UNIVERSITY OF PIRAEUS

DEPARTMENT OF BANKING AND FINANCIAL MANAGEMENT
M.Sc. IN FINANCIAL ANALYSIS FOR EXECUTIVES

MASTER'S THESIS

MACROECONOMIC FACTORS AND OIL FUTURES PRICES

STUDENT: KOSTAS KONSTANTATOS
MXAN0922

SUPERVISOR: Dr. NICHOLAS APERGIS

COMMITTEE

NICHOLAS APERGIS

ANGELOS ANTZOULATOS

GEORGE DIACOGIANNIS

FEBRUARY 2011

Abstract

The main purpose of this paper is to determine the relationships between various macroeconomic factors and oil futures, with underline commodity the WTI light sweet crude oil, trading in NYMEX. In this effort we use five oil futures' maturities and specifically the generic form contracts of 1, 3, 6, 9 and 12 months. We try to determine the interdependencies of certain macroeconomic factors and the price of each one contract starting from January 1990 until May of 2010. We test for Granger causality and then apply VAR specification accompanied by impulse response analysis and variance decomposition. We find evidence that there is a solid relationship between certain macroeconomic factors and oil variables.

Key words: oil futures, macroeconomic factors, VAR, transmission mechanism, variance decomposition.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 Presentation of the selected macroeconomic variables

We choose a particular set of macroeconomic variables because there aren't many studies that deal with them explicitly, although all of them are reliable proxies and expressions of very important real economic events and motions that happen worldwide. So in that sense there are no previous studies that much exactly this paper except only partially. That's why we try to capture relations between them and the oil variables in order to discover correlations and interdependencies that are not known.

In order to quantify these various macroeconomic factors we used a set of indices as proxies that each one represents a certain factor. Some of these proxies are announced once a month, so we had to take monthly prices for every other index and also for the futures prices in order to make a coherent set that could be processed. These proxies are:

1. S& P 500 stock index.
2. S & P Europe 350 stock index.
3. Nikkei 225 stock index.
4. Hang Seng stock index.
5. FED target funds rate.
6. Dry Bulk index.
7. US industrial production (MoM 2007=100, sa).
8. European Union industrial production (MoM, sa).
9. Capacity utilization for the US economy.

The first one, Standard & Poor's 500 contains 500 median and big US companies based on their market size, liquidity and sector. It is considered by many market participants as a benchmark for the overall US equity market. It can be used as a proxy for the overall health of the US economy. S & P 350 index is tracking almost 70% of the European market capitalization and therefore it can be used as a proxy for the European economy. Nikkei is a stock market index for the Tokyo stock exchange and it is consisted of 225 prominent Japanese stocks. It can be used as a major indicator for the Japanese economy. Hang Seng index consists of the 45 largest companies of the Hong Kong stock exchange and it represents almost 67% of its capitalization. Most of them are big Chinese companies and it is a good indicator of the Chinese economy. Fed effective funds rate is the target rate at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight. This is very close to the target rate that we use in this paper. Using the intention of Fed about funds rate, which is the target funds rate that we use, is an approximation of the certain point that the US economy is during an economic cycle. Low target funds rates means that US economy is not strong enough, so the Fed decreases target rate in order to motivate economic participants and strengthen economic activity. Dry bulk index (BDI) tracks worldwide shipping prices of various dry bulk carriers. It is assessed by taking into account 50 global shipping routes and it is an indicator of supply and demand in global transportation of raw materials. When global economy is robust the value of the index rises and vice versa. The next two indicators, US and EU industrial production, track industrial output in America and European Union. Industrial activity consumes a large amount of produced oil and changes in the level of industrial output affect oil prices. Capacity utilization is the extent to which the productive capacity of an economy is used to generate goods and services. Intuitively we can assume that the stronger the economy the more productive capacity uses, leading the value of the index upwards.

The main idea underlines the choice of the indices is firstly, the global character of the oil market and secondly, the correlation of global economy in such a way that the slowdown of a major economy such as US or Europe, could not be considered irrelevant of a slowdown in global economy. In contemporary world, economies are intertwined so much that even the bankruptcy of a small country like Greece could cause crackles in the globalised monetary system, something that couldn't be happen before 30 years. In that sense, if, let's say, the FED key interest rate are below 1%, we can safely assume that the US economy are in crisis and the same is almost certain for the rest of the world, with some unavoidable exceptions of course.

1.2 Data and symbols

For practical purposes we assign symbols to the various macroeconomic factors and the futures contracts that will be used.

spot= spot WTI oil price at Cushing, Oklahoma
cl1= futures contract matures in 1 month
cl3= futures contract matures in 3 months
cl6= futures contract matures in 6 months
cl9= futures contract matures in 9 months
cl12= futures contract matures in 12 months
sp500= S & P 500 stock index
sp350= S & P 350 stock index
nikk= Nikkei stock index
hase= hang seng stock index
fedr= Fed target funds rate
bdi= dry bulk index
indpreu= industrial production index for European union
indprusa= industrial production index for US
caput= capacity utilization for US

When letter d is in front of a symbol, it denotes logarithmic returns. Cl1, cl3, cl6, cl9, cl12, are the generic forms of futures contracts for maturities 1, 3, 6, 9 and 12 months respectively and have been downloaded from Bloomberg. Spot is the spot price of WTI crude oil as it is trading at Cushing, Oklahoma.

1.3 Brief oil pricing history

Pricing in the oil market evolved, as the significance of oil as an input in the production procedure increased dramatically, mostly after the Second World War. The use of oil can be traced back to ancient years where people used it for lighting, construction or even as a cure for kidney stones. Technological advances that took place after the industrial revolution in Europe convert oil from a low importance and usefulness commodity, to the main factor in production activity worldwide.

After World War II and until the 1970s major participants in the crude oil market were determining the prices. These participants were the big western oil companies, the seven sisters as they were been named at the time being and oil producing nations such as US, Mexico, Saudi Arabia. It was a market that was driven by supply and demand for spot oil and was characterized by monopolies and their power to determine oil price. But as oil became more important as an input in economy, more countries join the game and the companies that engaged in the production and distribution of oil increased dramatically. This led to a more globalized and fair pricing mechanism. In 1980s the monopoly was gradually broken and on March 30 1983 oil futures contracts with fixed characteristics started trading in the NYMEX. The number of market participants had increased during the previous years in such an extent that spot oil prices were determined by active trading in organized markets rather than by agreements between a few companies. From that date and on, futures contracts gain exponentially in significance and today their role as a pricing mechanism is without question unexceptionable. The biggest markets for oil futures today are the NYMEX, where WTI (West Texas Intermediate) light sweet is trading and the ICE (Intercontinental Exchange) where Brent oil futures are trading.

WTI futures contracts at NYMEX refer to 1000 or 500 barrels of crude oil and today anyone that has the money to cover the margin requirements can buy a contract. This indeed is a major change compared to the time that only big companies paying millions of dollars could trade crude oil.

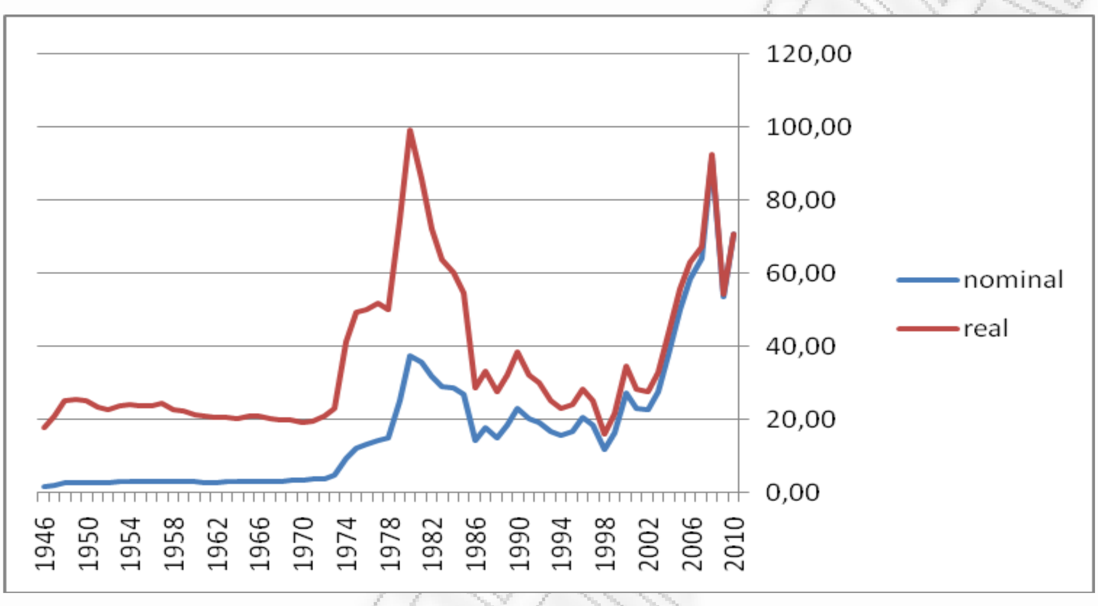
Oil contracts in NYMEX extend up to nine years and for the first six years (including the current) there are monthly consecutive maturities. After the sixth year we have only June and December contracts. New contracts are added after the December contract of each year matures, so the term structure is continuously renewed.

1.4 Impact of oil price on economy

When studying about oil prices the first thing that someone observes is a persistent increase, in real and nominal terms, from the 1970s until today. Diagram 1 shows the price per barrel (US dollars) in nominal and in real terms in a yearly basis for US imported oil .

Diagram 1

Real & nominal US imported oil price



As it is evident, until 1972 WTI oil prices were quite stable but an abrupt increase was caused due to Yom Kippur war in 1973 and the Iranian revolution in 1979, which created shocks in the form of oil production disruptions (supply shocks). From 1979 to 1985 oil prices had declined from their highs and they followed a relatively stable path until 2000, but from that year until today there is a huge spike in oil prices in real and in nominal terms. This sharp increase is attributed to the constant growth of developed countries such as China and India and the inability of global oil production to keep pace with demand.

There is a unanimous consensus among researchers that oil price increases inflict reductions in global GDP, except maybe for the oil producing countries and only in the short and median term. In the long term even oil producers may experience GDP decreases due to decelerating global growth. For example the higher earnings that

OPEC would have from increased oil prices in the short term could be outweighed by decrease in world production and subsequently less demand for oil. The estimates of the short term effect of oil prices on the economy vary. According to Huntington (2005) in a survey of several macroeconomic models conducted in 2005, a 10 dollars per barrel increase is expected to reduce output in US by about 0.25 percentage points in the first year and 0.5 percentage points in the second year. A study of the International Monetary Fund (2005), showed that an increase of $5 per barrel can reduce real world GDP by 0.25 percentage points for the next four years and by about 0.3 percentage points the US GDP. In another research which conducted in 2004 by IEA (International Energy Agency) in collaboration with OECD and IMF, an increase of 10 dollars in oil prices would result in a 0.4 percentage points loss of GDP per year, for two years, for all OECD countries and additionally in a 0.5 percentage points increase in inflation. Unemployment would also increase. OECD countries with high dependence on imported oil such as the European Union would suffer more losses in the short term than countries with less dependence such as US. The effects of the shock starting to diminish after about three years.

There is a difference on the impact of oil price shocks between developed and developing or underdeveloped countries. The results of a shock would be greater in developing and underdeveloped due to lower productivity of energy use. On average oil importing developing countries use twice as much oil to produce a product unit than OECD countries, meaning that they are more energy-consuming and energy-inefficient. For example in Asia a 10 dollars increase in oil price would result in a 0.8% loss in GDP and for the poorer and more indebted developing countries of the world, 1.6% loss. In sub-Saharan Africa the loss would be even greater than 3%.

Although there is consensus about the negative impact of oil prices in the economy there is a different level of responsiveness for every particular country which depends on many other factors. Oil imports as a percentage of GDP is a very important factor which shows how much an economy depends on foreign oil. Countries with total dependence on foreign oil suffer only disadvantages relatively to countries that produce even a small amount of oil which counteracts the negative effects of the price increase. Another factor is the ability of households and companies to substitute oil with other energy sources such as gas and the correlation of oil prices to gas prices.

Oil price shocks also affect negatively the exchange rates due to deterioration in the balance of payments. In order for a country to buy the same amount of oil as before the price spike, it has to sell more of its domestic currency to buy dollars, so its currency depreciates. Imports then become more expensive and exports yield less in terms of foreign currency, although here there is also a positive effect from the increase in exports due to the fact that domestic currency depreciation makes domestic products cheaper.

The effects of oil price spikes at first, act on a microeconomic level. Due to high correlation among oil and gasoline prices households have increased expenses for gasoline and heating oil which reduces their consumption for other goods and services leading companies to lower profits. Companies on the other hand except from reduced sales, they have also increased input costs, especially those which use oil as a primary input such as industrials and transportation companies. Lower profits means decline in stock exchanges, lower job vacancies or even layoffs and generally the triggering of a self-feed mechanism which produces economic depression. Also except inflation that is caused directly from the increased oil prices, (oil price is a parameter in the inflation estimation), the rise in input costs may be transferred to consumers through higher product prices. The employees on the other hand might ask for higher wages to counteract the decrease in their purchase power and all these factors lead to a self-feed inflation procedure.

The described recession mechanism needs to be unexpected in order to be powerful and effective. That is one of the reasons why the world economy keeps developing instead of the increase in oil prices. The oil price spike is already discounted and accounted for so it inflicts less turbulence in the economic system.

A common question that derives from the dependencies between oil price and the economy is its stability and power through time. Blanchard and Gali (2007) conclude that although the oil price shocks of 2000s are comparable in magnitude to the 1970s shocks, their effect on economy wasn't as strong as in 1970s suggesting that the relation between fluctuations in oil price and real economy after 2000 has been smoothed out. Hooker (2002) in his study suggests that in late 1980s a structural brake occurred between oil price and inflation and their dependence reduced in magnitude. Also Blanchard and Gali (2007) come down to a similar conclusion that there is a structural brake at the responses of output, wage inflation, prices and employment relatively to shocks in oil prices, from mid 1980s and on.

Many explanations have been given why the relation between oil prices and inflation has weakened. Blanchard and Gali (2007) suggest increased flexibility in labor markets, monetary policy improvements and adverse concurrent shocks such as a concurrent productivity increase. Central banks response is also a logical explanation especially concerning the US Fed. Before 2000, Fed used to concentrate more on the consequences of oil prices on output rather than on inflation. This stance were producing inflationary expectations to households and companies and these expectations were triggering the inflation cycle. After 2000 where Fed's attention on inflation became more important and it adjusted its policy in order to stabilize inflation, the consequences of oil prices shocks to economy have reduced as also the inflationary expectations of households and companies which trigger the inflation cycle. So by deteriorating inflation consciously Fed has reduced the correlation between oil shocks and inflation.

