of price volatility with other commodities is also presented. Later in the study, the dataset since 1990 is used. Figure 1 plots these data.

Figure 1-WTI price in USD (undeflated)



5.1. Oil price history with comments

The pre-embargo period dates from 1948 through the end of the 1960s. Crude Oil prices in this period ranged between $2.50 and $3.00. The crude oil price increased from $2.50 in 1948 to about $3.00 in 1957. If the prices are recalculated in 2004 dollars the crude oil prices fluctuated between $15 and $17 during the same period. The apparent 20 per cent price increase was only keeping up with inflation. From 1958 to 1970 prices were stable at about $3.00 per barrel, but in real terms the price of crude oil declined from above $16 to below $13 per barrel. The decline in the price of crude oil when adjusted for inflation was even greater for the international producers in 1971 and 1972 by the depreciation of the US dollar. From the moment of OPEC foundation in 1960 through 1972 member countries experienced steady decline in the purchasing power of a barrel of oil. Throughout the post-war period exporting countries found increasing demand for their crude

oil but also a 40 percent decline in the purchasing power of a barrel of crude oil. In March 1971 the Texas Railroad Commission decided that Texas producers are no longer limited in the amount of oil that they could produce. It meant that the power to control crude oil prices shifted from the United States to OPEC. A little over two years later OPEC would through the unintended consequence of war get a glimpse at the extent of its ability to influence prices.

Middle East Supply Interruptions - In 1972 the price of crude oil was about $3.00 per barrel and by the end of 1974 the price of oil had quadrupled to over $12.00. On October 5, 1973 the Yom Kippur War started with an attack on Israel by Syria and Egypt. The United States and many countries in the Western world showed strong support for Israel. As a result of this support several Arab exporting nations imposed an embargo on the countries supporting Israel. Arab nations decreased production by 5 MBD. Only about 1 MBD was offset by increased production in other countries. The net loss of 4 MBD extended through March of 1974 and represented 7 percent of the free world production. The ability to control crude oil prices had passed definitely to OPEC during the Arab Oil Embargo. The extreme sensitivity of prices to shortages became all too apparent when prices increased 400 per cent in six short months. From 1974 to 1978 world crude oil prices were relatively stable moving from $12.21 per barrel to $13.55 per barrel. When adjusted for inflation the price over that period of time exhibited a moderate decline.

Crisis in Iran and Iraq - Events in Iran and Iraq caused another rapid crude oil price increases in 1979 and 1980. The Iranian revolution resulted in the loss of 2 MBD to 2.5 MBD between November, 1978 and June, 1979. Iraq invaded Iran in September, 1980. By November the combined production of both countries was only 1 MBD and 6.5 MBD less than a year before. Worldwide crude oil production was 10 percent lower than in 1979. The result of the combination of the Iranian revolution and the Iraq/Iran War was doubling of crude oil prices from $14 in 1978 to $35 per barrel in 1981. Twenty-five years later Iran's production was only two-thirds of the level reached under the government of Reza Pahlavi the former Shah of Iran.

The higher prices resulted in increased exploration and production outside of OPEC. From 1980 to 1986 non-OPEC production increased by 10 MBD. OPEC faced lower demand and higher supply from outside the organization.

From 1982 to 1985 OPEC attempted to set production quotas low enough to stabilize prices. These attempts were not successful as many members of OPEC would not follow the recommended quotas. During the most of this period Saudi Arabia acted as the swing producer cutting its production to stem the free falling prices but in August of 1985, Saudi Arabia linked its oil prices to the spot market for crude oil and by early 1986 increased production from 2 MBD to 5 MBD. Crude oil prices fell below $10 per barrel by mid-1986.

OPEC price accord in December 1986 set to target $18 per barrel but this target was already breaking down by January of 1987. Prices remained weak. The price of crude oil peaked in 1990 with the uncertainty associated with Iraqi invasion of Kuwait and the ensuing Gulf War, but following the war crude oil prices entered a steady decline until in 1994 inflation adjusted prices attained their lowest level since 1973.

OPEC had mixed success with controlling prices. There were mistakes in timing of quota changes as well as the usual problems in maintaining production discipline among its member countries. The price cycle then reversed. The United States economy was strong and the Asian Pacific region was booming. From 1990 to 1997 world oil consumption increased by 6.2 MBD. Asian consumption accounted for all but 0.3 MBD of that gain and contributed to a price recovery that extended into 1997. The price increases came to a rapid end when the impact of the economic crisis in Asia was either ignored or severely underestimated by OPEC. In December, 1997 OPEC increased its quota by 2.5 MBD (10 per cent) to 27.5 MBD effective January 1, 1998. The rapid growth in Asian economies had come to a halt and in 1998, Asian Pacific oil consumption declined for the first time since 1982. The combination of lower consumption and higher OPEC production sent prices into a downward spiral. As a consequence OPEC cut quotas by 1.25 MBD in April and 1.335 MBD in July. Prices were declining through December 1998 but began to recover in early 1999 and OPEC reduced prices by another 1.719 MBD in April 1999. As usual not all of the quotas

were observed but between early 1999 and the middle of 1999 OPEC production dropped by about 3 MBD which was sufficient to move prices above $25 per barrel.

With minimal Y2K problems and growing US and world economies the price continued to rise throughout 2000 up to a post-1981 high. Between April and October 2000 three successive quota increases totaling 3.2 MBD were not able to stem the price increases. Prices finally started to fall down following another quota increase of 0.5 MBD effective from November 1, 2000. Russian production increases dominated non-OPEC production growth from 2000 forward and were responsible for the most of the non-OPEC increases since the turn of the century.

In 2001, a weakening US economy and increases in non-OPEC production put downward pressure on prices. In response OPEC once again entered into a series of reductions in member quotas cutting 3.5 MBD by September 1st, 2001. In the absence of the September 11th, 2001 terrorist attack this would have been sufficient to moderate or even to reverse the trend. In the wake of the attack the crude oil price plummeted. Spot prices for the U.S. benchmark WTI were down 35 per cent by the middle of November. Under normal circumstances a drop in price of this magnitude would have resulted in another round of quota reductions but given the political climate OPEC delayed additional cuts until January 2002 when it reduced its quota by 1.5 MBD and was joined by several non-OPEC producers including Russia who promised combined production cuts of an additional 0.46 MBD. This had the

desired effect with oil prices moving up to the $25 range by March, 2002. By mid-year, the non-OPEC members were restoring their production cuts but the prices continued to rise and U.S. inventories reached a 20-year low later that year. By the end of 2002 oversupply was not a problem any more. Political problems in Venezuela led to a strike causing Venezuelan production to decrease. In the wake of the strike Venezuela has never been able to restore the capacity of production to its previous level and still is about 0.9 MBD below its peak capacity of 3.5 MBD. OPEC increased quotas by 2.8 MBD in January and February, 2003. On March 19, 2003, just as some Venezuelan production was beginning to return, military action commenced in Iraq. Meanwhile, inventories remained low in the US and in other OECD countries. With improving economy the US demand was increasing and the Asian demand for crude oil was growing at a rapid pace. The loss of production capacity in Iraq and Venezuela combined with the increased production to meet growing international demand had led to the erosion of excess in oil production capacity. In the middle of 2002, there was over 6 MBD of excessive production capacity but by middle of 2003 the excess was below 2 MBD.

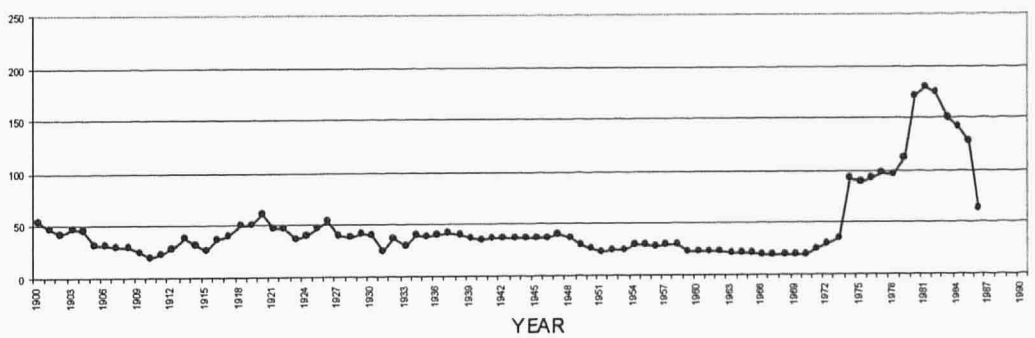
The fact that prices oscillate between $15 and $25 per barrel can be used as a proof of a collusive agreement in the long run among the OPEC members. When comparing the arithmetic mean and standard deviation of the OPEC crude oil price, the price volatility had decreased. Between 1980 and 1989 the arithmetic mean was 24.2 and the standard deviation was 8.3 $/barrel.

Between 1990 and 1999 the same figures decreased to 15.8 and 3.7 respectively. Even thought the OPEC members act as one body, the battle for market shares causes problems within OPEC and the destabilization of the organization.

5.2. Crude oil compared with other primary commodities

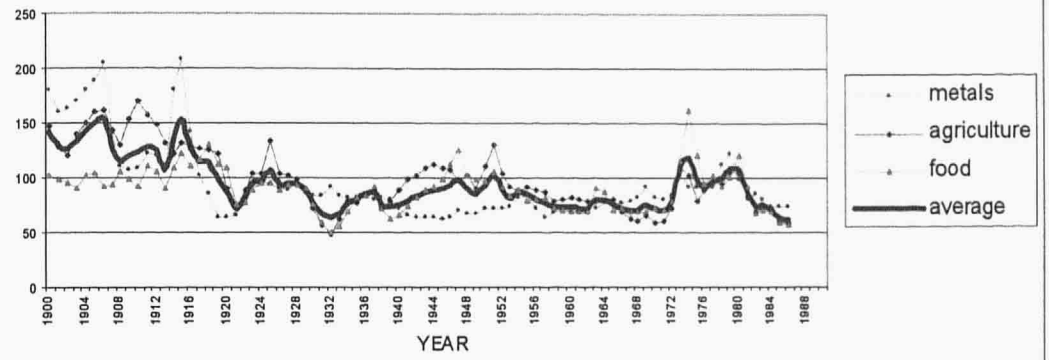
The commodity prices were obtained from sources similar to the study of Radetzki (1990)[5]. Figure 2 depicts the index of real prices for oil between 1900 and 1986 and the figure 3 shows the indices of real prices for metals and minerals, non-food agricultural commodities and food commodities and the compound average.

Figure 2 - Index of the real price of oil (1977 - 1979 = 100)



Source: Statistid Yearbook

Figure 3 - Index of the real price of commodities (1977 - 1979 = 100)



All charts show a downward slope between the World War I and the early 1970s. The slow downward slope is interrupted by much steeper temporary decline in the latter half of the 1940s. This acceleration was caused by the opening of the Middle East oil resources on a large scale. The exports from the Middle East rose from 33 MMB (0.09MBD) in 1938 (9 per cent of the global total) to 378 MMB (1 MBD) in 1950 (37 per cent).

When comparing with the other commodities, the price of oil shows lower volatility which can be the result of the oil market structure. Between 1930s and the 1970s, the oil market was dominated by an oligopoly of multinational firms and as pointed in Darmstadter (1970), such market structure favors price stability and no price changes at frequent intervals.

The result of the regressions of real commodity prices from the study of Radetzki (1990) provides a support for the similarities in price trends of oil when compared to other commodities. "The trend price decrease recorded for oil, 0.7 per cent per year for the 1900-1972 period, emerges as neither

particularly high or especially low. In this respect, developments in the oil market are not different from those that occurred in other major commodity markets."