Sill (2007) alleges that five out of seven recessions that have happened in the last 30 years were preceded by spikes in oil prices. At all these periods there were also other variables which simultaneously affected the economy such as hikes in commodity prices in 1970s and a strong global increase in productivity and output in the 2000s. These parameters obscure the real effect of oil price fluctuations in economy and someone have to employ econometric analysis in order to raise the possibility to conclude more reliably in the relation between oil and economy.

An interesting effect of high oil prices is reallocation of capital and production inputs among different industries. Alternative sources of energy which antagonize oil, gain advantage relatively to oil although not rapidly. Solar, wind or geothermal energy owe some of their development and usefulness in everyday life, to high oil prices. These sources of energy become relatively cheaper as oil prices increase and tend to operate as substitutes. Another example is the car industry. Major car manufacturers develop new ‘clean’ technologies in order to produce car engines which work without gasoline. Such reallocation is extended in other industries that produce car parts for the new ‘clean’ cars, such as batteries, solar cells or even biofuels. Especially biofuels can reallocate the whole agricultural production of an area or even a country by stimulating farmers to produce plants for biofuels instead of consumption, if the price is to their advantage.

The relation between oil price and the economy is also relative to the certain point that we are in the economic cycle. Huntington (2005) claims that oil price shocks that occur in an environment of low interest rates and low inflation are less interactive with economy than shocks that happen in an environment of high interests and high inflation.

1.5 Transmission mechanism & oil futures

The effect of various macroeconomic factors to oil futures is transmitted in two stages. At the first stage, there is a strong positive correlation of spot prices to futures prices that moves the term structure up or down. If for example we have a very strong global growth that demands great quantities of oil then the supply-demand mechanism will boost upward the spot price and the same will happen to futures contracts at all maturities. At this stage we have the primary reason that affects futures prices indirectly through spot prices. The second stage is as important as the first because most of the time we observe high deviation between the spot and future prices which become greater as time to maturity increases (ceteris paribus). This deviation could be attributed to the combination of cost of carry and convenience yield. When convenience yield becomes greater than the cost of carry, spot prices are higher than futures prices and the term structure is determined as backwardation (downward sloping). The opposite gives a term structure described as contango where futures prices are higher than spot prices (upward sloping term structure). This is visible in the pricing equation for commodity futures held for consumption:

$$F_t = S_t e^{(c-y)T}$$

c=cost of carry

y=convenience yield

F t=future contract price at time t

S t=spot price at time t

T=time to maturity annualized

e=base of natural logarithm (implies continuous compounding)

Cost of carry can be analyzed in two components for oil futures. The first is the risk free rate r_f, and the second is the storage cost per year as a percentage of oil price u. The equation that describes these components is:

$$c = r_f + u$$

As we said, when global economy is robust, central banks tend to increase their key interest rates. On the other hand when we have a growing global economy, there is a great possibility that storage cost will increase. This is due to higher rents for storage areas (the opposite holds true when global economy is in slowdown). Cost of carry in this case will increase and in combination with convenience yield the price of the futures contracts at all maturities changes. This is an indirect way where various macroeconomic factors that lead to an increase or decrease in global growth, affect oil futures prices. So the possible outcomes are infinite, depending on the values that cost of carry and convenience yield will take.

From the primary mechanism of supply and demand in spot market which is the first consequence in oil price if a change in a certain macroeconomic factor occurs, we passed to the deviation of spot price to futures price and its determinants. The spread of this deviation must be considered thoroughly if we are to find a reliable relationship between macroeconomic factors and futures oil prices. Because of the complexity of the mechanism we can only observe indirectly these effects to oil futures markets. Let's say that global economy in the near term is expected to grow rapidly and oil buyers want to pile into inventories in order to correspond to the upcoming demand for oil. Then the convenience yield will increase (ceteris paribus), and the more it increases the more futures contracts at all maturities deviate from spot prices heading downwards (backwardation). This deviation can be quite important and is a significant determinant of the futures contracts prices.

We observe that a key contributor to the change of convenience yield is expectations which play an important role to the transmission of macroeconomic effects to oil futures. Expectations that affect futures prices are not only concern macroeconomic factors but also geopolitical conflicts, weather changes, spare oil capacity, OPEC decisions about supply and numerous other factors.

One of the theories that have been proposed to explain the spike in oil prices after 2002 is peak oil theory. According to this, oil production will reach a peak at the near future when global demand will continue to rise, so there will be a shortage that will increase oil price. The peak oil theory advocates chart the amount of oil discovered over time and extrapolate this trend into the future. Evidence exists that the number of wells drilled, has been significantly reduced from 1980 until today, but it is not at all sure that this is due to lack of oil reserves instead of unwillingness to drill, from big oil companies. If this theory holds true, which is not at all sure, or even if market participants believe that it is true, we can see how expectations can affect futures prices in a direct way. Under these circumstances we will have a permanent contango because market participants will expect oil prices to keep rising in the future so they will buy futures in order to hedge rising oil prices.

There is a very important difference between expectations and other macroeconomic factors and this is the straightforward way in which expectations affect futures prices. In the first paragraphs of this paper we saw the indirect way witch various factors affect futures prices via 1.Spot prices and the current supply-demand mechanism. 2. Cost of carry and convenience yield. We implied a one way direction from spot prices to futures prices. Via expectations it is transformed into a two directions mechanism.

Many financial institutions (including ECB and IMF) and market participants use futures contracts prices as a proxy for expected spot prices (predictors). This implies that a change in futures contracts prices determines spot prices. Baek and Brock (1992) employed a nonlinear causality model to evaluate the lead lag relationship between spot and futures prices. In this paper they found that a two way feedback relationship exists, where futures prices always lead spot prices (efficiency of crude oil market). Also Kaufmann & Ullman (2008) investigated from where changes in the price of crude oil originate and how they spread, by examining causal relationships among prices for crude oil from North America, Europe, Africa and the Middle East on both spot and futures markets. One of their conclusions was that the spike in oil prices at the end of 2008 was generated by changes in market fundamentals as well as speculation. At first, increased demand and inelastic supply of oil caused a big hike in oil spot prices and then speculators came in by buying futures contracts to anticipate continuation of price hiking. The increased demand in futures contracts raised their price and this rise transmitted to the spot market at a level that couldn't be justified by the existing supply-demand balance. So in that case we can clearly see the two directions mechanism for oil pricing and also how macroeconomic factors indirectly affect oil futures prices.

Bekiros & Diks (2007) using a nonlinear model, conclude that the pattern of leads and lags between futures and spot market, changes over time in a way that we cannot say if the spot or the futures market always lead. This means that causality is bidirectional.

An important way by which expectations determine oil futures prices is through the use of contracts for hedging purposes, which indirectly relates to macroeconomic factors. If for example a company that uses oil as a production input expects continuous rise in oil prices due to constant growth in global industrial production, it might buy futures contracts to lock in current prices. Other market participants might expect a slowdown, so they sell oil contracts to lock in selling prices. The effect of buying and selling for hedging purposes, cause changes in oil futures prices.

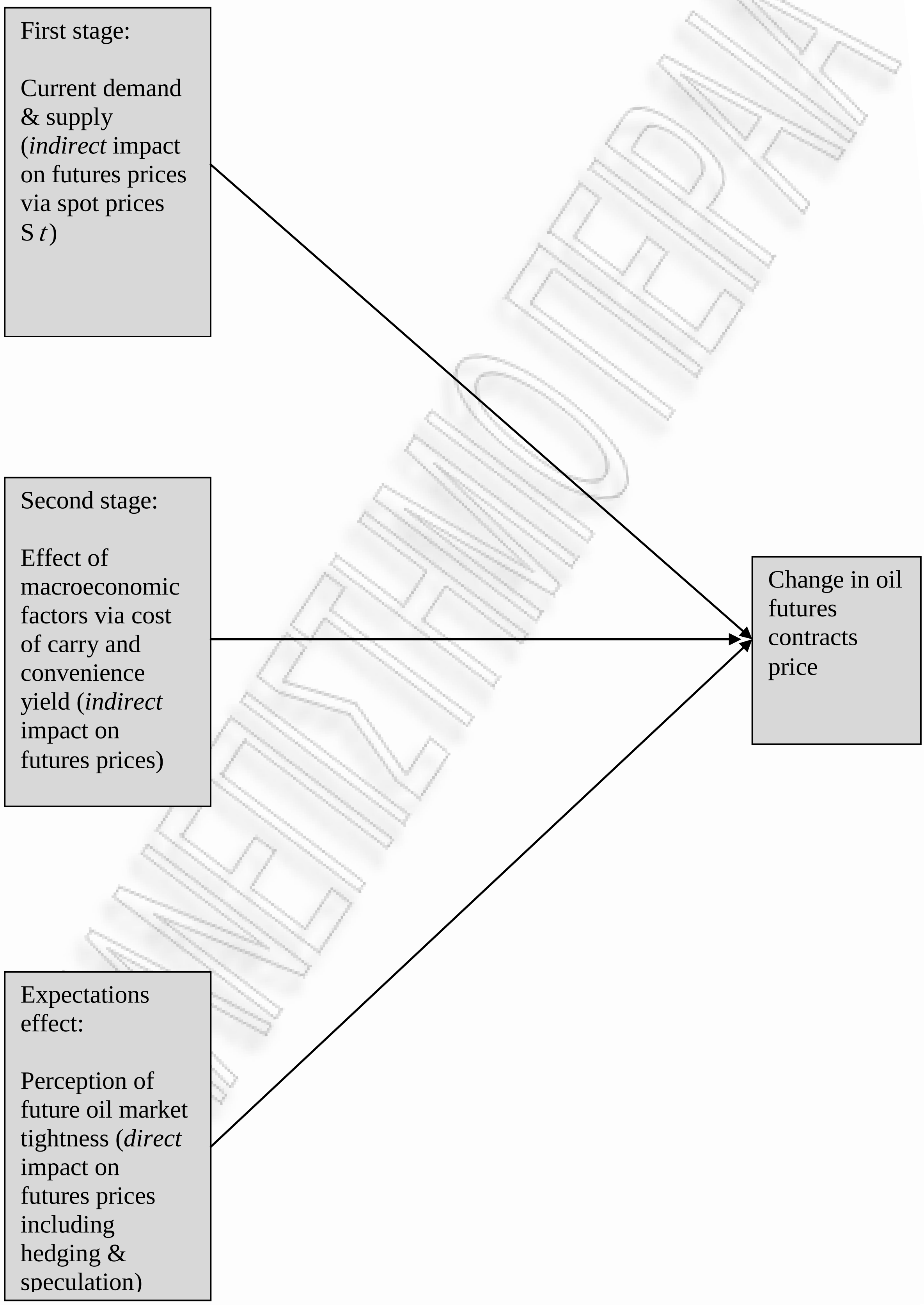
Bwo-Nung Huang, C.W. Yang and M.J. Hwang (2007) study the effect of speculative strategies on the term structure of oil futures. They defined the term ‘basis’ as the difference between futures price and spot price and they discovered that there is a critical threshold band of basis values, out of which there are arbitrage opportunities that when exercised tend to move the oil market towards equilibrium. In other words if basis is positive and greater than the upper limit of the threshold, then investors will start the arbitrage by selling futures contracts and buying oil in the spot market. When basis is negative (futures contracts price smaller than spot price) and bigger in absolute value from the lower bound of the threshold, then investors sell oil in spot market and buy futures contracts. The paper captures the interactions between spot and futures prices, at least to the extent that speculation opportunities exist.

There is no consensus for the magnitude of the change that hedging and speculation cause. There are opinions that attribute the current high price of oil to speculators and hedgers and others that support a small change in spot and futures prices due to speculative or hedging purposes.

We can draw the mechanism that has been described in the above paragraphs, for simplification reasons, as below:

Diagram 2

Determinants of oil futures prices



The above mechanism could be enriched to include other factors than macroeconomic, such as proven world oil reserves, geopolitical conflicts, spare oil capacity, expectations for supplemental alternative energy sources, etc, which are out of the scope of this paper.

In order to capture the importance of spot prices in the configuration of futures prices we run five regressions with dependent variables the returns of futures contracts of 1, 3, 6, 9, 12 months and independent variables:

1. The contemporaneous spot returns and three lags of spot returns,
2. Three lags of the dependent variable itself AR(3) and
3. Three lags of the moving average of the error term MA(3).

By using the adjusted R-squared of every regression we will depict the explicative power of the above three groups of variables to every WTI future price. We perform general to specific procedure by subtracting gradually the statistically insignificant coefficients (prob.>0.05) and after obtaining statistical significance of all coefficients we perform misspecification testing to correct for serial correlation and heteroskedasticity of the error term, if needed. An adjusted R-squared equals to 1 means that the independent variables explain 100% the dependent variable whereas an adjusted R-squared below 1 indicates that the remaining $1-R^2$ can be explained by other unknown variables. We use logarithmic returns in order to avoid the unit root problem that exists if we just take the time series data as they are. The results of the regression for the 5 aforementioned contracts are shown below.