5.3. Justified price of oil

The best estimation of the crude oil does not exist. The justified price depends on the scarcity of the crude oil. From the previous history can be concluded that the technological progress and new massive discoveries have overrun any impact that exhaustibility and depletion may have had on crude oil prices. It is therefore a matter of the known natural deposits, technology and overall world demand which justifies the crude oil price.

Since 1869 the US crude oil prices adjusted for inflation have averaged $18.59 per barrel compared to $19.41 for world oil prices. If the Iraq-Kuwait war in 1990, the Asia financial crisis in 1998 and the US low inventories and long winter in 2000 are disregarded, the period between 1990 and 1999 has been market by stable oil prices ranging between 15$ and $20 per barrel.

6. Technical analysis

6.1. Definitions and methods

What determines the value of the crude oil as any other commodity publicly traded is besides other channels also the market sentiment. The sentiment is in many ways influenced by crowd behavior and psychology of the masses.

From definition, the technical analysis is the method for predicting price movements which uses previous prices to infer with private information and thus gives stochastic information about the future price movements. Unlike the fundamental standpoint, technical analysis plays exclusively with past price information and uses many techniques of searching for visual patterns, support and resistance areas and other indicators of the market sentiment.

The questionable part about the technical analysis lies in the fact that traders around the world use similar charts and tools in predicting market trends. In general, if all traders would be equally skillful in describing the current situation on the market, no possibility for systematic long-term earnings should exist. The reason why some traders systematically earn and some systematically loose lies in the inequality of their predicting skills.

In the case of the currency markets or other very liquid commodities, traders using only technical analysis actually compete among other market participants in their technical skills. Because some traders have limiting priorities in the term of time, volume and price[6] and thus belong automatically to the "unskilled", those purely employed to follow the market sentiment might be able to systematically take money from the less skilled.

What is true for the currency markets is not necessarily valid for the market with the crude oil. As already mentioned, crude oil market with physical delivery is much less liquid because of the transaction costs connected with the participation on such market. Individual investors cannot participate in the market, unless they are willing to participate in the market with physical

deliveries as well (Phillips and Weiner (1994)). The trades on the spot market are done on a bilateral basis, the clearing house, the open outcry or any centralized exchange does not exist. Only at the end of the day is the information about the deals negotiated during the day widely disseminated among the other participants. During the day, traders must rely on their contracts for information on the transaction consummated[7].

For these reasons, it is questionable weather the tools of the technical analysis can produce relevant results. Certainly, there is no justification of trying to apply the technical tools on the short term intraday data sets. The basic presumption for the technical analysis is that there is the crowd mentality on the market, that is, the crowd psychology creates group movements. This assumption is certainly not valid for intraday spot crude oil price developments and is not necessarily valid if markets are thinly traded.

Regardless of these limitations of the crude oil market, this thesis tries to prove the validity of technical tools. The data sets consist of spot prices as well as of future contract prices. The markets with the future contracts are traded much more like any other financial instruments thus it can be expected that the technical analysis will provide better results on the futures markets than on the spot markets.

The technical analysis usually use the following tools to access the expected price movements:

Head-and-shoulders and inverse head-and-shoulders (T1)

Broadening tops and bottoms (T2)

Triangle tops and bottoms (T3)

Rectangle tops and bottoms (T4)

Double tops and bottoms (T5)

Fibonacci Retracements (T6)

Fibonacci Arcs (T7)

Fibonacci Fans (T8)

Fibonacci Time Zones (T9)

There are many other technical indicators nevertheless an assumption can be made that proving the validity of some of the selected nine tools justifies the statement that the technical analysis gives systematically better results than participating on the market on a random basis. If the technical indicators do not prove to be significant, the hypothesis that the technical analysis is fully useless can not certainly be refused.

The thesis focuses first on those tools which are not based on the Fibonacci theory. A former study of Lo, Mamaysky and Wang (2000) is a great help for the testing. This study proposes a systematic and automatic approach to technical pattern recognition using nonparametric kernel regression and applies this method to a large number of US stocks from 1962 to 1996 to

evaluate the effectiveness of technical analysis. This study found out that "certain technical patterns, when applied to many stocks over many time periods, do provide incremental information, especially for NASDAQ stocks. Although this does not necessarily imply that technical analysis can be used to generate 'excess' trading profits, it does raise the possibility that technical analysis can add value to the investment process".

The data set obtained for this study is smaller in both the time period and the variety of traded items. To increase the variety the techniques were applied also on the crude oil companies' stock prices.

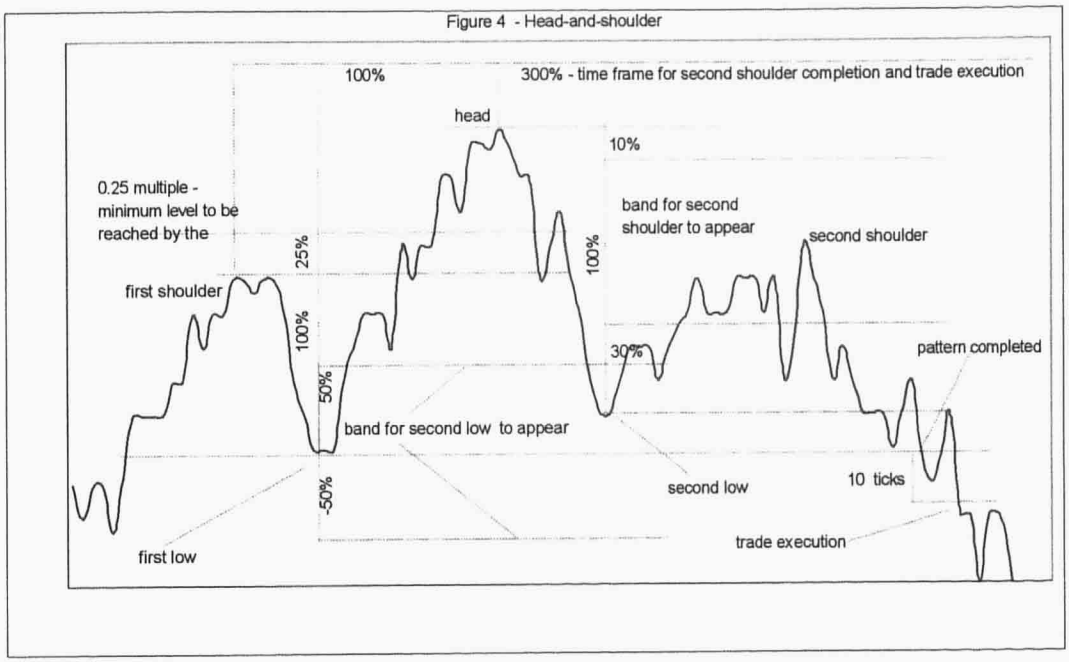
In modeling the tools certain specific characteristics were defined to ensure that the computer generated patterns correspond to the virtual practical reality.

Head-and-shoulders

This pattern consists of three tops out of which the second top (head) exceeds the other two (shoulders). The tops are separated by two lows. The head needs to reach a level which is a 0.25 multiple of the distance between the first shoulder and the first low (the height of the first shoulder) and the second shoulder needs to be built within a band which marks the 0.3 and 0.9 multiple of the distance between the head and the second low. The second low needs to appear in a band corresponding to ±50% of the height of the first shoulder. The second shoulder as well as the trade execution needs to complete in a time band no longer than twice the period from the first shoulder to the head. The trade is executed when 10 ticks level is reached.

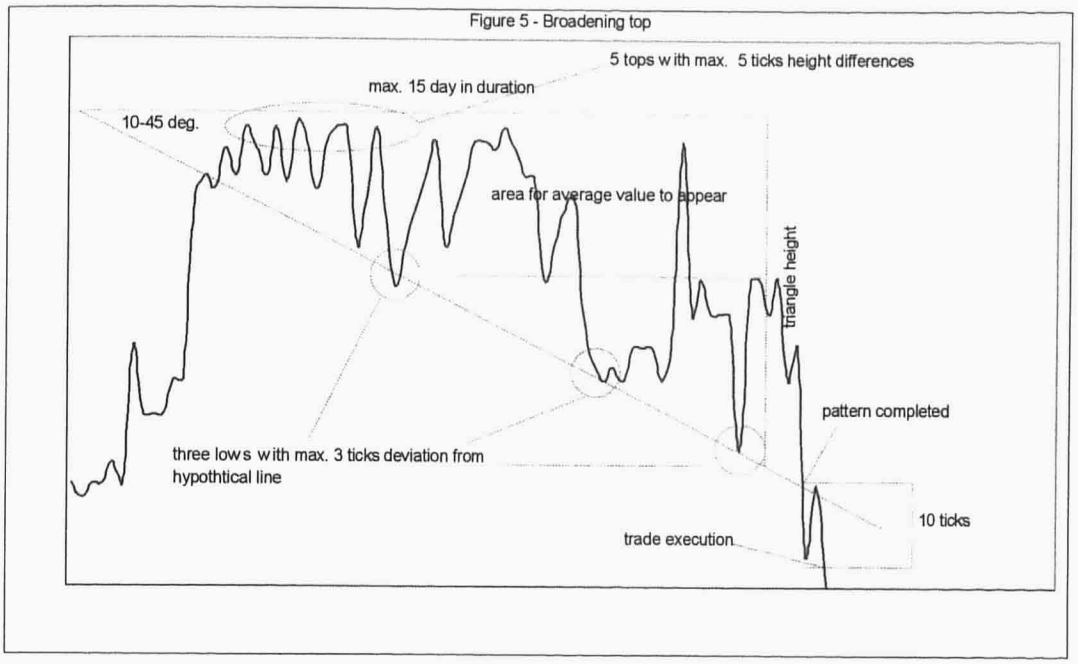
The inverse head-and-shoulder pattern is symmetric only tops and lows are reversed.

Figure 4 - Head-and-shoulder



Broadening top

The broadening tops were constructed by searching for 5 consecutive tops with heights no more than 5 ticks different. After such pattern was found, a 10-45 degree line was constructed so that within maximum 15 days three lows emerged which touch this line with a maximum 3 ticks deviation. The pattern was considered completed when the price broke the 10-45 degree line by more than 10 ticks. The value calculated as the average for the values inside the triangle right from the appearance of the first low has to be higher than the 50% value of the triangle height. The broadening bottom is symmetrical with tops and lows reversed.



Triangle top

The triangle top is similar to the broadening top with the difference that the price converts to a specific top value. The average value is calculated for prices until the last low. The pattern is considered completed when the price leaves the triangle and trade is executed if the 10 ticks level is broken from the completion.

Rectangle top

The rectangle top is constructed by searching for minimum 3 tops and 3 lows which do not differ by more than 5 ticks and the difference between the top and low is a minimum 20 ticks. The pattern is considered completed after these tops and lows were identified and the trade is executed at the moment the price breaks the low-line by more than 10 ticks within no more than 1-

multiple of the rectangle width when the price is kept within the low and top lines. The rectangle bottom is symmetrical with top and lows reversed.