Table 1
Oil future contract matures in 1 month

Dependent Variable: DCL1
Method: ML - ARCH (Marquardt) - Normal distribution
GARCH = C(5) + C(6)*RESID(-1)^2 + C(7)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-8.74E-05	8.01E-05	-1.091728	0.2750
DSPOT	1.000753	0.000558	1793.149	0.0000
DSPOT(-1)	0.648661	0.098017	6.617833	0.0000
DCL1(-1)	-0.648018	0.097727	-6.630921	0.0000
	Variance Equation			
C	2.70E-08	6.19E-09	4.360802	0.0000
RESID(-1)^2	0.265737	0.031661	8.393162	0.0000
GARCH(-1)	0.728923	0.005650	129.0169	0.0000
R-squared	0.995492			
Adjusted R-squared	**0.995378**			

Table 2
Oil future contract matures in 3 months

Dependent Variable: DCL3
Method: Least Squares

Vatiable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000477	0.000547	0.871229	0.3845
DSPOT	0.867744	0.011410	76.04873	0.0000
DSPOT(-1)	-0.754224	0.185973	-4.055555	0.0001
DSPOT(-2)	0.457565	0.142418	3.212827	0.0015
DCL3(-1)	0.892511	0.207078	4.310017	0.0000
DCL3(-2)	-0.554510	0.160542	-3.453984	0.0007
MA(1)	-1.014049	0.217201	-4.668709	0.0000
MA(2)	0.525103	0.187001	2.808018	0.0054
R-squared	0.964686			
Adjusted Rsquared	**0.963629**			

Table 3

Oil future contract matures in 6 months

Dependent Variable: DCL6 Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001381	0.001329	1.039034	0.2998
DSPOT	0.711687	0.016390	43.42249	0.0000
DCL6(-1)	0.066020	0.022556	2.926976	0.0038
MA(1)	-0.149259	0.067811	-2.201097	0.0287
R-squared	0.893026			
Adjusted R-squared	**0.891684**			

Table 4

Oil future contract matures in 9 months

Dependent Variable: DCL9 Method: Least Squares Newey-West HAC Standard Errors & Covariance				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000592	0.000558	1.061058	0.2898
DSPOT	0.619281	0.032234	19.21211	0.0000
DSPOT(-1)	-0.889010	0.059030	-15.06041	0.0000
DSPOT(-2)	0.428817	0.051171	8.380109	0.0000
DSPOT(-3)	0.072703	0.018160	4.003507	0.0001
DCL9(-1)	1.568112	0.028313	55.38545	0.0000
DCL9(-2)	-0.902561	0.030351	-29.73746	0.0000
MA(1)	-1.623291	0.011330	-143.2774	0.0000
MA(2)	0.969204	0.010065	96.29106	0.0000
R-squared	0.838526			
Adjusted R-squared	**0.832958**			

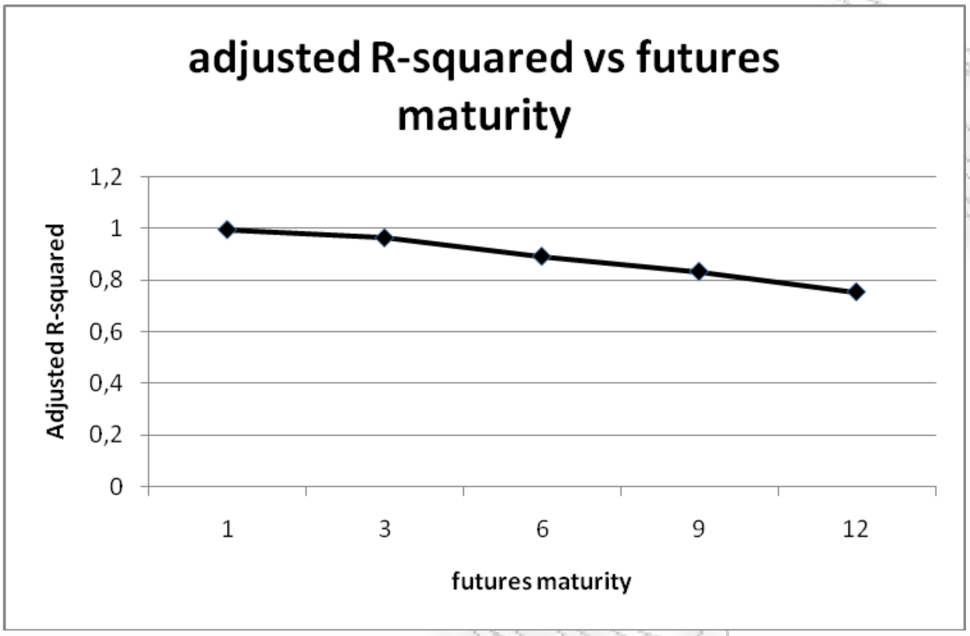
Table 5

Oil future contract matures in 12 months

Dependent Variable: DCL12				
Method: ML - ARCH (Marquardt) - Normal distribution				
GARCH = C(10) + C(11)*RESID(-1)^2 + C(12)*GARCH(-1)				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000812	0.003305	0.245787	0.8058
DSPOT	0.500706	0.016388	30.55373	0.0000
DSPOT(-1)	0.249713	0.019646	12.71093	0.0000
DSPOT(-2)	0.479046	0.016209	29.55419	0.0000
DSPOT(-3)	0.086965	0.014928	5.825484	0.0000
DCL12(-1)	-0.336312	0.024069	-13.97305	0.0000
DCL12(-2)	-0.942346	0.015611	-60.36482	0.0000
MA(1)	0.295716	0.005932	49.85144	0.0000
MA(2)	0.980658	0.003022	324.4701	0.0000
	Variance Equation			
C	5.61E-05	3.02E-05	1.859894	0.0629
RESID(-1)^2	0.406600	0.131666	3.088113	0.0020
GARCH(-1)	0.585019	0.105574	5.541298	0.0000
R-squared	0.764808			
Adjusted R-squared	**0.753511**			

We can see from adjusted R squared, that the closer the maturity of an oil future contract is to the spot price, the more it is correlated to spot price and its lags as also to its own lags. The 1 month maturity contract has an adjusted R ⊺ squared of 0.995378, the 3 months maturity has 0.963629, the 6 months 0.891684, the 9 months 0.832958and the 12 months 0.753511.

Diagram 3



So we observe a declining adjusted R-squared as maturity grows, meaning that the explicative power of the spot price and its lags and the futures' lags, relatively to futures prices tend to decrease. We could attribute this deviation to other factors that start to gain an important role as maturity increases which are not incorporated in spot prices. As we see in diagram 2, these factors could be cost of carry and convenience yield, as has been explained and expectations about the future of oil market (tight oil markets). Alquist and Kilian (2008) show that the spread between oil futures prices at different maturities are related to uncertainty about supply shortfalls and conclude that the variability of futures prices relatively to the spot price can be captured by the marginal convenience yield of oil inventories.

Expectations also can be macroeconomic or not. Unfortunately there are no indices or numbers that could quantify expectations, so the theory at this stage cannot be tested.

1.6 Relevant literature

We can roughly categorize the studies about oil in two categories. The first one which is the most abundant examines the term structure of oil futures and the causal relationship between spot and futures prices. It also studies the efficiency of the term structure, that is the predictive power of futures contracts as indicators of future spot prices. Some of them have been already referred to at the transmission mechanism section and others have also contributed in a better understanding of oil market and its interdependencies. Abosedra & Baghestani (2003) for example, tested the predictability of WTI 1, 3, 6, 9 and 12 months maturity futures contracts relatively to a naive forecast procedure and they conclude that the 1 and 12 months contracts are the best unbiased predictors of future prices.

Ripple and Moosa (2007) studied the determinants of the volatility of oil futures prices. They tested the significance of maturity, trading volume and open interest in a contract to contract analysis using daily prices for 131 WTI contracts traded on NYMEX. They used high and low intraday prices in order to construct a measure of volatility. Their findings suggest that trading volume and open interest are significant in determining price volatility whereas in the presence of these two the maturity variable can be excluded.

The second category examines the effects of various financial or generally economic factors relatively to oil futures prices and it is more fragmented than the first one because it tends to concentrate on the economic variables of particular countries. This paper can be considered as belonging in this category.

Samuel Imarhiagbe (2010) examined the relation of oil prices to stock prices and exchange rates in the long run for six countries, three oil producers and three oil consumers, from 2000 to 2010. The producers were Saudi Arabia , Russia and Mexico and the consumers were US, China and India. After using the Augmented Dickey-Fuller test for unit roots he performed the study for every country separately using five tests:

1. Johansen cointegration test to detect cointegration.
2. Forecast error variance decomposition to observe the proportion of variance to oil prices due to shocks in oil prices, exchange rates, stock markets and vice versa.
3. Impulse response analysis.
4. VECM pair-wise Granger causality to study if there are lead-lag relations among the three variables in every country.
5. Exclusion and weak exogeneity test to study the persistence of long-term cointegration relations between the variables.

By using the Schwarz information criterion he chose from 1 to 7 lags depending on the country. Evidence of cointegration exist in five countries, except Mexico, and that suggests that oil prices, exchange rates and stock market in these countries move together in the long run. Impulse response analysis shows that stock prices in all six countries are responsive to changes in exchange rates and shocks in oil prices and also that the impact of oil prices are greater for the exporting countries. Weak exogeneity evidence is only present in China and the long run exclusion test suggests that none of the variables can be excluded from the cointegration relation in five countries, except Mexico.

J. Park and R.Ratti (2007) investigated the relationships between real oil price shocks, real stock returns, industrial production and short term interest rates in 13 countries from 1986 to 2005. They started by conducting unit root tests and after finding non-stationarity they tested for cointegration among the variables for every country. From the 13 countries they studied only in UK the null hypothesis of no cointegration rejected meaning that there is a long term relation among the variables in this country. Their methodology comprises of a vector autoregression model for each country and subsequently impulse response analysis and variance decomposition. The effect of real oil prices to stock markets proved to be insensitive to reasonable changes in the VAR models such as inclusion of additional variables, which gives their results more credibility. According to impulse response analysis for ten of the thirteen countries (excluding Norway, Finland and UK), there is a negative impact of real oil price shocks to real stock prices which develops contemporaneously or within one month. In the next months there are positive or negative signs in the impulse response which some of them are statistically significant, but generally the variable returns to its mean after about 12 periods.

Park and Ratti also test for asymmetric effects of oil price shocks. We have asymmetric effects when an increase of oil prices has stronger impact on economy than a decrease. Until now most of the research that has been done on this field suggests a stronger impact of increases than of decreases, but Park and Ratti suggest that there is no evidence of asymmetric effects at least in the European countries under consideration.

Instead of studying the results of oil price shocks Park and Ratti investigate the response of real stock returns to oil price volatility. After defining monthly volatility as the log difference of daily oil price divided by the square root of the relevant month trading days, they incorporate this new variable in the vector autoregressive models and they run the same tests as with oil price shocks. They conclude that in more than half of the countries under consideration volatility has a negative statistically significant effect on the real stock prices, which develops contemporaneously or with one month lag.

Park and Ratti also use forecast error variance decomposition to conclude about the effect of real oil price changes in stock market prices. They found that in a 24 months horizon the variance of stock price which is due to oil prices, ranges from 3% for UK to 10% for Sweden and there is statistical significance in twelve cases.

The impact of real oil price changes to short term interest rates also studied in the context of a VAR model. The results of the impulse response analysis indicate that oil price has a positive correlation to short term interest rates and the effect develops within one or two months. The economic interpretation of an increase in interest rates after an increase in oil price is that the authorities are tightening their monetary policy to avoid inflation. Finally by comparing the contribution of oil price and interest rates variance to the real stock market returns variance, they concluded that oil prices have a greater effect than interest rates on stock markets.

Sadorsky (1999) examines the dynamics of industrial production, interest rates, real oil price, volatility of oil price and real stock returns in US from 1947 to 1996 using monthly data. After conducting unit root tests he takes the logarithmic returns of industrial production, interest rates and oil price to make them stationary. He employs a VAR model and consequently tests the impulse response functions and performs variance decomposition. Interest rate variance decomposition suggests that 87%, 6%, 5%, 2% of its variance, after 24 months, arises from itself, industrial production, real stock returns and real oil price respectively. The oil price variance decomposition suggests that almost all variance is caused by itself meaning that the other variables don't affect strongly oil price. For industrial production there is a 79%, 10%, 7% and 4% variance caused by itself, interest rates, real stock returns and oil price respectively. Regarding real stock returns there is an over 50%, 5% and 6% variance caused by itself, oil price and interest rates. Impulse response analysis shows the negative effect of oil prices on stock returns and the positive effect on interest rates at least at the first lag. Also industrial production has small impact on oil prices and stock returns.

Sadorsky also splits the sample in two periods after checking for structural brakes. The first period is from 1947 to 1986 and the second from 1987 to 1996. He discovers that in the second sample, the effect of oil price to real stock returns is higher than the effect of interest rates which is in accordance to Park and Ratti results in 2007. Also the variance decomposition indicates that in the second sample the change of variance to each variable due to itself declines, suggesting structural changes among the samples. Contrary though to Park and Ratti (2007), Sadorsky finds that oil price shocks are asymmetric and an increase in oil price affects economy more than a decline.

Rong-Gang Cong, Yi-Ming Wei, Jian Lin Jiao and Ying Fan (2008) investigate the effect of real oil price shocks and oil price volatility to Chinese real stock prices by taking monthly data from 1996 to 2007. They used the price of Brent crude oil, Shanghai and Shenzhen composite indices, ten sector indices and four oil stocks. They also consider short term interest rates, consumer price index and industrial production as these may influence the relations between oil prices and real stock market returns. They conducted unit root tests and after finding that interest rate, real oil price and industrial production at level are not stationary, they performed a Johansen cointegration test but found no evidence of cointegration between these variables. So they continue with vector autoregression, impulse response analysis and variance decomposition. Impulse response analysis shows that the only Chinese indices that are affected from oil price shocks are the manufacturing sector index and two oil companies stocks. The relation is positive and it develops within three months. The impulse responses revert to zero after 12 periods.

Relevantly to oil price volatility there is a statistically significant relation to manufacturing index (negative) and mining and petrochemicals sector indices (positive). Also in accordance with other studies they found by performing variance decomposition that the oil price effect is greater than the interest rate effect on real stock market prices.

George Filis (2009) investigate the relationship between oil prices and consumer price index, industrial production and stock market for Greece and found the interdependencies between these factors by employing a VAR model. One of his findings was that oil prices have a significant negative impact in Greek stock market.

Miller and Ratti (2008) studied the effects between world oil prices and the stock market of six OECD countries and they discovered that in the long run there is a negative relationship between oil prices and stock market indices. In particular they investigated the real stock market prices of Canada, US, France, Italy, Germany and U.K relatively to real crude oil prices with and without structural brakes.

Sadorsky (2000) investigated the interaction between futures prices for WTI crude oil, heating oil and unleaded gasoline with a trade-weighted index of exchange rates. He employed a vector error correction model (VECM) and investigated Granger causality relationships. His findings suggest that movements in exchange rates precede movements in heating oil futures price in the short and long run whereas movements in exchange rates precede movements in crude oil prices only in the short run. He also conducted unit root tests to check for nonstationarity of the time series and after finding that the variables were integrated of order 1, I(1), he run tests for cointegration. His findings suggest that there is not only Granger causality among the four variables but also cointegration which means that there is long run equilibrium between the four variables.

Zagaglia (2009) studies the dynamics of WTI spot and oil futures contracts returns for maturities of 1, 6 and 12 months, in the NYMEX, relatively to a dataset that consists of 239 time series. These series are categorized as price data, such as cost of crude oil imports from U.K. or Persian Gulf etc. stock and flow data such as petroleum consumed by the commercial sector, crude oil production of US, share price of big oil companies stocks etc. and macroeconomic and financial data such as S&P 500 stock index, capital utilization rate, US CPI index etc. After extracting common factors that determine oil returns he finds that the first eight common factors accounted for the 80% of the variance, but he uses the first four factors to run a factor augmented vector autoregression model (FAVAR) in order to much parsimony and fitness of the model. He concludes that the best determinants of oil prices are a) a price index of crude oil imports which can be interpreted as a cost indicator of the price pressure on oil futures, b) stock volumes of oil related products which have to do with the immediate demand for crude oil and c) purely financial factors that are disconnected from real developments in oil markets and as it seems contribute to the determination of oil prices.

The present paper can be considered as specified in the investigation of purely financial or macroeconomic data that affect WTI futures contracts, in order to achieve a better understanding of the interdependencies of these data relatively to crude oil market.

1.7 Expected effect of macroeconomic factors to oil futures

There is no certain theory about the effect of these macroeconomic factors to oil futures prices, but according to previous studies we could have some expectations although we cannot be absolutely positive about them.

Relatively to the four stock indices (S&P500, S&P350, Nikkei, Hang Seng), we expect a negative correlation between them and oil futures. These indices represent the economy of four of the more energy consuming economies in the world. They consume collectively almost 50% of global oil production and our expectation is that when there is an increase in oil prices their economies are affected negatively and the same happens to stock indices which are mirrors of the real economy. This is also consistent with other studies that assess the consequences of oil price shocks to stock market indices.

Regarding FED target rate we expect that high rates result to decreasing prices in oil futures. This happens because the purpose of increasing FED's target rate is to cool down an overheated economy. If Fed's policy is effective then total demand for goods and services should slow down and likewise should the demand for oil. But this isn't always the case. Total growth could be so strong that a spike in oil futures prices can take place despite of the FED's policy like it has happened in late 2007 when price per barrel reached $100 and not to mention other geopolitical or weather factors that can cause irregularities in our expected theory.

Dry bulk index is a proxy for the level of demand in dry bulk cargos. Dry bulk cargos can be coal, iron, bauxite, cement, chemicals, grain (wheat, rise, etc) and many other products that are used as basic inputs in the production of other goods. High prices of dry bulk index, means strong global production as companies need to produce more and more goods to keep up with demand. Strong growth means demand for oil, so we expect a positive relationship between dry bulk index and WTI futures in the sense that freight increases due to robust transportation services demand, precede oil price increases.

Relatively to the opposite direction, the effect of oil price to bdi, we know that dry bulk index measures the price of freights for dry bulk commodities and as oil is the primary input for a dry bulk carrier we would expect a positive correlation as the ship-owners try to maintain their profit intact by rising freights. But there is also the opposite opinion which states that a rise in oil prices will have a negative effect in world economy and as a result the demand for transportation services for raw materials will decline causing dry bulk index to also decline.

Industrial production indices for US and European Union indicate growth in the two economies, thus greater oil consumption. So we would expect a positive relationship regarding the effect of industrial production to oil variables and a negative relationship in the opposite direction and the same holds true for capacity utilization.

However we cannot assume anything about the lag structure of their dependence, meaning that we have no clue about the speed that changes in macroeconomic factors affect WTI futures and vice versa. This remains to be seen by the specification that we are going to use in order to capture the interdependencies of the variables.

CHAPTER 2: METHODOLOGY

2.1 Unit root tests

One major problem that someone has to deal with before starting modeling time series data is the non-stationarity problem. In order for the time series under consideration to have an explicative or predictive power beyond the time horizon that they refer to, they must fulfill three concurrent conditions. For a time series Y_t these conditions are:

1. $E(Y_t)=\mu \rightarrow$ the mean of the time series is constant
2. $Var(Y_t)=\sigma^2 \rightarrow$ variance of the time series is constant
3. $Cov(Y_t,Y_{t+s})=E(Y_t-\mu)(Y_{t+s}-\mu)=constant \rightarrow$ covariance of Y_t and Y_{t+s} ,where s is the number of periods apart, must be constant.

So if Y_t is stationary, then mean, variance and covariance must be time invariant and the same as $Y_{t+s.}$ In other words if Y_t is a time series with yearly data that starts from 2001 and ends at 2010 and we shift the origin to 2005, then the new time series $Y_{t+s,}$ (s=4) from 2005 until 2010 must have the same mean, variance and covariance as Y_t if we want the last one to be stationary, and this must hold true for every s. The above type of stationarity is the weak form. There is also the first order stationarity where only the first condition must hold. Unit root is another name for non-stationarity.

There is a problem with regressions that involve non-stationary data because the standard errors that they produce are biased. This means that by regressing the data, we might find a significant relation that in reality doesn't exist. We refer to such regressions as spurious. This also means that the standard criteria we use to judge if there is causal relation between variables are not reliable.

Many economic series are not stationary, therefore the first step before econometric modeling is unit root tests. The most popular tests are the Augmented

Dickey-Fuller and the Phillips-Perron test. The Augmented Dickey Fuller test (ADF) is based on the following regression:

$$\Delta y_t = \beta y_{t-1} + \sum_{i=0}^{N} \Delta y_{t-i} + u_t$$

The term $\sum_{i=0}^{N} \Delta y_{t-i}$ eliminates the autocorrelation of residuals. The value of the ADF test is compared with the critical values of the Dickey-Fuller table instead of the t-distribution. The ADF test has the disadvantage of low power, which means that many times it accepts the null of a unit root whilst it shouldn't. It is also more reliable when the time span of the data is wider.

If time series has a unit root then we transform it to stationary by taking first, second or more differences depending on the order of their integration, which means how many times we must differentiate them to make them stationary. If a time series is denoted as integrated of order two, I(2), then we have to differentiate it 2 times to make it stationary etc. Specifically in economic time series it is better to take logarithmic returns because instead of making them stationary, they also have meaningful empirical interpretation. The disadvantage of making time series stationary is the loss of an amount of information.

In this thesis in order to test for unit roots we use the Augmented Dickey-Fuller test with Schwarz info criterion and intercept. Unit root tests are exposed analytically in Appendix A but here we will mention the results. From the 15 series, six relative to oil and nine relative to macroeconomic factors, we detected four that are stationary, industrial production of European Union and US, Nikkei and dry bulk index. The rest eleven had unit roots and in order to proceed to the next level which is Granger causality, we make them stationary by taking logarithmic returns of the form:

d(series)=log(series)-log(series(-1))

where (-1) denotes the previous price and d(series) is the name we assign.

For example dsp500 is defined by equation

dsp500=log(sp500)-log(sp500(-1))

We could alternatively take first differences of the form

dsp500=sp500-sp500(-1)

in order to make them stationary but since we have economic series we prefer logarithmic returns which have also economic meaning and are easiest to comprehend. So in that part we construct eleven new series that are stationary.

2.2 Ordinary Least Squares (OLS)

At this point and before we proceed to the analytic representation of the methodology used in this thesis, we find it useful to make a brief reference to the Ordinary Least Squares method (OLS) as it is the foundation of the results that the econometric analysis in this paper will produce.

The OLS is generally a mathematical procedure used to approximate systems of equations that have no solution. One such case is when we have more equations in a system than unknown parameters. The majority of such systems have no solution so we employ OLS in order to approximate a decent and relative reliable answer as to what values the unknown parameters should take. We will demonstrate how this method works using simple equations in order to be more comprehensive. So suppose that we have the three below equations:

$$x_1 + x_2 = 2$$
$$x_1 - x_2 = 1$$
$$x_1 + x_2 = 3$$

The above system has no solution as we can easily see, because the first and third equations cannot be true simultaneously. We can rewrite it in matrices algebra:

$$\begin{bmatrix} 1 & 1 \\ 1 & -1 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix}$$

or

$$Ax = B$$

where

$$A = \begin{bmatrix} 1 & 1 \\ 1 & -1 \\ 1 & 1 \end{bmatrix}, x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}, B = \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix}$$

According to matrices algebra if we can't solve $Ax = B$ we can proceed in the solution of $A^T A x^* = A^T B$ where A^T is the transpose of A and x^* is a 2x1 vector of $x_1^* \approx x_1$ which means x_1^* approximates x_1 and $x_2^* \approx x_2$. The matrices representation of this system is:

$$\begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 1 \end{bmatrix} * \begin{bmatrix} 1 & 1 \\ 1 & -1 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} x_1^* \\ x_2^* \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -1 & 1 \end{bmatrix} * \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix}$$

And the solution of the system gives $x_1^* = 1.75$ and $x_2^* = 0.75$ which are the best approximations to a reliable result. The term approximation suggests that we have a divergence in the values of vector B from the values that produced if we substitute 1.75 and 0.75 (or else x^* instead of x), in the primary equations system $Ax = B$.

Specifically :

$$\begin{bmatrix} 1 & 1 \\ 1 & -1 \\ 1 & 1 \end{bmatrix} * \begin{bmatrix} 1.75 \\ 0.75 \end{bmatrix} = \begin{bmatrix} 2.5 \\ 1 \\ 2.5 \end{bmatrix} \neq \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix}$$

We can find the value of errors (or vector of errors) by subtracting Ax^* from B:

$$B - Ax^* = \begin{bmatrix} 2 \\ 1 \\ 3 \end{bmatrix} - \begin{bmatrix} 2.5 \\ 1 \\ 2.5 \end{bmatrix} = \begin{bmatrix} -0.5 \\ 0 \\ 0.5 \end{bmatrix}$$

In econometric analysis the above matrix of errors represents the error terms of the regressions. We observe that the mean of the errors equals to zero, which is one of the assumptions of the Classical Linear Model (CLM).

Let's see how Ordinary Least Squares are used in econometric analysis by employing a simple regression model such as:

$$y_t = a + bx_t + e_t$$

We solve for e_t and we have:

$$e_t = y_t - a - bx_t$$

In order to achieve the maximum fitting power of the data we must minimize the sum of the squared error terms. We take squares because it is the absolute values that we want to minimize as the error term can be negative or positive. In order to achieve minimization of $e_t^{\,2}$ we designate the first derivatives of e_t^2 relatively to a and b to be equal to zero simultaneously. We define:

$$f(x_t, y_t) = \sum_{t=1}^{n} e_t^2 = \sum_{t=1}^{n} (y_t - a - bx_t)^2$$

And the first derivatives are:

$$\left.\begin{aligned} \frac{\partial f(x_t, y_t)}{\partial a} &= 0 \Rightarrow \sum_{t=1}^{n} y_t - na - b\sum_{t=1}^{n} x_t = 0 \\ \frac{\partial f(x_t, y_t)}{\partial b} &= 0 \Rightarrow \sum_{t=1}^{n} y_t x_t - a\sum_{t=1}^{n} x_t - b\sum_{t=1}^{n} x_t^2 = 0 \end{aligned}\right\}$$

System of n equations and 2 unknown parameters

In the above system n is the number of observations in the sample. x_t and y_t are the observations and their values are known and a, b are the two unknown parameters. We have a system with more equations than unknown parameters and that’s why here we will use OLS to find an approximate solution. We obtain the residuals by substituting the estimated a, b in every equation that is defined from pairs of x_t, y_t and then by subtracting the value of this equation from the real value of the y_t observation.

2.3 Granger causality

When examining the relationships between economic variables, there is a high possibility to have simultaneity. This means that the exogenous variables can be influenced simultaneously by the dependent variable. Simultaneity is a form of endogeneity which is a general term we use when we have interdependence in the series and in order to detect it we can test our variables for Granger causality.

The term Granger causality may be somewhat misleading and confusing. When a change in variable X always precede a change in variable Y that doesn't necessarily means that Y is caused by X. Maybe there is a third unobservable variable Z which first causes X and then causes Y, but we detect only the last part of the chain, X and Y. A more appropriate and reliable term would be 'precede' instead of 'cause'.

Granger causality test is based on the same equations as a Vector Autoregressive model with p lags, VAR(p). The equations that describe a bivariate VAR(p) model are shown below:

$$y_t = c_1 + \sum_{i=1}^{p} \delta_{1,i} y_{t-i} + \sum_{j=1}^{p} \gamma_{1,j} x_{t-j} + u_{1,t} \qquad (1.1)$$

$$x_t = c_2 + \sum_{i=1}^{p} \delta_{2,i} y_{t-i} + \sum_{j=1}^{p} \gamma_{2,j} x_{t-j} + u_{2,t} \qquad (1.2)$$

In a bivariate model as the above we can test 2 null hypotheses:

Ho: y does not Granger cause x or $H_0 : \delta_{21} = \delta_{22} = ... = \delta_{2p} = 0$, to test if y helps in the prediction of x and

Ho: x does not Granger cause y or $H_0 : \gamma_{11} = \gamma_{12} = ... = \gamma_{1p} = 0$, to test if x helps in the prediction of y

So if we reject both null hypotheses we have two way causality between x and y, but if only one of the null hypotheses is rejected we have one way causality. Generally there are four forms of causality or non-causality between variables:

1. Unidirectional causality from x to y if the coefficients of x at 1.1 equation are statistically different from zero and simultaneously the coefficients of y at 1.2 equation are statistically equal to zero.
2. Unidirectional causality from y to x if the coefficients of y at 1.2 equation are statistically different from zero and simultaneously the coefficients of x at 1.1 equation are statistically equal to zero.
3. Bidirectional causality meaning that the coefficients of x are statistically different from zero in equation 1.1 and simultaneously the coefficients o y are also statistically different from zero in equation 1.2.
4. Independence when none of the coefficients of x and y are statistically different from zero in both equations.

The critical level of rejection for the null hypotheses is usually 0,05 (5% significance level) and null hypothesis is rejected if the estimated F-statistic is above its critical value from the F-distribution tables, or accepted if it is below. We obtain the estimated F-statistic using the below mathematical form:

$$\frac{n-f}{r} * \frac{RSS_{RESTRICTED} - RSS_{FULL}}{RSS_{FULL}}$$

Where:

n= number of observations
f= number of parameters for full model
r= number of parameters for restricted model
$RSS_{RESTRICTED}$ = sum of squared residuals for the restricted model
RSS_{FULL} = sum of squared residuals for the full model

Also the restricted forms which correspond to equations 1.1 and 1.2 are:

$$y_t = c_1 + \sum_{i=1}^{p} \delta_{1,i} y_{t-i} + u_{1,t} \quad \Big\} \quad \text{Reduced form of 1.1}$$

$$x_t = c_2 + \sum_{j=1}^{p} \gamma_{2,j} x_{t-j} + u_{2,t} \quad \Big\} \quad \text{Reduced form of 1.2}$$

We can also use the p-values in order to conclude about the null hypotheses. Generally in statistical significance testing, the p-value is the probability of obtaining a test statistic at least as large as the one that was estimated, assuming that the null hypothesis is true. The lower the p-value, the less likely the result is, if the null hypothesis is true and by reverse thinking the null hypothesis shouldn’t be true, so the result is statistical significant. We reject the null hypothesis when the p-value is less than 0.05 corresponding to a 5% chance of rejecting the null hypothesis when it is true (type I error).