Figure 6 - Triangle Top

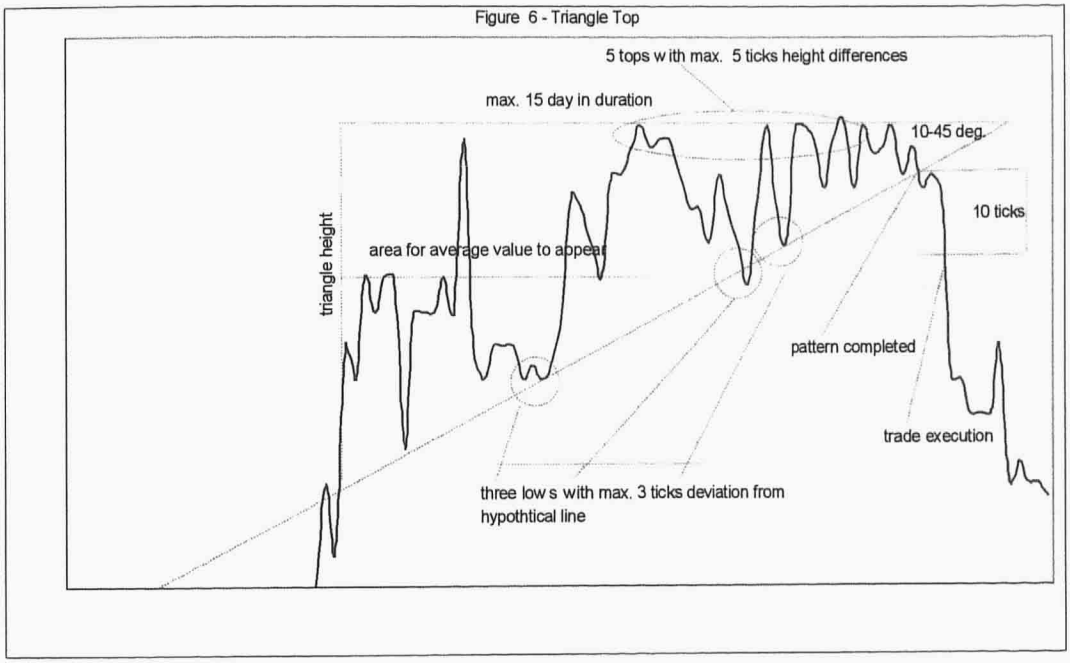
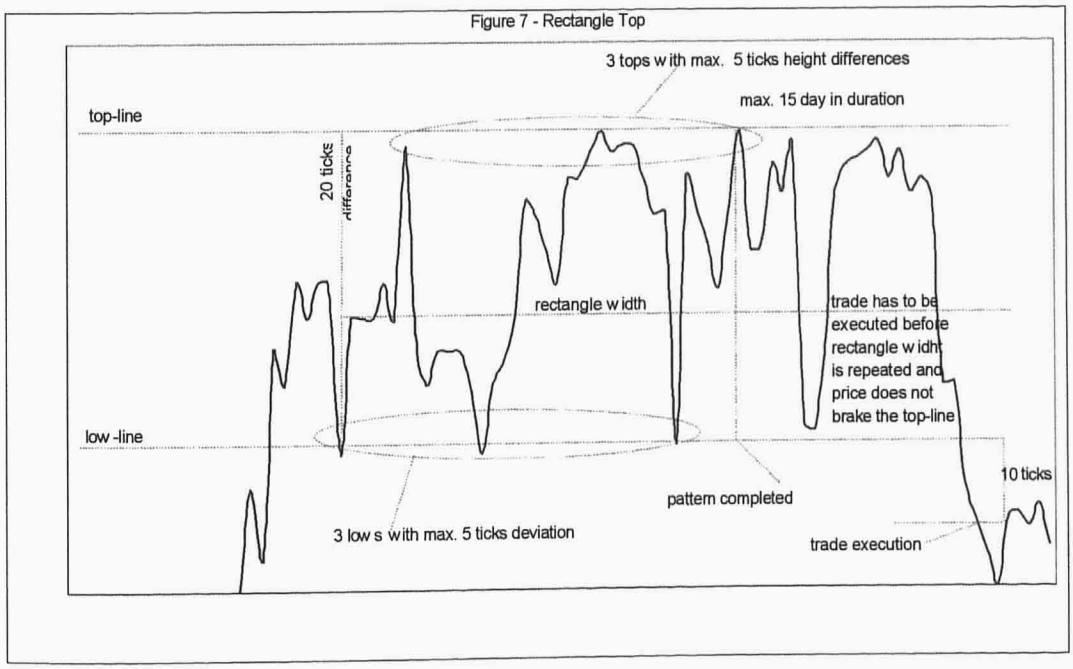


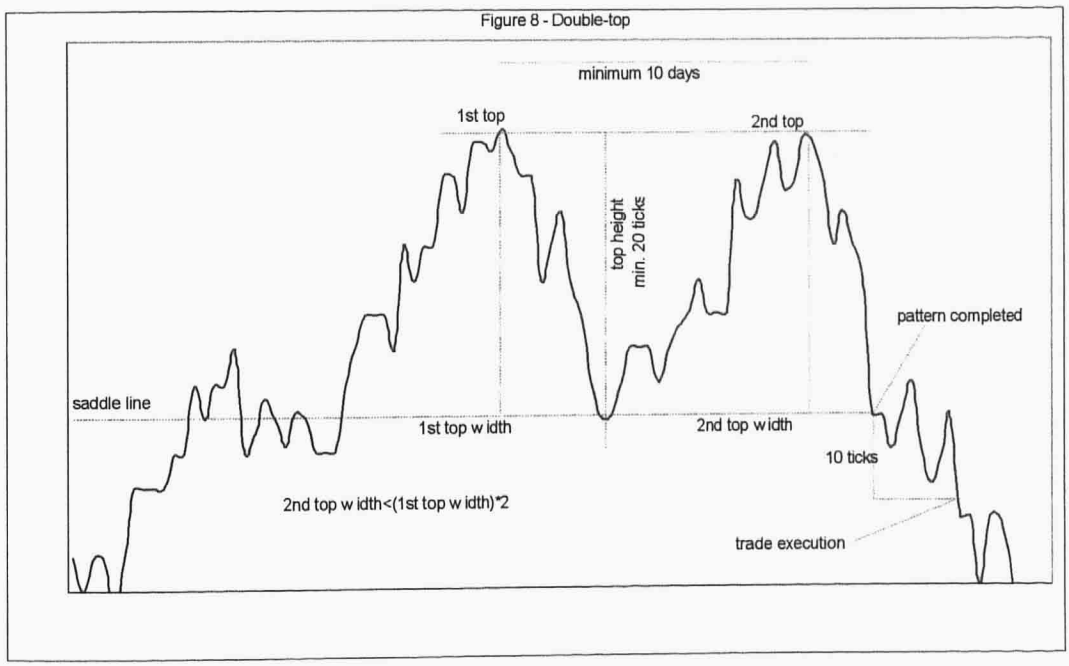
Figure 7 - Rectangle Top



Double-top

The double-top is constructed by first searching for a top of at least 20 pips and a second top appearing during a time period corresponding to the 2-multiple of the 1st top width. The two tops have to be at least 10 days apart to filter frequently appearing patterns with no significance. The pattern is considered complete when the price breaks the saddle line and the trade is executed 10 ticks below the saddle line. The double-bottom is identical with tops and lows reversed.

Figure 8 - Double-top



The tools based on the Fibonacci numbers were examined on the CL1 crude oil future prices. Out of the available crude oil futures, CL1 crude oil future is the most liquid commodity.

When the Fibonacci number[8] are used in technical analysis, the golden ratio is typically transformed into three percentages: 38.2 per cent, 50 per cent and 61.8 per cent. However, more multiples can be used when needed, such as 23.6 per cent (38.2*0.618), 161.8 per cent, 423 per cent (161.8*1.618*1.618) and so on. There are four primary methods for applying the Fibonacci sequence to finances: retracements, arcs, fans and time zones.

Fibonacci Retracements

Fibonacci retracements use horizontal lines to indicate areas of support or resistance. They are calculated by first locating the high and low of the chart. Then five lines are drawn: the first at 100 per cent (the top on the chart), the second at 61.8 per cent, the third at 50 per cent, the fourth at 38.2 per cent, and the last one at 0 per cent (the low on the chart). After a significant price movement up or down, the new support and resistance levels are often at or near these lines. The trade is executed if the price is capped/supported by this resistance/support level within 10 ticks deviation and falls/raises below/above the resistance/support level by 10 ticks.

Fibonacci Arcs

Finding the high and low of a chart is the first step when composing Fibonacci arcs. Then, with a compass-like movement, three curved lines are drawn at 38.2 per cent, 50 per cent and 61.8 per cent, from the desired point.

These lines anticipate the support and resistance levels. The trade is executed as in the case of the retracement levels.

Fibonacci Fans

Fibonacci fans are composed of diagonal lines. After the high and low of the chart is located, an invisible vertical line is drawn through the rightmost point. This invisible line is consequently divided into 38.2 per cent, 50 per cent and 61.8 per cent, and lines are drawn from the leftmost point through each of these points. These lines indicate areas of support and resistance and trade is executed as in the previous cases.

Fibonacci Time Zones

Unlike the other Fibonacci methods, time zones are a series of vertical lines. They are composed by dividing a chart into segments with vertical lines spaced apart in increments that conform to the Fibonacci sequence (1, 1, 2, 3, 5, 8, 13, etc.). These lines indicate areas in which major price movement can be expected.

Other concept using the Fibonacci levels is the Elliott wave principal identified by R.N. Elliott 60 years ago. This principle is based on the fractal geometry[9].

The implementation of the Fibonacci numbers and the golden ratio into the technical analysis is the best example of the crowd mentality of the markets. It is necessary to mention that the crowd mentality exists only on markets which are very liquid, where the number of participants is very high and all players have perfect information about the price.

6.2. The results of the computations

6.2.1. Non-Fibonacci tools

The five selected techniques were applied on the interday dataset and the computer generated results confirmed the appearance of all five types of patterns. The patterns have been visually checked to ensure that the computer generated mechanism produced the patterns which corresponded with the practical needs. One of each pattern is shown in Figure 9 as an example on the data set used. Table 3 summarizes the number of appearance of each pattern in each commodity type.

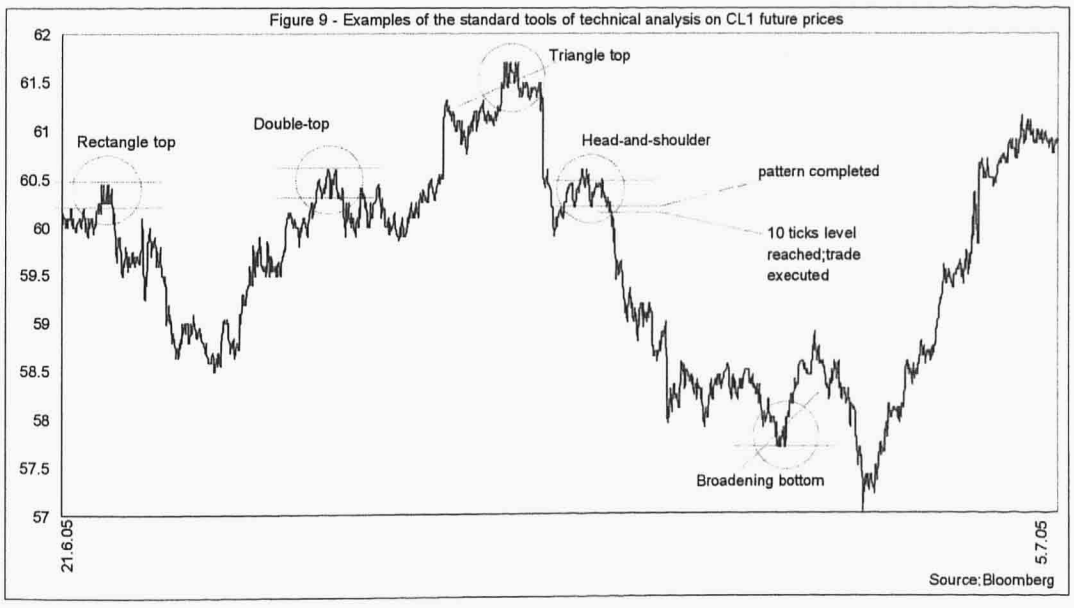


Table 3
Pattern occurances and balances on the hypothetical trading account – non-fibonacci tools

	T1	T2	T3	T4	T5	total patterns completed	Trading account balance (pips)
Spot	2	1	0	2	0	5	-157
CL1	32	24	14	23	5	98	90
CL2	5	15	13	20	10	63	85
CL3	8	4	15	11	6	44	-95
CL4	5	6	3	9	10	33	79
CL8	3	11	6	9	6	35	120
CL12	5	5	9	6	7	32	-135
						Total oil:	-13
XOM	21	8	11	9	13	62	560
BP	15	11	20	4	21	71	370
RDA	16	13	6	11	15	61	795
						Total stock:	1725

Each time when given pattern was proved complete, hypothetical speculative investment in given direction was made. A pattern was considered completed at the moment when the pattern was recognized and the price broke a 10 ticks security level. Because some technicians use a different security level, the patterns were also tested for 5, 15 and 20 levels but the results changed insignificantly.