2.4 Cointegration

We have cointegration under three concurrent circumstances:

a. The series under consideration must not be stationary or I(0).
b. The series under consideration must be integrated of the same order I(p). This means that in order to make them stationary we have to differentiate them 1 time if they are integrated of order one, I(1) or p times if they are integrated of order p, I(p)
c. There must be a linear combination of these series that produce a stationary series.

The economic interpretation of cointegration is that the distance between two or more economic variables is the same in the long run. So no matter how big is the short run divergence between the variables, in the long run they tend to converge.

There are two ways of detecting cointegration. The first one is the Engle-Granger procedure for two possible cointegrating series. In this procedure we estimate a regression between the two series with constant term and after saving its residuals we check if they are stationary. For two series let's say X and Y we estimate the below regression:

$$x_t = a + by_t + u_t \quad (1.3)$$

Then we isolate the residuals:

$$u_t = x_t - a - by_t \quad (1.4)$$

and proceed with unit root tests. If residuals are stationary, this means that the linear combination between X and Y is stationary and we have cointegration. The invisible mechanism which makes these series converge in the long run is described by the second part of equation (1.4) which called cointegration equation and the VAR equations (1.1) and (1.2) are transformed as below:

$$\Delta y_t = c_1 + \rho_1 \overbrace{(Y_{t-1} - a - \beta X_{t-1})}^{\text{Correction mechanism}} + \sum_{i=1}^{p} \delta_{1,i} \Delta y_{t-i} + \sum_{j=1}^{p} \gamma_{1,j} \Delta x_{t-j} + u_{1,t} \qquad (1.5)$$

$$\Delta x_t = c_2 + \rho_2 (Y_{t-1} - a - \beta X_{t-1}) + \sum_{i=1}^{p} \delta_{2,i} \Delta y_{t-i} + \sum_{j=1}^{p} \gamma_{2,j} \Delta x_{t-j} + u_{2,t} \qquad (1.6)$$

The second method for detecting cointegration is the Johansen's method which uses two statistics to conclude if there is cointegration: Trace test and maximum Eigenvalue test. It has the advantage that can be used when we have more than two series to test. It leads to the same correction mechanism as the first method (equations 1.5,1.6).

In the present paper our purpose is to construct 6 VAR models using the nine macroeconomic factors and one oil variable each time. Since four of the macroeconomic variables under consideration are stationary of order zero, I(0), means they are stationary at the first level, we cannot by definition test for cointegration because it is a contradiction to the first prerequisite. There is also a contradiction to the second prerequisite because the macroeconomic variables aren't integrated of the same order.

2.5 VAR and VEC

We have already explained the term endogeneity in economic series. When we have endogeneity the Classical Linear Regression (CLR) like the one in equation (1.3) isn't capable to capture the interdependencies of the series. In that case we deploy a VAR (Vector Autoregressive) model. There are three types of Vector autoregressive models: Recursive VAR, structural VAR and reduced form VAR. The recursive VAR estimates each equation by ordinary least squares (OLS) and constructs residuals that are uncorrelated to the error term of the previous equation by adding contemporaneous values as regressors. A structural VAR requires economic theory that establish causal links between variables and it uses also contemporaneous values as regressors in combination with lags. The equations that can describe a bivariate structural VAR with one lag and their representation as matrices are:

$$\left.\begin{aligned} y_t &= c_1 - c_{12}x_t + \delta_{11}y_{t-1} + \gamma_{12}x_{t-1} + u_{1t} \\ x_t &= c_2 - c_{21}y_t + \delta_{21}y_{t-1} + \gamma_{22}x_{t-1} + u_{2t} \end{aligned}\right\}$$

Bivariate structural VAR(1)

$$\begin{bmatrix} 1 & c_{12} \\ c_{21} & 1 \end{bmatrix}\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} + \begin{bmatrix} \delta_{11} & \gamma_{12} \\ \delta_{21} & \gamma_{22} \end{bmatrix}\begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t} \\ u_{2,t} \end{bmatrix}$$

$$\Gamma Z_t = B_0 + B_1 Z_{t-1} + E_t$$

Matrices representation

We can pass from a structural VAR to a reduced form VAR by multiplicating the above system with Γ^{-1} which is the inverse matrix of Γ. The solution of a system like this can be achieved by using OLS (Ordinary Least Squares). More specifically we want to find the values of the unknown coefficients by using our time series data which are known. The bivariate reduced form VAR with one lag and its representation as matrices is shown below:

$$\left.\begin{aligned} y_t &= c_1^* + \delta_{1,1}^* y_{t-1} + \gamma_{1,1}^* x_{t-1} + u_{1,t}^* \\ x_t &= c_2^* + \delta_{2,1}^* y_{t-1} + \gamma_{2,1}^* x_{t-1} + u_{2,t}^* \end{aligned}\right\}$$

Bivariate reduced form VAR(1)

$$\begin{bmatrix} y_t \\ x_t \end{bmatrix} = \begin{bmatrix} c_1^* \\ c_2^* \end{bmatrix} + \begin{bmatrix} \delta_{1,1}^* & \gamma_{1,1}^* \\ \delta_{2,1}^* & \gamma_{2,1}^* \end{bmatrix}\begin{bmatrix} y_{t-1} \\ x_{t-1} \end{bmatrix} + \begin{bmatrix} u_{1,t}^* \\ u_{2,t}^* \end{bmatrix}$$

$$Z_t = \Gamma^{-1}B_0 + \Gamma^{-1}B_1 Z_{t-1} + \Gamma^{-1}E_t$$

Matrices representation

The solution of the above algebraic representation of equations by using OLS produces the coefficients of the endogenous variables and then we can test their statistical significance by using the t-statistic.

Also there are assumptions for the error term:

1. $E(u_t) = 0$ $\rightarrow$ every error term has mean zero

2. $Cov(u_{1,t}, u_{2,t}) = 0$ $\rightarrow$ covariance of the contemporaneous error terms is zero

3. $E(u_t, u_{t-k}) = 0$ $\rightarrow$ for any non-zero k — there is no serial correlation in individual error terms across time.

.

Reduced form VAR models use as independent variables the lags of all other variables under consideration and the lags of the dependent variable itself. The dependent variable in the first equation becomes independent in the second equation, in an attempt to capture endogeneity. In order to conclude about the statistical significance of a coefficient we compare its t-statistic with absolute 1,96 which is the critical value at the confidence level of 5%. The null hypothesis in this case is that the coefficient is zero. If the t-statistic of the coefficient is bigger in absolute terms than 1,96 then we conclude that the coefficient has statistical significance (reject the null hypothesis) and the independent variable that is related to, interact with the dependent. The t-statistic of the coefficient is estimated by dividing the value of the coefficient to its standard error. From now on when we refer to VAR or vector autoregressive we will mean reduced form VAR.

A very important parameter of vector autoregressive models is the selection of the optimal lag length. Many lags lead to loss of degrees of freedom and reduced statistical significance of every particular coefficient although the collective effect of all coefficients can still be significant. A possible reason for this could be multicollinearity which means that there is linear relation between the coefficients. On the other hand too few lags lead to specification errors. We can use lag length criteria such as Akaike before we starting modeling, or use trial and error method to first run VAR regressions with different lags and then by comparison choose the regression with the smallest Akaike.

VEC (Vector Error Correction) is a variation of VAR which takes into account cointegration to some or to all series under examination. The error correction mechanism together with the cointegrating equation corrects the model in such a way to take into account the invisible mechanism of cointegration. The error correction mechanism is the coefficient in front of the cointegrating equation (first part of equation (1.4)).

So to model endogeneity between series we use VAR if there is no cointegration and VEC if there is cointegration between any of the variables. We have already explained why we will not test for cointegration, so we will use VAR models to study the interdependencies of the time series. For the purpose of this paper we will specify 6 VAR models each one with one time series relative to oil (spot, cl1, cl3, cl6, cl9, cl12) and all the other nine macroeconomic factors. We have already made non stationary series stationary by taking the logarithmic returns and we will use them in the construction of VAR. The Akaike lag length criterion suggests 4 lags in each one of the VAR.

2.6 Impulse response analysis & Variance decomposition

We will also conduct impulse response analysis for every VAR model relatively to FED's funds rate, S&P 500, S&P 350 and EU industrial production which are statistically significant in every VAR. Impulse response analysis generally measures and depicts the response of a variable to an exogenous shock and also the response on the other endogenous variables of the model which occurs from the same exogenous shock. The exogenous shock to one variable is transmitted to all the other variables via the certain VAR specification and lag structure of the model. Analytically we can present the mechanism through a bivariate reduced form VAR(1):

$$y_t = c_1 + \delta_{11} y_{t-1} + \gamma_{12} x_{t-1} + u_{1t}$$
$$x_t = c_2 + \delta_{21} y_{t-1} + \gamma_{22} x_{t-1} + u_{2t}$$

A shock in innovation u_{2t} will cause a direct change in variable x_t through the second equation, which in turn will alter the value of y_{t+1} through the first equation. Also the disturbance of u_{2t} will cause change in u_{1t} due to no zero covariance between the error terms, so the effect of the initial shock will multiply.

The shock of the exogenous variable is one standard deviation and on the vertical axis of the diagram we can see the response that a particular variable will have. On the horizontal axis we will assume 20 time intervals which is a sufficient time period in order to observe the responses.

Variance Decomposition or Forecast error variance decomposition reflects the amount of information each variable contributes to the other variables in a Vector autoregressive model. Variance decomposition determines how much of the total variance of each variable can be explained by the variance of other variables due to exogenous shocks. This estimation is produced in the context of a certain VAR model and it uses all the interdependencies that have been produced through the equations of the VAR model. The variance contribution of all the other variables to the one under consideration are processed period by period. We will use 10 time periods.

CHAPTER 3: EMPIRICAL RESULTS

3.1 Granger causality results

We will now test if there is Granger causality between WTI oil returns (spot and futures) and macroeconomic factors. By using the Akaike lag length criterion we will take four lags for the Granger causality testing. The column prob. denotes the estimated probability value that has to be below 0.05 in order to reject the null hypothesis of no Granger causality. We emphasize the variables that are bound with Granger causality although there are some causal relations that rejected marginally because they exceeded the critical level of 0.05 by a tiny amount. We will not study causality among macroeconomic factors or between oil variables as it is out of the scope of this paper.

Table 6

Granger causality of WTI spot price and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DSPOT	2.12376	0.0787
DSPOT does not Granger Cause BDI	0.79578	0.5290
DCAPUT does not Granger Cause DSPOT	3.12804	0.0157
DSPOT does not Granger Cause DCAPUT	1.23558	0.2965
DFEDR does not Granger Cause DSPOT	0.80694	0.5218
DSPOT does not Granger Cause DFEDR	3.69568	0.0061
DHASE does not Granger Cause DSPOT	1.89978	0.1113
DSPOT does not Granger Cause DHASE	0.60142	0.6620
DSP350 does not Granger Cause DSPOT	2.23527	0.0660
DSPOT does not Granger Cause DSP350	2.07264	0.0852
DSP500 does not Granger Cause DSPOT	2.71089	0.0309
DSPOT does not Granger Cause DSP500	1.87182	0.1162
INDPREU does not Granger Cause DSPOT	0.33820	0.8520
DSPOT does not Granger Cause INDPREU	5.84541	0.0002
INDPRUSA does not Granger Cause DSPOT	2.53755	0.0408
DSPOT does not Granger Cause INDPRUSA	0.96403	0.4280
NIKK does not Granger Cause DSPOT	1.93508	0.1054
DSPOT does not Granger Cause NIKK	0.48497	0.7468

From the above table we conclude that US capacity utilization, S&P 500 and US industrial production Granger cause WTI oil spot price and WTI spot price Granger causes FED funds rate and European Union industrial production.

Table 7

Granger causality of WTI future contract 1 month and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DCL1	2.12817	0.0781
DCL1 does not Granger Cause BDI	0.79800	0.5275
DCAPUT does not Granger Cause DCL1	3.08502	0.0168
DCL1 does not Granger Cause DCAPUT	1.20667	0.3087
DFEDR does not Granger Cause DCL1	0.83206	0.5060
DCL1 does not Granger Cause DFEDR	3.66396	0.0065
DHASE does not Granger Cause DCL1	2.00950	0.0940
DCL1 does not Granger Cause DHASE	0.62824	0.6428
DSP350 does not Granger Cause DCL1	2.42137	0.0492
DCL1 does not Granger Cause DSP350	2.14525	0.0761
DSP500 does not Granger Cause DCL1	2.93775	0.0214
DCL1 does not Granger Cause DSP500	1.78446	0.1327
INDPREU does not Granger Cause DCL1	0.32679	0.8598
DCL1 does not Granger Cause INDPREU	5.65731	0.0002
INDPRUSA does not Granger Cause DCL1	2.52561	0.0416
DCL1 does not Granger Cause INDPRUSA	0.91963	0.4532
NIKK does not Granger Cause DCL1	2.93848	0.0214
DCL1 does not Granger Cause NIKK	0.32820	0.8589

Contrary to spot price the WTI future contract of 1 month maturity is Granger caused by more macroeconomic variables. These are US capacity utilization, S&P 500 and US industrial production as in the spot price plus S&P 350 and Nikkei. It Granger causes exactly as the spot price FED funds rate and European Union industrial production.

Table 8

Granger causality of WTI future contract 3 months and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DCL3	1.87465	0.1157
DCL3 does not Granger Cause BDI	0.96362	0.4282
DCAPUT does not Granger Cause DCL3	3.84187	0.0048
DCL3 does not Granger Cause DCAPUT	1.34062	0.2556
DFEDR does not Granger Cause DCL3	1.04777	0.3833
DCL3 does not Granger Cause DFEDR	4.71202	0.0011
DHASE does not Granger Cause DCL3	1.95313	0.1025
DCL3 does not Granger Cause DHASE	0.43625	0.7824
DSP350 does not Granger Cause DCL3	2.07914	0.0843
DCL3 does not Granger Cause DSP350	2.40694	0.0503
DSP500 does not Granger Cause DCL3	2.17733	0.0723
DCL3 does not Granger Cause DSP500	2.25998	0.0635
INDPREU does not Granger Cause DCL3	0.36094	0.8363
DCL3 does not Granger Cause INDPREU	5.87499	0.0002
INDPRUSA does not Granger Cause DCL3	3.12664	0.0157
DCL3 does not Granger Cause INDPRUSA	1.05179	0.3813
NIKK does not Granger Cause DCL3	1.62066	0.1698
DCL3 does not Granger Cause NIKK	0.52188	0.7197

The future contract of 3 months maturity is Granger caused by US capacity utilization and US industrial production one macroeconomic variable less than the spot price and three less than the future 1 month maturity. It causes exactly as the previous two, FED funds rate and European Union industrial production.