At the end these hypothetical speculative investments for each commodity type or stock were compared. In the case of the oil company stock a significant positive balance on the hypothetical account was generated. For the crude oil future and spot contracts though, the balance was on average close to zero (four contracts CL1, CL2, CL4 and CL8 generated slightly positive balance, spot, CL3 and CL12 generated negative balance).

The technical tools applied on the spot crude oil interday prices generated only 5 investment recommendations which gives no justification for taking these results seriously because of the low number of observations.

The same techniques were applied on the intraday prices. Unfortunately, only the CL1 crude oil future data set contained a significant number of pattern appearances. The intraday dataset of spot crude oil prices contained only 270 records which mean that on average the price changed every 50 minutes. This also proves the inadequateness of the technical analysis application on the low frequency crude oil commodities. When the prices move rarely no crowd mentality may be observed.

6.2.2. Fibonacci tools

This study does not provide scope for the complex investigation of the Fibonacci practical usefulness. It just suffices to state that technicians use these tools and because they use them these tools provide some additional information about the market sentiment. A separate study dedicated to this topic would be needed to bring more insight into these techniques and its real values on a large data sample.

The validity of the Fibonacci tools was tested on the CL1 crude oil future data set and the evidence of a predicting value was searched for. These tools were applied on both the interday and intraday crude oil CL1 future prices. A hypothetical account was again created for each tool and the

behavior of speculative investors using only the technical analysis was imitated.

When searching for top and lows of any price development, always a time-span of at least 40 ticks were searched for and the difference between the top and low was set to at least 20 ticks. This ensures that the model does not generate too many patterns and the results are realistic.

Each Fibonacci tool has some problematic point. The Fibonacci retracement levels, fans and arcs show the assumed levels of support and resistance. The hypothetical result of any investment based on these tools depends heavily on the expected profit per trade and the earnings/loses ratio. In case of short-term investments with a 20 ticks earnings and 4:1 ration used (the position is cleared when a +20/-10 ticks profit/loss is reached), the model gave worse results than in a situation when higher profit levels were targeted. In many cases the trade was cleared negative even though the support or resistance signal proved to be significant but more flexibility was needed to conform to this signal. Another variable under consideration was the deviation from each support or resistance level. Usually the support/resistance is considered to stop the advance of the price if the price is capped in the area of -+10 ticks around the support/resistance level. Table 4 summarizes the results for 5-20 ticks options. The 10 and 15 ticks deviation gives the best results. There has been a minimum of 40 trades executed on each account.

Table 4
Balances of the hypothetifcal trade accounts in pips - testing of Fibonacci tools for CL1 crude oil future

Deviation from support/resistance levels (average number of trades per account)	Targeted profit level per trade in pips	Earnings/loses ratio			
		1:1	2:1	3:1	4:1
5 (56)	10	130	120	145	144
	20	154	140	167	199
	30	190	195	201	237
	40	189	201	210	232
	50	210	245	267	266
10 (67)	10	152	168	201	143
	20	302	321	365	267
	30	298	346	376	367
	40	342	436	412	401
	50	358	460	432	399
15 (73)	10	90	86	120	145
	20	241	234	167	265
	30	235	245	301	267
	40	360	376	403	260
	50	450	465	379	238
20 (94)	10	-35	5	54	10
	20	-120	-104	30	34
	30	32	43	68	120
	40	3	54	36	47
	50	56	74	36	98

In case of the Fibonacci retracement levels and arcs, the examined time period after the selected low or high point needs to be limited. The time period examined was based on the length from the initial high/low point to the low/high point and a multiple of this length was taken as a variable. Multiples from 1-5 were tested. It remains unclear which multiple is optimal as each Fibonacci tool gives optimal results for a different multiple. For the Fibonacci retracement levels the 2-multiple proved to be optimal, for the Fibonacci fans it was 3. The results in table 4 are shown for these optimal multiples for each tool.

The concept of the Fibonacci time zone proved to produce too many trade signals, most of them wrong. The time zones were based on 1-minute to 1-day averages and in most cases the model generated negative trade balances. Table 5 summarizes the results of the Fibonacci time zones.

Figures 5-8 chart the examples of each Fibonacci tool.

Table 5
Results of testing for Fibonacci time zones

Period used for averages	Balance of testing account in pips
1 minute	-230
10 minutes	-43
30 minutes	30
1 hour	-10
1 day	-620

6.3. Consequences for crude oil price development

The basic concept of Fibonacci tools applied on the CL1 crude oil future prices seems to yield some valuable trade signals. Even though in many cases the Fibonacci tools generated valuable information, the modeling of these methods on a larger data sample is needed to confirm the validity of this information. If only the optimal trade strategies were applied for each Fibonacci tool and the lack of a broader supportive data sample is disregarded, a conclusion can be made that a pure speculative investor who focuses solely on the results of the Fibonacci tools will end up with a slightly positive balance.

Generally speaking, anyone who would rely on the technical analysis for the prediction of the crude oil price movements and would have the same tools that were presented would be faced with the same problems with the

trustworthiness of the results. Even though the future prices are liquid enough to be used for some techniques on the daily basis, the spot crude oil price as well as the intraday future prices of CL2-CI12 futures make any results of the technical analyses unconvincing. It is obvious that the crude oil from its nature does not represent the ideal commodity for technical analysis. The crowd behavior exists on these markets but is influenced to a very small extend by the results of any tools of the technical analysis. The hypothesis that the crude oil prices are widely influenced by the tools of the technical analysis therefore cannot be confirmed.

Figure 10 - Fibonacci Retracement Levels

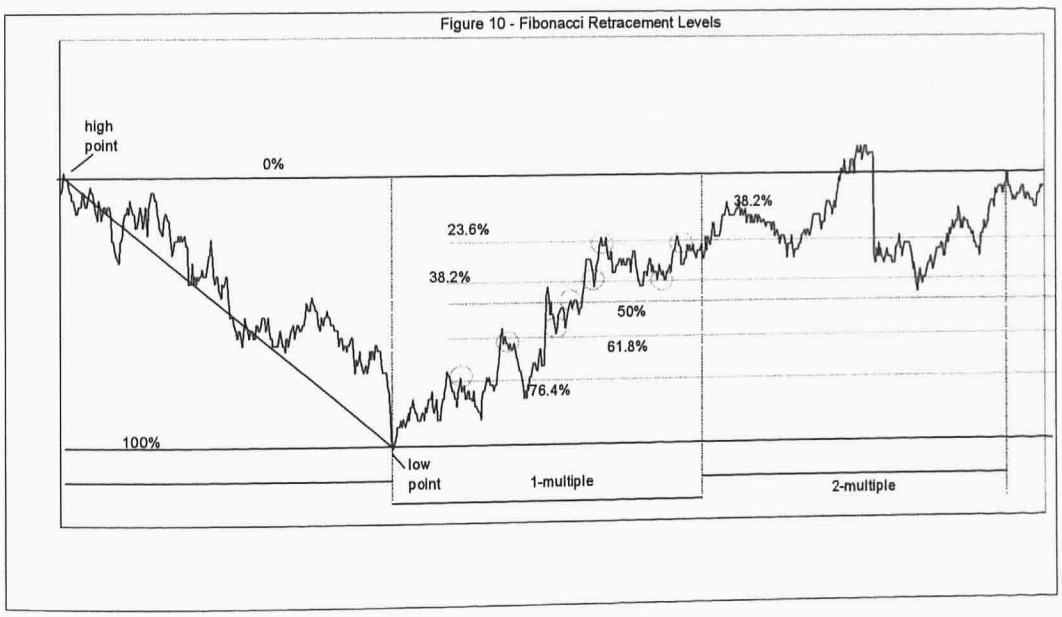


Figure 11 - Fibonacci Fans

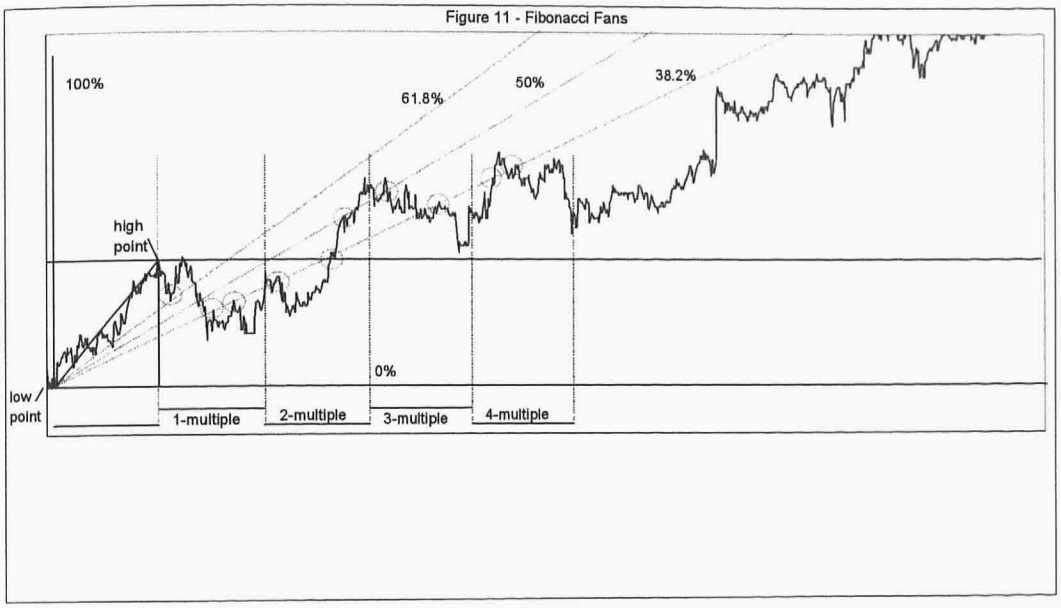
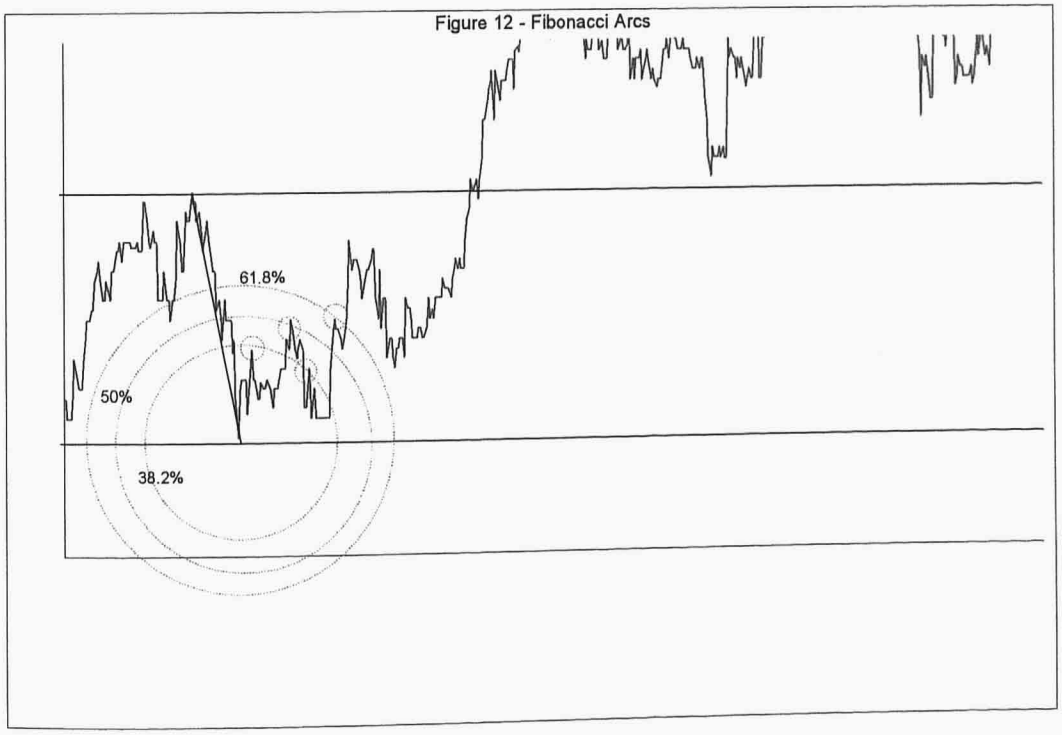
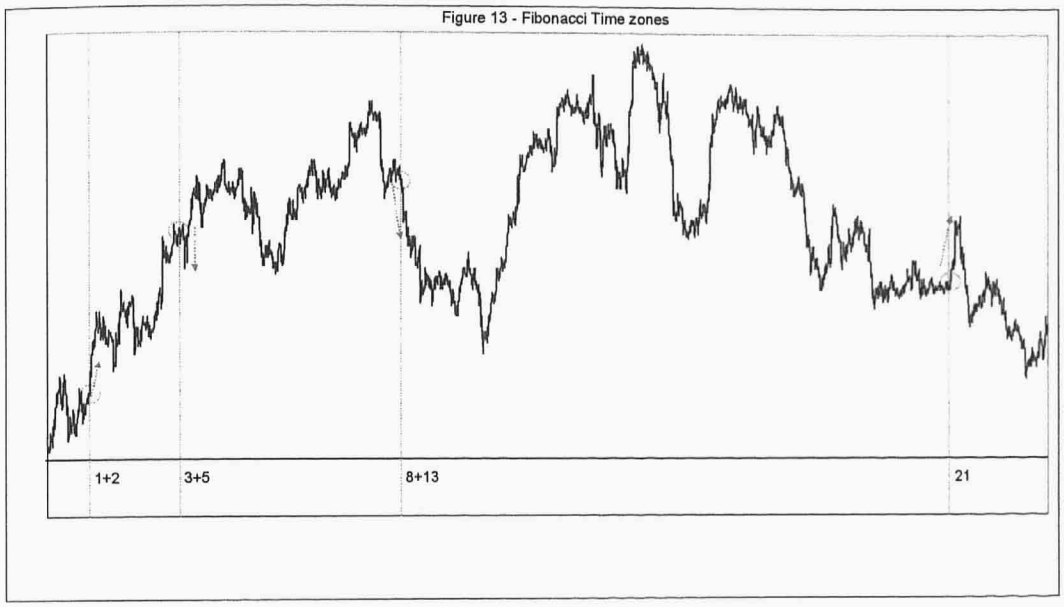


Figure 12 - Fibonacci Arcs

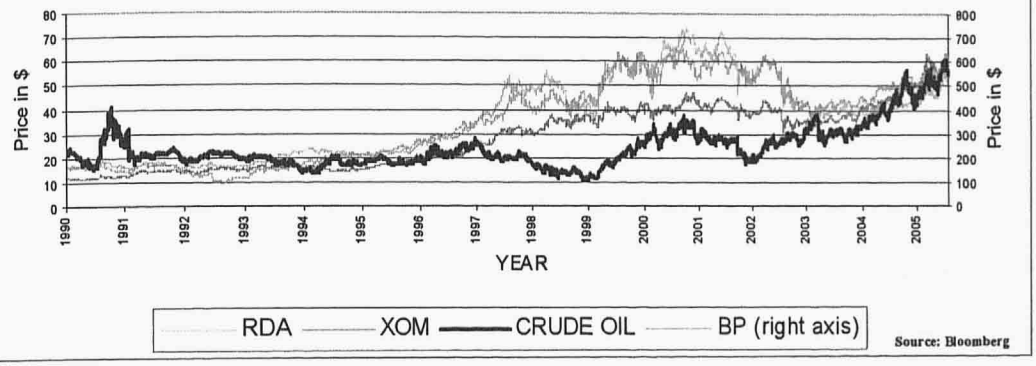




7. Fundamental analysis

When analyzing the fundamental impacts on the crude oil price, this thesis attempts to separate the speculative forces. In the beginning the result of the analysis of oil company stock prices are being presented. The correlation between the oil company stock prices and the spot oil prices is interestingly different among all companies. The lowest correlation in the case of RDA (0.32) followed by BP (0.46) and XOM (0.63) was measured. Figure 14 shows the development. The stock prices which might have been influencing the crude oil prices were used to filter the speculative effects. Unfortunately no evidence form the data set that would show a usable guide to determining the speculative price movements in the crude oil prices was found.

Figure 14 - Stock and crude oil prices



Before analyzing the effect of variables on the crude oil prices, there is a need to look at the impacts of crude oil price shocks on the economy.

7.1. Defining the oil price influence on economy

7.1.1. Short-term

The most important effect of higher oil prices on the economy is the decrease in aggregate demand. The higher oil bill paid by the oil products consumers to the oil producing countries can be thought of as an excise tax levied on the oil products. Initially, only parts of the proceeds of this tax are being re-spent by the oil producing countries on imports from the oil importing countries[10]. Sales lost by industries producing consumer goods are not offset by increased exports to the oil exporting countries.

The indirect impact from the drop in the exports to other nations whose economies are being affected by the oil price increase is the second negative effect. The initial net change in aggregate demand resulting from the oil price

increase is later amplified by multipliers which translate the initial shock into the ultimate effect on aggregate demand and gross national product.

7.1.2. Long-term

The long-run effects of the oil price increase may be defined as those that will remain once the deflationary impact has run its course and the oil-importing countries have returned to full employment. These effects can be divided into the effects affecting the overall macroeconomic community welfare, the microeconomic effects and the effects affecting distribution and economic growth.

The macroeconomic effects are connected with the change in terms of trade accounted for by the oil price increase. The loss in terms of trade is given by the difference between the new and the old relative price of imports times the new level of imports, plus the cost of producing domestically what would otherwise have been produced abroad and restricting demand for importable goods. If in the long run the members of OPEC find it expedient to accept a continuing inflow of OPEC funds into oil-importing countries, the long-run terms-of-trade loss will be reduced. On the microeconomic level, the increase in the relative price of oil and other energy materials gives rise to a complex pattern of reallocation of demand and production and may therefore cause sectoral inefficiency and rigidity losses and a change in the traditional ranking of industries in terms of their advantage in international trade. The rigidities are in particular the losses caused by labor's inability to find at least

temporary employment in other sectors. The rise in the price of oil will also affect the distribution of income among capital, labor, and domestic owners of fixed resources. An open economy by importing primary products reduces the rent to be paid to domestic owners of land and physical capita and the rate of profit is increased for given real wages. An increase in the price of imported oil would increase rents in domestic energy industries and in foreign energy-production countries while lowering the overall profit rate of the domestic economy. The fall in the profit rate may reduce the rate of growth of the economy, unless the rate of saving rises substantially and aggregate demand is maintained at the full-employment level. While the rise in the rate of savings may be provided externally by the members of OPEC (or other oil exporting country), it is not certain that this would indeed occur if investment opportunities should yield a rate of profit lower than that yielding elsewhere.

The purchasing power parity changes between countries exporting and importing oil will change with oil price movements. The changes of purchasing power parity are correlated with the extent of oil-intensity of production in given country. The study by Backus and Crucini (1998) documents how the changes in the terms of trade in major industrialized countries during the period of 1972 and 1987 were driven primarily by the dramatic changes in the relative price of oil. The authors found out that the unstable relationships between relative prices and quantities are to be expected when the oil price shocks play different roles across time periods.

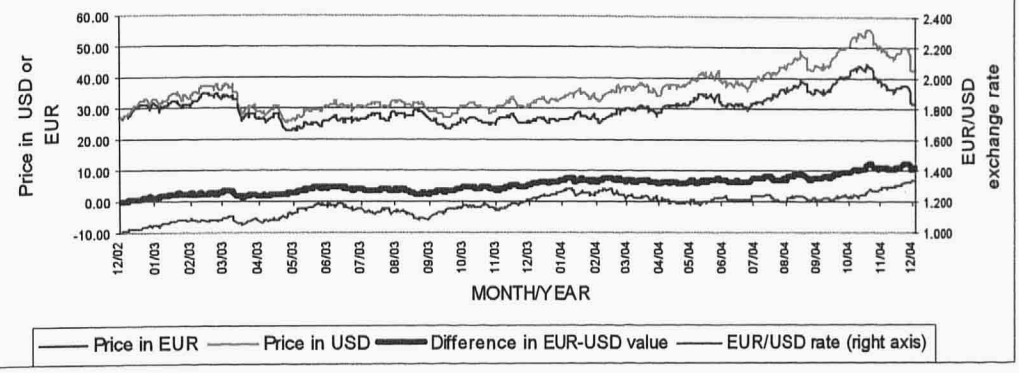
Given the timing of the oil price shocks, the volatility in the terms of trade seems to be explained by the increased volatility in the relative price of oil rather than by the increased volatility of the exchange rates.

7.2. Channels influencing the crude oil price

7.2.1. Exchange rate

The crude oil is traded in US dollars. Even though certain attempts existed to trade the crude in Euro, US dollar despite its volatile behavior in the last years is the major currency for all trades. There are two direct channels which influence the crude oil price. First, as the exchange rate of US dollar and major world currencies change, the demand for the crude oil fluctuates in the countries where US dollar is not the official currency. Even though the price elasticity of demand is very low, increased cost to the consumers decreases the demand for petroleum products. Second, the OPEC members tend to require the same purchasing power in Euro as in US dollars. When the US dollar depreciates, the Arab shakes loose the purchasing power in Euro and push for lowering the oil production and increasing the oil price. Figure 15 shows an example of the development of EUR/USD exchange rate from its unit parity at the end of 2002 until the historic maximum in 2004. During this period the EUR/USD escalated from unit parity to 1.344. When the crude oil price in Euro is expressed, a difference of 11 USD at the end of the period is created.