Table 9

Granger causality of WTI future contract 6 months and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DCL6	2.07350	0.0851
DCL6 does not Granger Cause BDI	1.21607	0.3047
DCAPUT does not Granger Cause DCL6	4.50299	0.0016
DCL6 does not Granger Cause DCAPUT	1.41350	0.2302
DFEDR does not Granger Cause DCL6	1.25680	0.2878
DCL6 does not Granger Cause DFEDR	5.90060	0.0002
DHASE does not Granger Cause DCL6	2.12580	0.0784
DCL6 does not Granger Cause DHASE	0.43204	0.7854
DSP350 does not Granger Cause DCL6	2.22243	0.0674
DCL6 does not Granger Cause DSP350	2.31918	0.0578
DSP500 does not Granger Cause DCL6	1.95627	0.1020
DCL6 does not Granger Cause DSP500	2.40766	0.0502
INDPREU does not Granger Cause DCL6	0.32253	0.8627
DCL6 does not Granger Cause INDPREU	6.22380	9.E-05
INDPRUSA does not Granger Cause DCL6	3.72460	0.0059
DCL6 does not Granger Cause INDPRUSA	0.97800	0.4203
NIKK does not Granger Cause DCL6	1.74927	0.1400
DCL6 does not Granger Cause NIKK	0.79980	0.5264

We see that the future of 6 months maturity behaves exactly as the 3 months maturity future meaning it is Granger caused by US capacity utilization and US industrial production. It Granger causes FED's funds rate and European Union industrial production.

Table 10

Granger causality of WTI future contract 9 months and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DCL9	2.27550	0.0620
DCL9 does not Granger Cause BDI	1.37451	0.2435
DCAPUT does not Granger Cause DCL9	4.64879	0.0013
DCL9 does not Granger Cause DCAPUT	1.53558	0.1927
DFEDR does not Granger Cause DCL9	1.46876	0.2125
DCL9 does not Granger Cause DFEDR	6.88069	3.E-05
DHASE does not Granger Cause DCL9	2.18075	0.0719
DCL9 does not Granger Cause DHASE	0.45499	0.7687
DSP350 does not Granger Cause DCL9	2.17167	0.0730
DCL9 does not Granger Cause DSP350	2.09100	0.0828
DSP500 does not Granger Cause DCL9	1.76502	0.1367
DCL9 does not Granger Cause DSP500	2.30735	0.0589
INDPREU does not Granger Cause DCL9	0.29037	0.8841
DCL9 does not Granger Cause INDPREU	6.40296	7.E-05
INDPRUSA does not Granger Cause DCL9	3.88278	0.0045
DCL9 does not Granger Cause INDPRUSA	1.00005	0.4083
NIKK does not Granger Cause DCL9	1.70438	0.1498
DCL9 does not Granger Cause NIKK	0.99408	0.4115

We observe the same results for 9 months maturity future as for the previous two. It is caused by US capacity utilization and US industrial production and it Granger causes FED’s funds rate and European Union industrial production.

Table 11

Granger causality of WTI future contract 12 months and macroeconomic factors

Null Hypothesis	F-Statistic	Prob.
BDI does not Granger Cause DCL12	2.38131	0.0524
DCL12 does not Granger Cause BDI	1.46406	0.2139
DCAPUT does not Granger Cause DCL12	4.61039	0.0013
DCL12 does not Granger Cause DCAPUT	1.63954	0.1651
DFEDR does not Granger Cause DCL12	1.60642	0.1735
DCL12 does not Granger Cause DFEDR	7.49238	1.E-05
DHASE does not Granger Cause DCL12	2.19553	0.0703
DCL12 does not Granger Cause DHASE	0.53178	0.7125
DSP350 does not Granger Cause DCL12	2.05225	0.0879
DCL12 does not Granger Cause DSP350	1.80163	0.1293
DSP500 does not Granger Cause DCL12	1.50111	0.2027
DCL12 does not Granger Cause DSP500	1.95030	0.1030
INDPREU does not Granger Cause DCL12	0.25065	0.9091
DCL12 does not Granger Cause INDPREU	6.47220	6.E-05
INDPRUSA does not Granger Cause DCL12	3.87138	0.0046
DCL12 does not Granger Cause INDPRUSA	1.08477	0.3648
NIKK does not Granger Cause DCL12	1.68635	0.1539
DCL12 does not Granger Cause NIKK	1.18951	0.3161

We see exactly the same interdependencies as in the previous three future contracts meaning that the 12 months maturity future is Granger caused by US capacity utilization and US industrial production and it is Granger causes FED’s funds rate and European Union industrial production.

So generally Granger causality tests suggest that only the spot price and the 1 month maturity future contract interact with more macroeconomic variables with the second to be the most interactive as it causes and is caused by seven of our selected variables. As we approaching more distant maturities the number of macroeconomic factors that interact with oil futures reduces to four.

We can summarize results from the Granger causality tests in two tables to achieve a better image of the interdependencies:

Table 12

Granger causation of oil variables to macroeconomic variables

Granger → causes	***bdi***	***dcaput***	***dfedr***	***dhase***	***dsp350***	***dsp500***	***indpreu***	***indprusa***	***nikk***
spot			yes				yes		
dcl1			yes				yes		
dcl3			yes				yes		
dcl6			yes				yes		
dcl9			yes				yes		
dcl12			yes				yes		

From table 12 we can see that changes in all oil variables precede FED’s funds rate changes and the same is true for European Union industrial production. Notice that S&P 350 and S&P 500 fail to Granger caused by oil variables in the 5% significance level marginally, especially until the 9 months maturity contract, which tells us that we cannot very easily reject a relationship among them.

Table 13

Granger causation of macroeconomic variables to oil variables

Granger → causes	***spot***	***dcl1***	***dcl3***	***dcl6***	***dcl9***	***dcl12***
bdi						
dcaput	yes	yes	yes	yes	yes	yes
dfedr						
dhase						
dsp350		yes				
dsp500	yes	yes				
indpreu						
indprusa	yes	yes	yes	yes	yes	yes
nikk		yes				

The stronger causation in table 13 occurs between US capacity utilization and industrial production to all oil variables. This suggests a solid relation among these parameters contrary to the causation of S&P 350, S&P 500 and Nikkei to the 1 month maturity contract which in our opinion could be provoked by a third unobservable factor such as strong global demand.

3.2 Vector autoregression results

We will now proceed with the vector autoregression analysis. In every table there is one oil variable and all the macroeconomic factors. We will examine only the coefficients of oil prices relatively to the macroeconomic factors and vice versa. Coefficients that are statistically significant and relative to our study are put into frames. Below every table there is the relevant annotation.

Table 14

Spot oil price and macroeconomic factors

	DSPOT	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DSPOT(-1)	0.084158	-108.8980	0.001491	0.108158	-0.048132	-0.127778	-0.104852	1.817496	0.135220	-353.7172
	[1.09778]	[-0.25820]	[0.33455]	[1.49950]	[-0.75802]	[-3.48887]	[-3.14603]	[2.91351]	[0.30720]	[-0.39181]
DSPOT(-2)	-0.067063	164.9394	0.000221	0.147239	-0.056380	0.022277	0.016798	0.677691	0.184892	-915.1171
	[-0.85003]	[0.38002]	[0.04816]	[1.98358]	[-0.86280]	[0.59105]	[0.48977]	[1.05563]	[0.40816]	[-0.98500]
DSPOT(-3)	0.049853	61.68749	-0.001076	-0.016032	0.045912	-0.033239	0.002632	0.745544	-0.189215	196.6658
	[0.63114]	[0.14196]	[-0.23431]	[-0.21572]	[0.70176]	[-0.88084]	[0.07666]	[1.15994]	[-0.41721]	[0.21143]
DSPOT(-4)	-0.156459	-759.6368	-0.005518	-0.048638	-0.052989	-0.028574	0.010783	0.732939	-0.548110	-178.5783
	[-2.01043]	[-1.77426]	[-1.21999]	[-0.66426]	[-0.82207]	[-0.76855]	[0.31870]	[1.15740]	[-1.22663]	[-0.19486]
BDI(-1)	2.19E-05	1.354334	-4.45E-07	2.74E-05	2.30E-05	1.22E-05	1.71E-05	2.33E-05	-7.33E-05	0.046239
	[1.56314]	[17.5918]	[-0.54673]	[2.08447]	[1.98677]	[1.81873]	[2.81684]	[0.20433]	[-0.91286]	[0.28059]
BDI(-2)	-2.37E-05	-0.479412	1.30E-06	-2.43E-05	-1.36E-05	-7.01E-06	-1.40E-05	2.46E-05	0.000146	0.214901
	[-1.03553]	[-3.80887]	[0.97851]	[-1.13042]	[-0.71664]	[-0.64143]	[-1.40945]	[0.13197]	[1.10945]	[0.79765]
BDI(-3)	1.34E-05	0.006258	-8.21E-08	3.74E-05	-1.54E-05	-7.32E-06	-1.32E-06	2.93E-05	-1.34E-05	-0.370468
	[0.59625]	[0.05061]	[-0.06283]	[1.76932]	[-0.82988]	[-0.68191]	[-0.13534]	[0.16023]	[-0.10376]	[-1.39965]
BDI(-4)	-1.00E-05	0.057189	-1.51E-06	-4.59E-05	2.71E-06	7.29E-07	-3.39E-06	-0.000125	-0.000135	0.065900
	[-0.69362]	[0.71779]	[-1.79991]	[-3.36635]	[0.22612]	[0.10543]	[-0.53834]	[-1.06112]	[-1.62737]	[0.38641]
DCAPUT(-1)	8.961173	98608.27	0.386232	9.276969	7.572875	-4.335136	-3.217122	32.44635	9.037477	-154932.0
	[1.39500]	[2.79026]	[1.03456]	[1.53493]	[1.42331]	[-1.41261]	[-1.15199]	[0.62073]	[0.24503]	[-2.04813]
DCAPUT(-2)	-9.892271	-24043.60	0.080678	-18.53194	-2.732934	-1.907715	-1.033152	-31.49344	-7.507432	190673.0
	[-1.45989]	[-0.64498]	[0.20487]	[-2.90683]	[-0.48695]	[-0.58932]	[-0.35072]	[-0.57118]	[-0.19296]	[2.38958]
DCAPUT(-3)	8.212540	-35964.96	0.055855	9.037524	-1.223762	-0.419766	1.398959	89.04572	-11.15574	-19187.25
	[1.22979]	[-0.97894]	[0.14392]	[1.43838]	[-0.22125]	[-0.13157]	[0.48187]	[1.63867]	[-0.29094]	[-0.24399]
DCAPUT(-4)	-2.346949	2102.283	0.395352	6.386839	2.213734	4.898137	1.050474	-81.03990	12.65977	-30808.61
	[-0.39055]	[0.06359]	[1.13203]	[1.12962]	[0.44477]	[1.70615]	[0.40210]	[-1.65730]	[0.36691]	[-0.43537]
DFEDR(-1)	0.054534	-767.5526	0.004712	-0.180639	0.006817	0.041023	0.058033	1.266899	0.384211	328.5477
	[0.76327]	[-1.95273]	[1.13469]	[-2.68718]	[0.11520]	[1.20186]	[1.86834]	[2.17911]	[0.93657]	[0.39050]
DFEDR(-2)	0.006505	-217.1135	0.001192	0.260143	0.070552	0.114728	0.083532	0.995192	0.034248	645.4024
	[0.08883]	[-0.53895]	[0.28021]	[3.77590]	[1.16327]	[3.27957]	[2.62398]	[1.67020]	[0.08146]	[0.74847]
DFEDR(-3)	-0.052194	347.2556	0.001086	0.025016	0.084931	0.021318	-0.012094	-0.308858	0.152398	460.7044
	[-0.72302]	[0.87438]	[0.25887]	[0.36831]	[1.42045]	[0.61814]	[-0.38537]	[-0.52579]	[0.36768]	[0.54195]
DFEDR(-4)	-0.091494	-915.5015	-0.002495	-0.154317	-0.003609	-0.047637	-0.037089	-0.088859	0.060731	254.6102
	[-1.30802]	[-2.37904]	[-0.61370]	[-2.34480]	[-0.06229]	[-1.42552]	[-1.21966]	[-0.15612]	[0.15121]	[0.30910]
DHASE(-1)	0.047562	758.8719	-0.000972	-0.129698	0.065146	0.026741	0.071195	-0.415601	-0.159946	-532.6902
	[0.41724]	[1.21010]	[-0.14673]	[-1.20930]	[0.69000]	[0.49105]	[1.43664]	[-0.44806]	[-0.24438]	[-0.39684]
DHASE(-2)	-0.015858	-137.1251	0.001756	-0.016713	-0.005868	0.008383	-0.009583	-0.611392	0.126024	568.2759
	[-0.14010]	[-0.22021]	[0.26689]	[-0.15694]	[-0.06260]	[0.15503]	[-0.19475]	[-0.66382]	[0.19392]	[0.42635]
DHASE(-3)	-0.011868	-211.6827	0.006158	-0.079302	-0.139143	-0.024609	-0.041970	-0.144220	0.544723	526.2862
	[-0.10497]	[-0.34033]	[0.93726]	[-0.74551]	[-1.48588]	[-0.45561]	[-0.85388]	[-0.15676]	[0.83913]	[0.39530]
DHASE(-4)	0.032333	87.50443	0.006254	0.036892	-0.102387	0.033495	0.017310	0.480077	0.438352	541.4209
	[0.29236]	[0.14382]	[0.97306]	[0.35455]	[-1.11776]	[0.63396]	[0.36004]	[0.53347]	[0.69032]	[0.41573]
DSP350(-1)	0.126933	-1998.903	0.002569	0.248244	-0.290785	-0.032881	0.057335	-0.627570	0.846907	1501.352
	[0.47830]	[-1.36910]	[0.16657]	[0.99420]	[-1.32289]	[-0.25935]	[0.49695]	[-0.29061]	[0.55579]	[0.48041]