Figure 15 - Crude oil price in USD and EUR; EUR/USD exchange rate



When taking the exchange rate into consideration, a substantional difference in the oil price movements is created. For the period mentioned above, the crude oil price increased by 61 per cent, but when the price is measured in Euro the increase is only 20 per cent. The hypothetical purchasing power of the oil producer was three times lower in Euro than in USD.

It is worth mentioning a study by Kofman, Viaene and Vries (1990) explaining the effects of the exchange-rate volatility on primary commodity prices.

7.3.2. Media news

The crude oil price is influenced through media in two ways. First, the media create news which affect the decisions of the oil producers and firm consumers. Second, media influence the public opinion and create a social reality which might be different from the actual reality.

The crude oil producers have a strong interest in keeping the crude oil prices high. From the perspective of the producing company, any negative event that is easily associated with crude oil can easily be used to create a stress

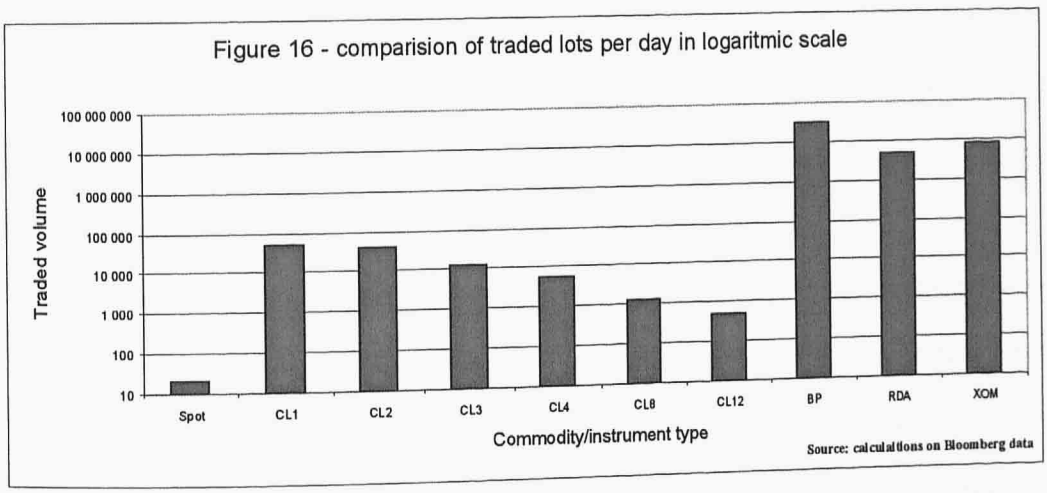
on the consuming firms to increase demand because of a possible supply disruption. The media coverage of world-wide news has the potential to be misused for the benefit of oil producers. In the data sample 24 cases when crude oil spot price change over 10 per cent between two days were observed out of which in 14 cases the price returned to the original level within the next 7 days. Searching for evidence for this hypothesis and uncovering the reasons of these sudden price movements and their relation to possible media objectivity is a matter of a different study.

The media influence also the public opinion of the future development of final refined products, especially gasoline. In case the media overestimate certain information and misinform the public about the future price expectations, the public might adjust the demand in accordance with such information without the expected price increase to happen in reality. A unique study on this topic by Kepplinger and Roth (1979) concludes that " the mass media influence the development of social reality especially when they create a false image of reality" and '...if the mass media present a false (or inadequate) image of reality, then individuals react in a different manner than they would to reality". It is worth making a remark on the existence of a similar study by Erfle, McMillan and Grofman (1990) which presented the link between the media coverage and the regulatory decision of the US administration on the gasoline prices.

7.3.3. Speculators

In the oil industry the role of speculators is relatively easy to estimate on the spot market. A starting assumption that there is a daily volume of consumed crude oil in the world of approximately 80 MMB is made out of which 10MMB goes to the USA. This makes approximately 3650 MMB year crude oil consumption for the USA. If this value is compared with the volume of total spot trades on NYMEX which is the only major crude oil exchange in the USA, a ratio of approximately 365:1000, so approximately 3,6:10 is obtained. This means that for every oil barrel consumed in the USA, three barrels are being sold on the exchange. Further, the dataset provides on average a transaction every 50 minutes. Figure 16 shows the proportions of the traded volume on the spot, future and stock market. Note that the scale is logarithmic.

Figure 16 - comparision of traded lots per day in logaritmic scale

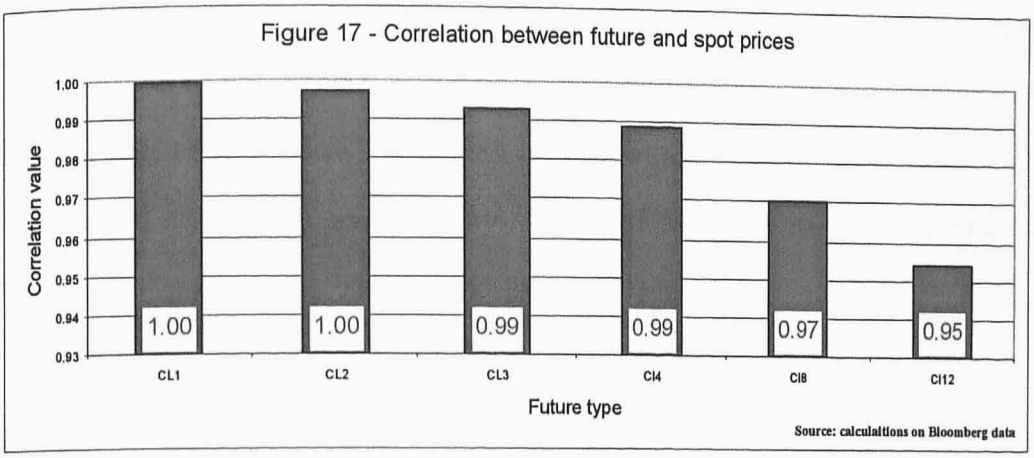


If the intraday speculators are being imagined in the same sense as on the financial markets[11], there would be only relatively small opportunities for the

speculators to make transactions. The fixed transaction costs connected with trading on the spot market are also very high. The non-existence of intraday speculators does not mean that the interday speculators do not exist on the spot markets. The spot markets are based on physical delivery therefore only those with excess storage capacity can speculate on the oil price. This thesis assumes that since the existing market participants hedge against any price change, this type of speculations (spot interday) does not play a major role in the oil price creation.

Because the markets with the crude oil futures are closer to the characteristics of financial markets, speculation definitely exists there. This can be also demonstrated on the fact that every individual can buy or sell crude oil futures (with no physical delivery) over the internet having to lay an initial margin of only 200 USD[12]. Because the future prices are correlated with the spot prices, it needs to be examined weather the spot prices are influenced by the future prices or vice versa. The average correlation is 0.98 and it decreases with the increasing maturity of the futures. Figure 17 plots these results.

In the study by Borenstein, Cameron and Gilbert (1997), the correlation was estimated to 0.95 which corresponds to the findings. From the evidence from the dataset, the spot price moved in most cases first being followed by the future prices or at the same moment as the future prices. The hypothesis that the more liquid future markets where many speculative players exist do not influence the spot price can not be rejected.



Any such influence would mean that crowd mentality would tent to amplify the price volatility in situations when market rumors appear.

The speculators have large sums of money available immediately for speculative purchases on markets with higher rate of return. Speculators trade oil futures with a view of profiting from the rise or fall of prices. The speculators do not buy the commodities physically. Even though the positions held by non-commercial traders make up only a relatively small proportion of total futures and options contracts traded, their net positions can be very significant and any sudden changes in these net positions can play an important role on the spot and forward prices. Such actions increase the oil price volatility. On the other hand the oil price volatility is lowered if the speculative actions are successful in predicting the turning points in prices and sell or buy the commodity before the actual peak.

Another aspect of the speculative influence in the crude oil price markets is the relative speed of settling back to regular pre-shock prices after a rumor appears. In the case of financial markets any rapid price movement caused

by a false rumor is usually corrected within a very short time (minutes, hours). In the case of the crude oil spot or future prices, any such corrections which would be similar to the situation described above can not be identified. If any such correction appears after such price movement, it takes usually many days for the price to return to its initial level.

7.3.4. Transportation capacity

There is a limited number of tankers available for importing countries to supply enough oil in cases when demand shock occurs. The transportation supply elasticity is low. The time needed to adjust the overseas transportation capacity counts in years and therefore this problem plays important role in the price volatility as well. If any positive demand shock takes place, the transportation shortage tents to increase the crude oil price.

7.3.5. Interfuel substitution

Important part of the long-term price volatility is the exploration and investments into crude oil production of the non-OPEC oil producers. The high oil prices in the 1970's caused for instance the non-OPEC countries (especially Mexico, the United Kingdom and Norway) to increase its market share and decrease the dependence on the OPEC cartel. As another effect of high oil prices there are the improvements of the efficiency use of the crude oil. The emergence of oil as a major source of energy in the 1930's, when it first exceeded 20 per cent of global primary energy consumption

(Darmstadter (1970)) and the fast growth in its share of the total to over 40 per cent during the following four decades, imposed an effective cap on the price of coal. The same can happen if any oil-substitute will start playing a major role.

Nuclear energy might have developed into such a substitute, if all the expectations held about this energy source in the 1960s and early 1970s had become true. As events turned out, nuclear power costs have risen, because of safety concerns and ensuing regulations. In addition, public fear and apprehension have come to constitute an absolute restraint on nuclear expansion. For these reasons, nuclear energy is unlikely to develop into an aggressive substitute for crude oil in the time span under consideration. Gas might conceivably emerge as a formidably competitive substitute for oil in the future. The impact of any such substitute on the crude oil price will be the stronger the more crude oil will be substituted.

7.3.6. Crude oil supply and OPEC behavior

While OPEC's share in the world production has been reduced in the past decade to less than a third, most non-OPEC oil is domestically consumed, and the cartel continues to hold very dominant position in the exported supply.

In any historical perspective, a commodity producer group which succeeded in withholding one-third of its supply capacity, thereby raising prices to three

times the competitive market level, would be deemed an extraordinarily successful cartel.

In the late 1970's, the total incremental cost of producing an additional barrel per day was about $8 in the US, but less than $0.15 in Saudi Arabia (Adelman (1986)). An estimate of $0.20 for the Persian Gulf and $7-$11 for the USA comes from Mancke (1975). The exceedingly uneven quality and geographical concentration of oil deposits provides great scope for profitable monopolistic coordination in the long run, through restricted access to the rich parts of the resource base for capacity expansion. Psychologically, the management of long-run supply through investment restraints is probably easier to accomplish than management of supply in the shorter run through cuts of production from existing capacity. The former merely involves deferral of decisions about the future, while the latter requires immediate and highly visible action.

A historical experience worth noting in this context is that where the external market preconditions for monopolistic profits exist, they will be utilized by the suppliers, irrespective of prevailing institutional relationships (Mackie-Mason and Pindyck (1986)).

OPEC remains the major price-maker of the crude oil price especially the long-term OPEC strategy decides the overall crude oil price level.

7.3.7. Natural and strategic oil reserves

As will be closer described in the following subchapter, the global natural energy resource and new discoveries of oil fields play a major role in the long-term price creation. It has been believed for a long time that the natural reserves are not very expandable thus crude oil was considered as a scarce resource which will dry out one day. Even though many studies suggest the validity or invalidity of this fact, it is clear these days that the natural crude oil reserves are expandable by better technology. Any major geological or technical discovery of this type will make a downward push on the crude oil price.

Unlike the natural oil reserves the strategic reserves are artificially built and their volume is publicly known. Because the strategic reserves cover between 2-3 months of crude oil imports in the industrialized countries, any major announcement of the increase or decrease sends a strong signal to the market participants. In the short-run, these announcements are always followed by a rapid price adjustment. From this point of view, the strategic reserves act as a destabilizing oil speculator.

7.3.8. World's demand

Besides the above mentioned channels of influence, it is the world's crude oil consumption that states the most relevant level of crude oil prices. While oil products are used for many energy services (i.e., heating, steam generation, electricity generation, etc.) and as industrial feedstock, the major use of

petroleum products is for transportation. As a result, the worldwide demand for transportation services is the key driver for oil demand. In turn, the demand for transportation services in the various regions and countries is driven by the projected level of income per capita, complemented by other important region-specific factors, such as the state of the transportation infrastructure. The projected growing role of the developing countries in the world economy and oil markets makes understanding the impact of economic growth on oil demand critically important. For the industrialized countries with well-developed transportation networks, demand for transportation services is influenced primarily by projected income levels and lifestyles of citizens. For developing countries, the lack of transportation infrastructure can be a significant constraint.

Even though in the OECD countries the oil consumption per production has fallen dramatically in last decades, the developing countries like China and India are becoming major oil consumers with their economy growth exceeding EU and USA. The technologically advanced countries are able to offset its growing industry by cleaner technologies.

The demand mismatch plays a short-run influence on the crude oil. In the short-term different types of oil can prove to be missing in different parts of the world. The regional mismatches between the grade of oil supplied and demanded cause the price volatility to increase.

7.3.9. Elasticities

The sensitivity of oil demand to income is called the income elasticity of demand, defined as the percentage change in oil demand with respect to the percentage change in real income. The sensitivity of oil demand to oil price – the price elasticity of demand – is defined as the percentage change in oil demand with respect to the percentage change in the oil price. The sensitivity of oil supply to oil price – the supply price elasticity – is defined as the percentage change in the oil supply with the respect to the percentage change in the oil price. Many studies exist to calculate the values of these elasticities being the important variable in predicting the crude oil price change impacts. Most studies confirm a low short-term price and high income elasticities of demand and low price elasticity of supply. The income elasticity is estimated close to or higher than unity in both the short and long run. The demand price elasticity in the long-run is being estimated below unity level and in the short-run the demand price elasticity is considered to be highly inelastic. A very sophisticated framework of estimating the elasticities can be found in Krichene (2005). Most studies have found that developing countries generally have higher income elasticities than the industrialized economies.

Because of technological limitations the supply side cannot flexibly respond to short-term demand increases. The OPEC countries set a production limits and keep only limited reserves to cover short-term demand shocks. The

current excessive production over long term demand is estimated at approximately 1 MBD which corresponds to approximately 2 per cent demand shock. Higher demand shocks are accommodated only by price increase.

7.4. Consequences for crude oil price development

From the above description the conclusion can be made that in the long-run the global consumption of oil on the demand site and the behaviors of OPEC on the supply site plays the major role in the crude oil price creation. In the short-run many demand and supply shocks may elevate or decrease the crude oil price.

8. The Hotelling rule

The Hotelling rule claims that in an environment of utility and profit maximizing agents who use an unchanging technology to exploit a natural resource from a given and uniform stock, the value of a unit of that unexploited resource will rise at the rate of interest (Hotelling (1931)). Any new discovery of stock broadens the known stocks of the resource in the ground. The Hotelling theory assumes that the unit cost of any new discovery must correspond to the unit value of that resource. Since the resource in the ground is supposed to rise over time at the rate of the interest rate, the cost of discovery can rise with the same speed. The Hotelling rule is a model based on theory and has very limited implication to the real world. First, in

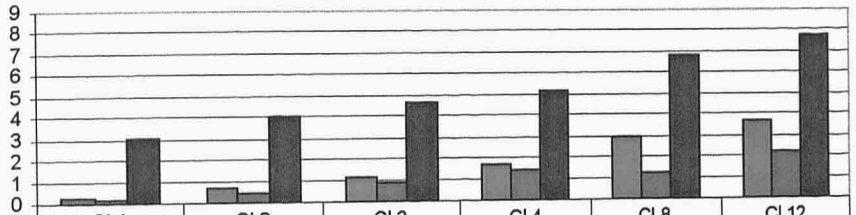
the real world it is hard to trace the rate at which discoveries are made and the costs involved. The history of crude oil discoveries are marked by many massive finds (Middle East, Alaska, Nordic-See) and each such massive discovery pushes prices down in the long-term as such commodity is suddenly less exhaustible than it has been before. Second, any technological improvements create further doubts about the validity of the Hotelling rule. Advanced methods of exploring and exploiting the crude oil have a large impact on the price by lowering the per unit cost. "....any relationship between the value of exhaustible resources in the ground, and the rate of interest, is tenuous and unstable...(Radetzki (1990))".

9. Backwardation vs contango in crude oil future contracts

The theory of backwardation was touched already by Keynes (1930). The classic economic rationale for future markets is that they facilitate hedging. That is, futures markets allow those who deal in commodities to obtain contracts through which the risk of price changes can be transferred to those who are willing to assume it. A side benefit of the market is that a publicly known uniform future value for a commodity is created. Therefore all commodity market participants can make production, storage and processing decisions by looking at the pattern of futures price, even if they do not take positions in the futures market. Many believe that the current price of a futures contract equals the market consensus expectation of the spot price on the delivery date. The dataset is used to test the validity of this

assumption. The results do not support this hypothesis. The prices for given future contract were systematically different from the future spot prices of the crude oil. Figure 18 summarizes the standard deviation, average value and median for the future contracts. Figure 19 plots the average non-deflated prices for all 6 types of futures.

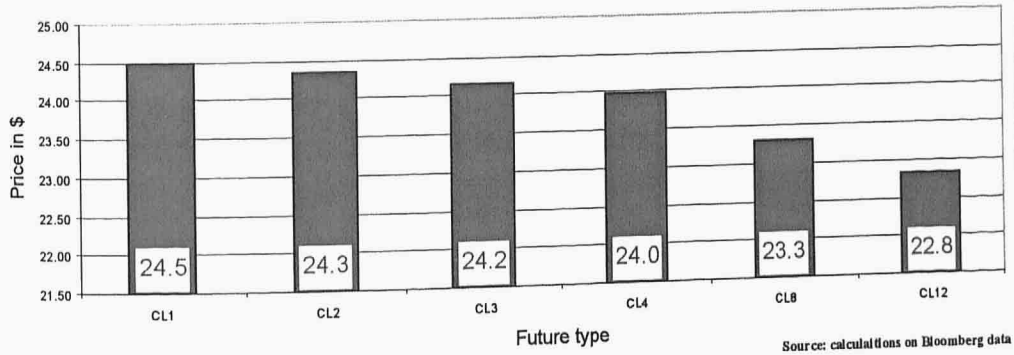
Figure 18 - comparision of the average, median and standard deviation values for futures spreads



	CL1	CL2	CL3	CL4	CL8	CL12
Average	0.28	0.69	1.17	1.66	2.95	3.68
Medain	0.18	0.46	0.89	1.41	1.24	2.17
Standard deviation	3.08	4.02	4.64	5.14	6.82	7.82

Source: calculaitions on Bloomberg data

Figure 19 - Average price of crude oil futures



Source: calculaitions on Bloomberg data

When collecting evidence from the employees of the oil company the irrelevance of the future price in regard to the future spot price has also been stressed.

A commodity is being backwarded when the spot prices exceed futures prices (and short-dated futures exceed longer-dated futures). Contango is the opposite situation. A related but somewhat different concept is the normal backwardation which exists when future expected spot prices exceed futures prices. The opposite is called the normal contango.

When collecting the evidence about backwardation from the dataset the price differences among the CL1-CL12 futures and the spot prices were examined. Figure 20 shows the 15 years period development of the future prices. Figure 21 shows the future spread from 1990. Figure 22 shows the percentage which corresponds to the contango situation for all 6 future contracts. From there it can be clearly seen that the more distant futures tend to be more backwarded.

Figure 20 - Spot and future crude oil prices

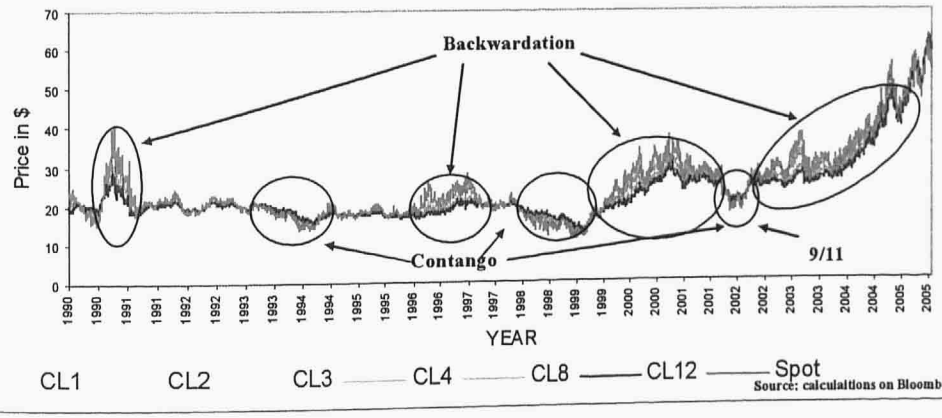
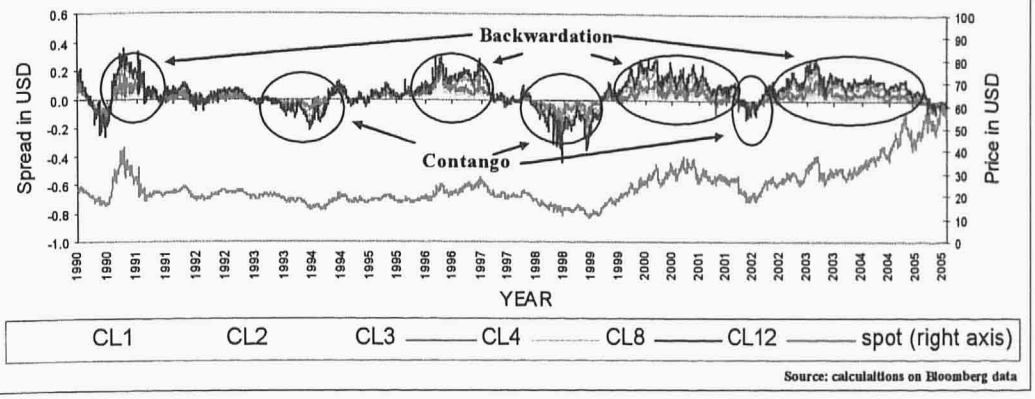


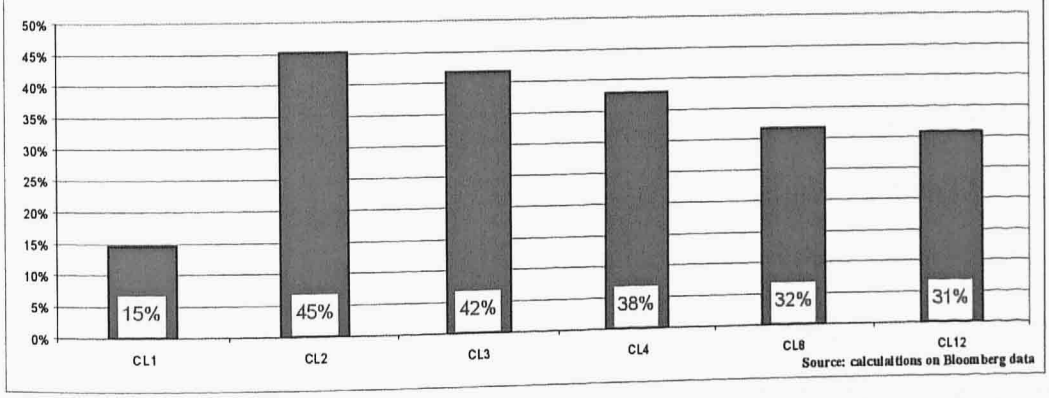
Figure 21 - Crude 1-12 months spreads



The only exception is the CL1 future which was backwarded 85 per cent during the period. The case of CL1 future can be a proof of the existence of the normal backwardation because it is not probable that the market would systematically undershoot the expected 1-month spot price.