DSP350(-2)	0.248467	959.3933	0.000511	0.180001	0.083498	-0.155364	-0.090781	0.050894	-0.304735	-1710.605
	[0.94371]	[0.66235]	[0.03340]	[0.72664]	[0.38289]	[-1.23519]	[-0.79312]	[0.02376]	[-0.20158]	[-0.55173]
DSP350(-3)	-0.205777	123.6553	0.015114	-0.034100	0.031352	0.013092	-0.061976	4.425273	1.525829	238.1157
	[-0.78743]	[0.08601]	[0.99517]	[-0.13869]	[0.14485]	[0.10487]	[-0.54552]	[2.08104]	[1.01690]	[0.07738]
DSP350(-4)	0.269480	-638.3724	-0.010498	0.283750	-0.136628	-0.116546	-0.183317	2.418961	-0.970026	3691.443
	[1.09753]	[-0.47259]	[-0.73569]	[1.22828]	[-0.67183]	[-0.99357]	[-1.71737]	[1.21072]	[-0.68807]	[1.27671]
DSP500(-1)	-0.111689	840.4810	0.002028	-0.114162	0.055711	0.145050	-0.131941	3.958635	-0.000743	1718.950
	[-0.40778]	[0.55777]	[0.12741]	[-0.44300]	[0.24558]	[1.10851]	[-1.10805]	[1.77615]	[-0.00047]	[0.53294]
DSP500(-2)	0.013273	276.3404	0.011912	0.234115	-0.104868	0.194158	0.025946	3.201117	1.108910	-268.3204
	[0.04785]	[0.18109]	[0.73897]	[0.89710]	[-0.45647]	[1.46523]	[0.21517]	[1.41830]	[0.69630]	[-0.08215]
DSP500(-3)	0.358707	-711.1738	0.013562	0.161045	0.103037	0.081056	0.132583	-2.285208	1.571195	716.8927
	[1.29509]	[-0.46672]	[0.84252]	[0.61799]	[0.44915]	[0.61258]	[1.10109]	[-1.01394]	[0.98798]	[0.21980]
DSP500(-4)	-0.446648	-841.8194	0.021318	-0.371612	0.182304	0.124686	0.139508	-2.216664	2.432375	-3657.603
	[-1.64492]	[-0.56353]	[1.35093]	[-1.45459]	[0.81060]	[0.96119]	[1.18181]	[-1.00324]	[1.56015]	[-1.14389]
INDPREU(-1)	-0.007575	79.91151	0.000274	0.007823	0.007818	0.001339	0.002793	-0.314614	0.037334	56.63412
	[-0.87127]	[1.67061]	[0.54304]	[0.95632]	[1.08563]	[0.32245]	[0.73889]	[-4.44680]	[0.74783]	[0.55313]
INDPREU(-2)	-0.005796	8.139610	0.000156	0.002756	-0.009191	-0.003285	-0.004007	0.120675	0.024850	-217.4188
	[-0.67098]	[0.17129]	[0.31061]	[0.33914]	[-1.28467]	[-0.79611]	[-1.06701]	[1.71689]	[0.50106]	[-2.13749]
INDPREU(-3)	0.006377	81.53733	0.000665	-0.005350	-0.003288	-0.002025	-0.002248	0.313988	0.055396	-2.501402
	[0.74518]	[1.73184]	[1.33618]	[-0.66448]	[-0.46393]	[-0.49536]	[-0.60421]	[4.50887]	[1.12736]	[-0.02482]
INDPREU(-4)	6.77E-05	86.51627	0.001345	-0.018140	-0.014099	-0.003540	-0.002681	0.061843	0.129073	97.62975
	[0.00809]	[1.87891]	[2.76421]	[-2.30349]	[-2.03379]	[-0.88543]	[-0.73694]	[0.90803]	[2.68584]	[0.99055]
INDPRUSA(-1)	-0.059522	-923.5780	-0.005418	-0.068365	-0.051952	0.051985	0.045886	-0.173297	-0.216228	1753.877
	[-0.90793]	[-2.56075]	[-1.42199]	[-1.10836]	[-0.95676]	[1.65981]	[1.60998]	[-0.32485]	[-0.57443]	[2.27184]
INDPRUSA(-2)	0.114857	285.7959	-5.42E-05	0.178792	0.034098	0.027003	0.018760	0.188307	0.142741	-2029.339
	[1.65151]	[0.74696]	[-0.01340]	[2.73238]	[0.59194]	[0.81272]	[0.62047]	[0.33275]	[0.35746]	[-2.47790]
INDPRUSA(-3)	-0.075275	445.4295	0.000967	-0.050608	0.008932	-0.003686	-0.020023	-0.921435	0.244328	155.4396
	[-1.10340]	[1.18681]	[0.24383]	[-0.78845]	[0.15808]	[-0.11309]	[-0.67511]	[-1.65985]	[0.62375]	[0.19349]
INDPRUSA(-4)	0.011442	-100.4209	-0.003422	-0.037074	-0.036746	-0.053922	-0.014950	0.788069	-0.073163	274.4259
	[0.18485]	[-0.29489]	[-0.95123]	[-0.63659]	[-0.71672]	[-1.82344]	[-0.55553]	[1.56459]	[-0.20585]	[0.37648]
NIKK(-1)	-7.65E-06	0.012159	-2.49E-07	4.94E-06	3.80E-06	-1.33E-06	-1.83E-06	-3.51E-05	-2.68E-05	0.897518
	[-1.13276]	[0.32734]	[-0.63341]	[0.77713]	[0.67966]	[-0.41374]	[-0.62482]	[-0.63893]	[-0.69057]	[11.2886]
NIKK(-2)	1.27E-05	-0.041552	5.79E-07	-1.62E-06	-5.65E-06	-2.07E-06	2.03E-06	0.000154	7.73E-05	0.041049
	[1.38109]	[-0.82015]	[1.08227]	[-0.18669]	[-0.74096]	[-0.47135]	[0.50598]	[2.05794]	[1.46250]	[0.37852]
NIKK(-3)	-2.31E-07	0.054185	-1.38E-07	8.80E-06	9.84E-07	2.17E-06	-2.66E-06	-0.000141	-3.79E-05	-0.076664
	[-0.02573]	[1.09771]	[-0.26559]	[1.04200]	[0.13239]	[0.50677]	[-0.68116]	[-1.92478]	[-0.73584]	[-0.72558]
NIKK(-4)	-4.12E-06	-0.026770	-3.18E-07	-1.18E-05	2.41E-06	5.54E-07	1.97E-06	1.84E-05	-2.29E-05	0.071955
	[-0.65371]	[-0.77152]	[-0.86634]	[-1.98708]	[0.46162]	[0.18385]	[0.71720]	[0.35794]	[-0.63184]	[0.96883]
C	-0.006687	225.2271	0.004674	-0.007885	0.006733	0.014736	0.012424	0.226367	0.459806	1036.298
	[-0.24795]	[1.51806]	[2.98217]	[-0.31076]	[0.30142]	[1.14374]	[1.05970]	[1.03153]	[2.96946]	[3.26315]

We are interested in the first column and the four first rows of the above table as the interdependencies between the macroeconomic factors will not studied in this thesis. The templates denote that a certain coefficient is statistical significant where the first value is the coefficient and the second in brackets is the t-statistic.

So at first we observe that WTI spot price is affected by its forth lag negatively with a coefficient of -0,156. This means that if before 4 months the returns on spot oil price were positive at the present month the returns will be negative and vice versa. For example if the present month is December and spot oil returns were positive in August then we expect that December returns will be negative by a factor of 0,156 per return unit relatively to August returns.

FED’s funds rate have a positive correlation to the second lag of spot oil price and its coefficient is 0,147. This means that at the present month FED’s fund rate is expected to be increased by a factor of 0,147 per return unit if before two months the returns on oil spot price were positive and vice versa.

Returns on S&P 350 have a negative correlation to the first lag of WTI spot price with a coefficient of -0,128 meaning that if returns of spot price are negative in the previous month S&P 350 will be positive in the end of the current month by a factor of 0,128 per return unit.

The same reaction to oil spot price can be observed to the S&P 500 but with a smaller coefficient of -0,105 meaning that returns on S&P 500 are expected to be positive by a factor of 0,105 given that returns on spot oil price the previous month were negative.

The last one, European Union industrial production, is affected positively by the first lag of spot oil price and the coefficient is 1,817, a quite strong correlation. This means that if oil spot returns in the previous month is up by one point then European Union industrial production will be up by 1,817 points at the end of current month and vice versa if returns on WTI oil spot price are negative.

Table 15

WTI 1 month maturity future contract price and macroeconomic factors

	DCL1	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DCL1(-1)	0.101814	-157.6244	0.001560	0.101613	-0.048998	-0.131288	-0.104770	1.853756	0.144798	-477.5663
	[1.31924]	[-0.36916]	[0.34577]	[1.39161]	[-0.76228]	[-3.54580]	[-3.10234]	[2.93407]	[0.32479]	[-0.52207]
DCL1(-2)	-0.082326	208.2291	-8.20E-05	0.152428	-0.056719	0.027727	0.016750	0.543262	0.157216	-719.2507
	[-1.04633]	[0.47836]	[-0.01783]	[2.04762]	[-0.86553]	[0.73454]	[0.48651]	[0.84342]	[0.34590]	[-0.77124]
DCL1(-3)	0.053479	30.69603	-0.000633	-0.014699	0.045391	-0.039489	-7.56E-05	0.817822	-0.153058	-26.17968
	[0.68354]	[0.07092]	[-0.13836]	[-0.19857]	[0.69658]	[-1.05201]	[-0.00221]	[1.27685]	[-0.33866]	[-0.02823]
DCL1(-4)	-0.163979	-742.4883	-0.005583	-0.050065	-0.056541	-0.025689	0.011661	0.693899	-0.546112	-71.95443
	[-2.12202]	[-1.73671]	[-1.23598]	[-0.68478]	[-0.87850]	[-0.69292]	[0.34485]	[1.09688]	[-1.22340]	[-0.07856]
BDI(-1)	2.05E-05	1.357292	-4.49E-07	2.79E-05	2.30E-05	1.25E-05	1.72E-05	2.00E-05	-7.37E-05	0.052730
	[1.46976]	[17.5854]	[-0.55075]	[2.11173]	[1.98035]	[1.86958]	[2.82387]	[0.17481]	[-0.91449]	[0.31889]
BDI(-2)	-2.16E-05	-0.484661	1.32E-06	-2.51E-05	-1.35E-05	-7.65E-06	-1.41E-05	3.41E-05	0.000147	0.200533
	[-0.94697]	[-3.84158]	[0.98780]	[-1.16494]	[-0.71256]	[-0.69953]	[-1.41580]	[0.18270]	[1.11625]	[0.74192]
BDI(-3)	1.27E-05	0.009674	-1.12E-07	3.78E-05	-1.55E-05	-6.85E-06	-1.28E-06	2.10E-05	-1.59E-05	-0.353274
	[0.56845]	[0.07818]	[-0.08563]	[1.78656]	[-0.83145]	[-0.63836]	[-0.13073]	[0.11448]	[-0.12307]	[-1.33253]
BDI(-4)	-1.01E-05	0.056128	-1.50E-06	-4.59E-05	2.75E-06	5.53E-07	-3.41E-06	-0.000123	-0.000134	0.056427
	[-0.70180]	[0.70425]	[-1.77687]	[-3.36636]	[0.22940]	[0.08006]	[-0.54137]	[-1.04041]	[-1.60786]	[0.33047]
DCAPUT(-1)	7.779983	99520.89	0.393603	9.385136	7.671881	-4.244412	-3.159203	31.60750	9.587359	-156497.1
	[1.21353]	[2.80584]	[1.05027]	[1.54726]	[1.43679]	[-1.37994]	[-1.12612]	[0.60223]	[0.25888]	[-2.05947]
DCAPUT(-2)	-9.249291	-25716.94	0.074821	-18.72012	-2.906434	-2.076647	-1.105752	-28.83623	-7.964109	190729.2
	[-1.36583]	[-0.68641]	[0.18901]	[-2.92179]	[-0.51531]	[-0.63918]	[-0.37315]	[-0.52015]	[-0.20359]	[2.37620]
DCAPUT(-3)	8.315262	-35305.78	0.053603	9.092295	-1.206853	-0.327360	1.425827	87.78014	-11.18610	-17233.96
	[1.25116]	[-0.96020]	[0.13797]	[1.44599]	[-0.21803]	[-0.10267]	[0.49028]	[1.61338]	[-0.29137]	[-0.21878]
DCAPUT(-4)	-1.990672	2355.880	0.395321	6.436430	2.259006	4.893862	1.035896	-81.52491	12.53493	-30596.71
	[-0.33309]	[0.07125]	[1.13156]	[1.13830]	[0.45383]	[1.70679]	[0.39610]	[-1.66628]	[0.36308]	[-0.43193]
DFEDR(-1)	0.055438	-758.7306	0.004700	-0.179569	0.007168	0.041494	0.057989	1.268220	0.383249	350.7592
	[0.78043]	[-1.93060]	[1.13175]	[-2.67185]	[0.12115]	[1.21756]	[1.86557]	[2.18084]	[0.93397]	[0.41660]
DFEDR(-2)	0.006295	-215.9544	0.001201	0.260637	0.071300	0.114762	0.083784	1.006091	0.034269	633.9709
	[0.08646]	[-0.53610]	[0.28211]	[3.78354]	[1.17576]	[3.28533]	[2.62969]	[1.68790]	[0.08148]	[0.73461]
DFEDR(-3)	-0.049709	345.5151	0.001097	0.024473	0.085703	0.020936	-0.012034	-0.299138	0.152475	450.5511
	[-0.69241]	[0.86990]	[0.26140]	[0.36030]	[1.43330]	[0.60785]	[-0.38305]	[-0.50898]	[0.36766]	[0.52948]
DFEDR(-4)	-0.085146	-920.3979	-0.002537	-0.154567	-0.003647	-0.047810	-0.037031	-0.086239	0.057004	252.3443
	[-1.22449]	[-2.39246]	[-0.62404]	[-2.34941]	[-0.06296]	[-1.43312]	[-1.21701]	[-0.15149]	[0.14191]	[0.30617]
DHASE(-1)	0.041629	761.8378	-0.000798	-0.130207	0.067456	0.026071	0.071496	-0.397897	-0.146654	-591.4795
	[0.36642]	[1.21207]	[-0.12019]	[-1.21136]	[0.71289]	[0.47832]	[1.43814]	[-0.42782]	[-0.22346]	[-0.43924]
DHASE(-2)	-0.016227	-145.2277	0.001650	-0.018587	-0.006899	0.008360	-0.009403	-0.602834	0.117402	598.1805
	[-0.14403]	[-0.23299]	[0.25049]	[-0.17437]	[-0.07352]	[0.15467]	[-0.19071]	[-0.65359]	[0.18039]	[0.44793]
DHASE(-3)	-0.005100	-206.4046	0.006133	-0.078079	-0.138334	-0.024335	-0.042151	-0.147872	0.542029	537.3633
	[-0.04534]	[-0.33166]	[0.93272]	[-0.73363]	[-1.47652]	[-0.45091]	[-0.85631]	[-0.16058]	[0.83414]	[0.40303]
DHASE(-4)	0.033863	87.84111	0.006323	0.037053	-0.100865	0.033062	0.017422	0.485532	0.443012	506.3612
	[0.30769]	[0.14427]	[0.98290]	[0.35586]	[-1.10041]	[0.62618]	[0.36177]	[0.53891]	[0.69684]	[0.38818]
DSP350(-1)	0.089907	-2015.862	0.002160	0.244533	-0.296781	-0.029357	0.058354	-0.707627	0.818420	1639.972