There are many views on the existence of backwardation. In the following subchapter the closer look at the existing studies and theories and their results is taken. A closer look is now taken on the situation after September 11, 2001.

Figure 22 - percentage of contango in crude oil futures by type from 1990-2005



This period is interesting from the point of backwardation because the prices dropped from approximately 28$ per barrel to approximately 21$ per barrel thus forming the contango period. The backwardation returned after 6 months.

Figure 23 - Curde oil spread for 8 month and 12 month future for 2001-2002

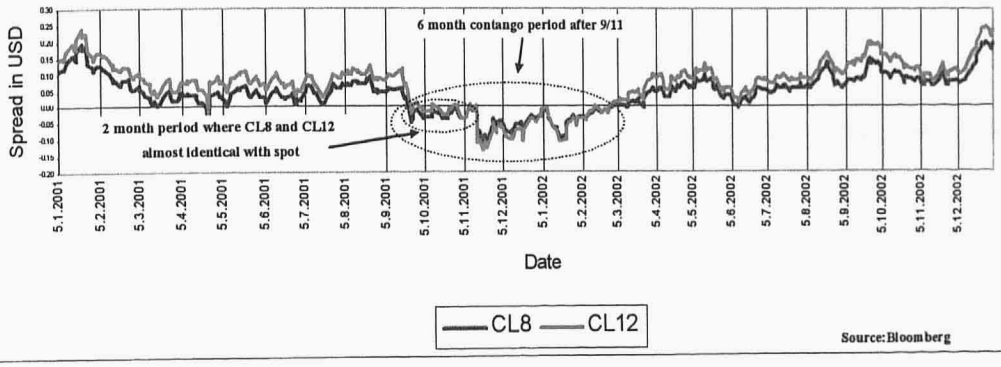


Figure 23 shows in detail the period of 2001-2002. It charts the 6-months and 12-months future price differences to the spot price of WTI. From figure 20 can be seen that the period before 11/9 from the middle of 1999 is strongly backwarded. Then following the 11/9 events, all futures became slightly contango and in March 2002 the backwardation started again and lasted till 2005. The markets are in contango these days.

Using the theoretical outcomes of the existing studies the situation covering the period of 9/11 events was closely examined. The drop of the spot prices caused a shift from backwardation to contango for a period of 6 months. The spot prices made higher shift than the future prices. When observing the prices of refined products, no major changes of prices were present. For the first two months till November the future prices were almost identical with the

spot prices. When examining the detailed situation, the move from backwardation to contango was not caused by a different level of inventories or by different level of technological conditions. It was purely caused by a lower demand which resulted in a lower spot price which was not fully followed by the future price. The market participants first did not expect any additional demand to come and for two months the prices remained equal with the spot prices, later the market participants expected the spot prices to increase in near future with increased demand and therefore the future contracts price remained on higher level.

9.1. Existing studies

The existing studies are now being looked at and some basic theory about the usefulness of backwardation to the fundamental analysis of crude oil prices as being abstracted. Logically, the future contracts should experience less volatility because any short term price movements based on market hysteria or temporary imbalance might be seen by the market participants as short-term and the price of future contracts should be adjusted to these price movements with less dynamics if at all.

Keynes (1930) in his theory of normal backwardation suggests that it is unlikely that the future markets can simultaneously fulfill both the hedging function and the future spot estimation of the given commodity. He argues that hedgers use the futures market to avoid risks, and that they pay a significant premium to speculators for this insurance. He concludes implicitly

that the futures price is an unreliable estimate of the spot price prevailing on the date of expiration of the futures contract. Keynes' conclusion is based upon the argument that the long/short speculator realizes the premium by refusing to purchase a contract from the short/long hedger at a price below/above that which the futures price is expected to approach. Grauer and Litzenberger (1979) in their study have shown that the price of a commodity future contract is a biased estimate of the future spot price of the commodity due to the real social risk and the inflation exposure of the contract. Telser (1958) examined trends in futures prices and found no evidence to support the theory of normal backwardation. Dusak (1973) examined the existence of a risk premium within the context of the Capital asset pricing model. She found that the systematic risks of the three commodity contracts investigated were not significantly different from zero. Cootner (1960) on the other hand presented several cases in support of the contention that risk premiums exist in commodity futures. He showed that it was possible for speculators to profit merely by being long after the peak of net short hedging and by being short after the peak of net long hedging. Also Carter, Rausser and Schmitz (1983) found non-zero estimates of systematic risk for most of the speculative return series they examined. Chang (1985) presents statistical evidence in support of the theory of normal backwardation as suggested by Keynes. He also concluded that the presence of such risk premiums tends to be more prominent in recent years than in earlier years. Williams (1987) in his study stressed the importance of

the costs in the spot and futures markets and shipping costs. In Pindick (1994) and Brennan, Williams and Wright (1997) is discussed the 'convenience yield', that is, inventories have a yield for the producer by enabling to lay hands on them the moment they are wanted and thus saving the cost and trouble of ordering request deliveries, or of waiting for deliveries. Fort and Quirk (1988) examined the inventory effect, that is, the high correlation between spot and future prices. When inventories of a commodity are large can lead to the backwardation. O'Hara (1985) in his work proves the idea of John Hicks that the technology could lead to an imbalance in long and short hedging which would induce normal backwardation in forward prices. One additional reason for contango state is that it is quite common for futures prices to be bid up higher than the spot physical price. This happens when traders win a tender, which may span several months of demand. Prices are often hedged first on futures before the necessary physical product is acquired. Ultimately, the hedges are unwound as the physical side of the transaction is completed, increasing spot market pressure and removing futures pressure.

There are more studies on this topic, all of them giving unclear straightforward evidence of the normal backwardation.

From the above studies, the conclusion if the hypothesis that commodity futures prices are unbiased estimates of the corresponding future spot prices is consistent with the normal backwardation cannot be made. One assumption can be made though, the normal backwardation evidence was

studied on different types of commodities (from soybean over crude oil to wheat) and because of the crude oil characteristics a closer look is taken at the study examining the backwardation on the crude oil futures. Such study is Phillips and Weiner (1994) which exactly corresponds to the needs of this research on the crude oil price influences.

In their study Phillips and Weiner (1994) stated no support for the theory of normal backwardation. Their model was based on the Brent dataset and unlike other studies their dataset consisted also of the information about the type of buyers/sellers thus being able to track the speculative part of the transactions. Their result about the non-existence of the normal backwardation on the Brent crude oil futures provides important feedback for this study. If no premium for speculators exists (future prices are only a function of the expected future spot prices, no systematic premium is present to cover the speculators' risk), the assumption that the crude oil prices are main influence by speculative demand and supply may be abandoned. Because no unity about the existence of normal backwardation exists, it cannot be uniquely concluded that speculative demand and supply plays major role in the crude oil price development.

10. Summary

In this study the crude oil price determinants were examined. The historical development of the crude oil price shows that the price was highly responsive to escalations in regions supplying the crude oil. The technical analysis modeling in general gave no convincing result about the usefulness of the tools of technical analysis which imply that the forces influencing the crude oil price as a result of speculations based on the tools of the technical analysis are very limited. Even though the tools based on the Fibonacci number proved to capture some market sentiment, more complex examination on larger data sample is needed to state any stronger statements about the influence on the crude oil price. In the chapter focused on the fundamental analysis, the major fundamental price determinants were explained. A conclusion can be made that because no major substitutes for the crude oil exist the crude oil price is highly responsive to even minor demand and supply disruptions. The oligopoly structure of the crude oil supply broadens the uncertainty of the market and increases the risk premium necessary to cover any sudden political decisions of the OPEC countries. The backwardation summary in this thesis does not unilaterally prove that a speculative element would be present on the future markets. This conclusion gives another support for rejecting the hypothesis about the speculative force playing major role.

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NOTES

[1] When crude oil first came into large-scale commercial use in the United States in the 19th century, it was stored in wooden barrels.
[2] www.bloomberg.com
[3] Roayl Dutch Petroleum Company owns 60 per cent of the Royal Dutch/ Shell Group of companies. Through this interest, the company explores for, produces, refines, and markets petroleum products, manufactures chemicals, and produces solar cells.
[4] www.argus.com
[5] Marian Radetzki publicized his study "Long-run factors in oil price formation" as a part of the "Primary commodity prices:economic models and policy" edited by L.Alan Winters and David Sapsford, Cambridge: Cambridge University Press. In his study he built a price chart for oil, metals and minerals, non-food agricultural commodities and food commodities. Nominal oil prices have been obtained from three sources, for 1900-1948 US domestic average prices at wellhead from Manthy (1978), for 1948-1984 Saudi Arabian light crude prices.
[6] For example a factory exporting cars might need to exchange currency immediately without waiting for any price pattern to develop, some participants do not pay any attention to the technical analysis at all.
[7] Subscribers to the services of the survey companies in this market receive an electronic report at the end of each trading day that includes individual transactions consummated that day. During the day, periodic price 'assessments', in the form of bid/ask quotes, are sent out by the various survey companies, but these quotes are not necessarily based on actual transactions.
[8] Leonardo Fibonacci was born around 1175 AD. This Italian mathematician first discovered the sequence of numbers where each term in this sequence is simply the sum of the two preceding terms (1, 1, 2, 3, 5, 8, 13, 21, 34, 55, etc.). Fibonacci also described the special ratio that is obtained by dividing any two neighboring numbers. This ratio is known by the technicians as the golden ratio and it approximately equals 1.618, or its inverse value 0.618. From the mathematical point of view, the golden ratio in its inverse form is the only number which inverse value is the same number plus 1: $1/x=1+x$
More about the mathematical meaning of this number can be found in many studies, the basic principle is explained for example in Horadam (1961).
The Fibonacci number can allegedly be used to describe the proportions of everything from nature's smallest building blocks, such as atoms, to the most advanced patterns in the universe, such as unimaginably large celestial bodies. Nature relies on this innate proportion to maintain balance, but the financial markets also seem to conform to this 'golden ratio'.
[9] The basics of the Elliott wave are fully described in www.elliotwave.com.
[10] Considerably different view is presented in Abu al Khail (1979):".. as the increased earnings of the eporter were used to purchase a larger volume of goods and services from other countries, the initial deflationary effect on demand as a result of the rise in oil prices in these countries was offset by the subsequent growth of demand for their products...".
[11] On the financial markets short-term speculations are being done frequently. Any such trade usually does not span into more than 2 days.
[12] For instance www.realtimetrades.com