	[0.33972]	[-1.37679]	[0.13964]	[0.97661]	[-1.34643]	[-0.23122]	[0.50389]	[-0.32661]	[0.53534]	[0.52281]
DSP350(-2)	0.263933	1002.535	0.000834	0.191083	0.084785	-0.157449	-0.095476	0.044005	-0.278531	-1722.699
	[1.00865]	[0.69251]	[0.05450]	[0.77183]	[0.38903]	[-1.25418]	[-0.83383]	[0.02054]	[-0.18427]	[-0.55544]
DSP350(-3)	-0.205805	119.4239	0.015314	-0.033748	0.028128	0.013660	-0.060482	4.452552	1.552424	157.5019
	[-0.79283]	[0.08316]	[1.00920]	[-0.13741]	[0.13010]	[0.10969]	[-0.53246]	[2.09525]	[1.03529]	[0.05119]
DSP350(-4)	0.279047	-628.1613	-0.010414	0.275646	-0.131877	-0.120157	-0.185186	2.438608	-0.970090	3767.763
	[1.14465]	[-0.46574]	[-0.73081]	[1.19509]	[-0.64951]	[-1.02735]	[-1.73595]	[1.22191]	[-0.68886]	[1.30394]
DSP500(-1)	-0.016173	861.8475	0.002093	-0.108862	0.058734	0.138633	-0.137807	4.016678	-0.003140	1764.390
	[-0.05940]	[0.57213]	[0.13151]	[-0.42259]	[0.25900]	[1.06127]	[-1.15664]	[1.80201]	[-0.00200]	[0.54672]
DSP500(-2)	-0.028860	254.5162	0.011877	0.230400	-0.104331	0.200155	0.033108	3.153071	1.108283	-389.2099
	[-0.10477]	[0.16701]	[0.73758]	[0.88404]	[-0.45475]	[1.51452]	[0.27466]	[1.39821]	[0.69649]	[-0.11921]
DSP500(-3)	0.373475	-714.8679	0.013553	0.155101	0.106674	0.075572	0.128645	-2.268385	1.556823	790.0180
	[1.35726]	[-0.46957]	[0.84260]	[0.59576]	[0.46545]	[0.57245]	[1.06839]	[-1.00697]	[0.97941]	[0.24222]
DSP500(-4)	-0.478737	-843.7511	0.021141	-0.365397	0.176702	0.130912	0.142610	-2.273264	2.423329	-3662.037
	[-1.77266]	[-0.56470]	[1.33913]	[-1.43003]	[0.78558]	[1.01036]	[1.20674]	[-1.02820]	[1.55334]	[-1.14401]
INDPREU(-1)	-0.007969	79.82219	0.000279	0.007693	0.007970	0.001366	0.002908	-0.313246	0.037608	53.75103
	[-0.92169]	[1.66875]	[0.55119]	[0.94052]	[1.10679]	[0.32933]	[0.76871]	[-4.42566]	[0.75299]	[0.52451]
INDPREU(-2)	-0.005508	6.694546	0.000148	0.002445	-0.009144	-0.003409	-0.004007	0.122523	0.023953	-217.2902
	[-0.64139]	[0.14091]	[0.29563]	[0.30093]	[-1.27849]	[-0.82739]	[-1.06629]	[1.74288]	[0.48288]	[-2.13485]
INDPREU(-3)	0.005245	81.20917	0.000655	-0.005255	-0.003390	-0.001865	-0.002176	0.311530	0.054679	-1.610610
	[0.61645]	[1.72531]	[1.31728]	[-0.65281]	[-0.47839]	[-0.45690]	[-0.58449]	[4.47287]	[1.11257]	[-0.01597]
INDPREU(-4)	0.000838	87.19115	0.001354	-0.017983	-0.014047	-0.003686	-0.002847	0.062078	0.129827	97.06702
	[0.10063]	[1.89296]	[2.78202]	[-2.28303]	[-2.02579]	[-0.92287]	[-0.78136]	[0.91082]	[2.69949]	[0.98365]
INDPRUSA(-1)	-0.047138	-932.4291	-0.005486	-0.069500	-0.052873	0.051061	0.045312	-0.164789	-0.221223	1768.654
	[-0.72063]	[-2.57652]	[-1.43475]	[-1.12299]	[-0.97049]	[1.62706]	[1.58303]	[-0.30773]	[-0.58546]	[2.28119]
INDPRUSA(-2)	0.107181	303.6249	2.91E-06	0.180742	0.035912	0.028767	0.019479	0.160154	0.146895	-2026.606
	[1.54174]	[0.78942]	[0.00072]	[2.74791]	[0.62023]	[0.86249]	[0.64033]	[0.28140]	[0.36578]	[-2.45946]
INDPRUSA(-3)	-0.076989	437.8262	0.000994	-0.051133	0.008624	-0.004700	-0.020305	-0.905249	0.245240	131.9248
	[-1.13411]	[1.16574]	[0.25061]	[-0.79612]	[0.15254]	[-0.14431]	[-0.68355]	[-1.62889]	[0.62537]	[0.16396]
INDPRUSA(-4)	0.008619	-102.5129	-0.003429	-0.037483	-0.037289	-0.053801	-0.014784	0.792680	-0.072167	275.3442
	[0.14000]	[-0.30097]	[-0.95267]	[-0.64351]	[-0.72722]	[-1.82151]	[-0.54879]	[1.57278]	[-0.20292]	[0.37733]
NIKK(-1)	-1.16E-05	0.011141	-2.56E-07	4.88E-06	3.67E-06	-1.03E-06	-1.56E-06	-3.77E-05	-2.72E-05	0.894484
	[-1.73635]	[0.30069]	[-0.65328]	[0.77095]	[0.65792]	[-0.31973]	[-0.53133]	[-0.68809]	[-0.70218]	[11.2689]
NIKK(-2)	1.97E-05	-0.040810	5.97E-07	-1.63E-06	-5.46E-06	-2.86E-06	1.40E-06	0.000161	7.84E-05	0.044112
	[2.15179]	[-0.80472]	[1.11454]	[-0.18769]	[-0.71500]	[-0.65038]	[0.34791]	[2.15180]	[1.48088]	[0.40600]
NIKK(-3)	-4.44E-06	0.055068	-1.64E-07	9.15E-06	6.76E-07	3.17E-06	-2.00E-06	-0.000150	-3.93E-05	-0.074743
	[-0.49157]	[1.10082]	[-0.31013]	[1.06924]	[0.08970]	[0.73151]	[-0.50526]	[-2.03187]	[-0.75295]	[-0.69740]
NIKK(-4)	-3.08E-06	-0.027404	-3.03E-07	-1.21E-05	2.64E-06	4.65E-08	1.67E-06	2.35E-05	-2.22E-05	0.069982
	[-0.48575]	[-0.78226]	[-0.81980]	[-2.01461]	[0.50060]	[0.01530]	[0.60336]	[0.45376]	[-0.60629]	[0.93243]
C	-0.004600	225.7816	0.004677	-0.007982	0.006918	0.014563	0.012277	0.227403	0.459871	1038.592
	[-0.17155]	[1.52185]	[2.98388]	[-0.31459]	[0.30973]	[1.13198]	[1.04626]	[1.03587]	[2.96871]	[3.26761]

We observe that we have exactly the same interdependencies as to the spot price but with slightly different coefficients. The 1 month maturity contract is affected by its forth lag negatively with a coefficient of -0,164. So if the present month is December and the 1 month future returns were positive in August then we expect that December returns will be negative by a factor of 0,164 per return unit relatively to August returns and vice versa if returns in August were negative .

FED's funds rate have a positive correlation to the second lag of spot oil price and its coefficient is 0,152. This means that at the present month FED's fund rate is expected to be increased by a factor of 0,152 if before two months the returns on 1 month future contract were up by one unit and vice versa.

Returns on S&P 350 have a negative correlation to the first lag of WTI spot price with a coefficient of -0,131 meaning that if returns of 1 month future contract are negative in the previous month S&P 350 will be positive in the end of the current month by a factor of 0,131 per return unit.

S&P 500 has a coefficient of -0,105 exactly the same as the spot price, meaning that returns on S&P 500 are expected to be positive by a factor of 0,105 given that returns on 1 month future contract the previous month were negative by one point.

European Union industrial production, is affected positively by the first lag of the contract and the coefficient is 1,854. This means that if the contract returns in the previous month is up by one point then European Union industrial production will be up by 1,854 points at the end of current month and vice versa if returns on the contract are negative.

Table 16

WTI 3 months maturity future contract price and macroeconomic factors

	DCL3	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DCL3(-1)	0.125521	-289.8933	0.002431	0.116828	-0.071490	-0.157641	-0.131965	2.105263	0.202137	-802.6583
	[1.63978]	[-0.60626]	[0.48066]	[1.43070]	[-0.99202]	[-3.81775]	[-3.50954]	[2.97910]	[0.40463]	[-0.78440]
DCL3(-2)	-0.085980	198.1986	0.000859	0.189364	-0.058089	0.050196	0.033612	0.482498	0.245014	-940.0866
	[-1.08254]	[0.39948]	[0.16358]	[2.23498]	[-0.77686]	[1.17160]	[0.86151]	[0.65804]	[0.47270]	[-0.88543]
DCL3(-3)	-0.002615	-70.76902	-0.001740	0.002077	0.043932	-0.043766	-0.001460	0.979950	-0.277305	33.68366
	[-0.03260]	[-0.14121]	[-0.32811]	[0.02427]	[0.58164]	[-1.01128]	[-0.03706]	[1.32305]	[-0.52963]	[0.03141]
DCL3(-4)	-0.125646	-892.7239	-0.005223	-0.025917	-0.056979	-0.035970	-0.001014	0.994730	-0.547749	-595.6117
	[-1.58743]	[-1.80556]	[-0.99863]	[-0.30694]	[-0.76465]	[-0.84247]	[-0.02607]	[1.36132]	[-1.06041]	[-0.56292]
BDI(-1)	2.00E-05	1.360568	-5.04E-07	2.79E-05	2.38E-05	1.30E-05	1.81E-05	2.26E-05	-7.77E-05	0.062782
	[1.61883]	[17.6086]	[-0.61613]	[2.11112]	[2.04093]	[1.95572]	[2.97682]	[0.19809]	[-0.96305]	[0.37969]
BDI(-2)	-2.05E-05	-0.486988	1.33E-06	-2.67E-05	-1.41E-05	-8.45E-06	-1.52E-05	2.77E-05	0.000147	0.197028
	[-1.01402]	[-3.85849]	[0.99316]	[-1.23972]	[-0.74045]	[-0.77505]	[-1.52707]	[0.14853]	[1.11490]	[0.72949]
BDI(-3)	9.19E-06	0.011360	-4.61E-08	3.77E-05	-1.53E-05	-6.72E-06	-1.01E-06	1.96E-05	-9.96E-06	-0.356036
	[0.46344]	[0.09174]	[-0.03518]	[1.78195]	[-0.81865]	[-0.62851]	[-0.10325]	[0.10733]	[-0.07699]	[-1.34361]
BDI(-4)	-6.64E-06	0.055378	-1.52E-06	-4.46E-05	2.43E-06	8.28E-07	-3.37E-06	-0.000122	-0.000136	0.057706
	[-0.52053]	[0.69508]	[-1.80465]	[-3.27752]	[0.20261]	[0.12041]	[-0.53818]	[-1.03532]	[-1.62935]	[0.33847]
DCAPUT(-1)	7.859139	99718.60	0.369658	9.685996	7.554816	-4.602183	-3.369775	37.36269	7.921315	-150077.3
	[1.40275]	[2.84924]	[0.99841]	[1.62061]	[1.43230]	[-1.52277]	[-1.22441]	[0.72235]	[0.21664]	[-2.00382]
DCAPUT(-2)	-7.841687	-22521.89	0.105705	-18.12377	-2.770652	-1.599619	-1.002891	-33.33108	-4.698891	181920.0
	[-1.32319]	[-0.60837]	[0.26991]	[-2.86677]	[-0.49659]	[-0.50038]	[-0.34450]	[-0.60922]	[-0.12149]	[2.29633]
DCAPUT(-3)	7.583719	-34357.18	0.068027	8.229321	-0.824362	-0.649402	1.307997	87.32585	-10.73724	-14276.06
	[1.29985]	[-0.94271]	[0.17644]	[1.32222]	[-0.15008]	[-0.20634]	[0.45639]	[1.62129]	[-0.28200]	[-0.18304]
DCAPUT(-4)	-3.548463	-802.7402	0.376014	6.370690	1.970766	5.179347	1.310569	-83.58717	10.85427	-30206.37
	[-0.67330]	[-0.02438]	[1.07963]	[1.13314]	[0.39720]	[1.82184]	[0.50623]	[-1.71796]	[0.31558]	[-0.42875]
DFEDR(-1)	0.058739	-720.8602	0.004839	-0.181896	0.007760	0.036418	0.054121	1.297421	0.403239	401.8229
	[0.93508]	[-1.83706]	[1.16565]	[-2.71442]	[0.13121]	[1.07476]	[1.75391]	[2.23723]	[0.98363]	[0.47852]
DFEDR(-2)	0.013882	-170.4053	0.001101	0.260636	0.068990	0.115749	0.085550	0.995827	0.042451	708.1714
	[0.21588]	[-0.42423]	[0.25919]	[3.79954]	[1.13962]	[3.33695]	[2.70835]	[1.67748]	[0.10116]	[0.82384]
DFEDR(-3)	-0.042216	359.1981	0.000825	0.018861	0.086809	0.023056	-0.007891	-0.315554	0.131200	506.1699
	[-0.66781]	[0.90962]	[0.19759]	[0.27968]	[1.45863]	[0.67612]	[-0.25410]	[-0.54070]	[0.31802]	[0.59898]
DFEDR(-4)	-0.050914	-953.7969	-0.002665	-0.163482	-0.004596	-0.051099	-0.037942	-0.075713	0.037258	270.3799
	[-0.83148]	[-2.49357]	[-0.65859]	[-2.50275]	[-0.07973]	[-1.54703]	[-1.26142]	[-0.13393]	[0.09324]	[0.33032]
DHASE(-1)	0.026854	749.3506	-0.001421	-0.132140	0.063595	0.019470	0.069082	-0.297825	-0.196786	-501.0302
	[0.26765]	[1.19561]	[-0.21430]	[-1.23458]	[0.67326]	[0.35974]	[1.40166]	[-0.32153]	[-0.30053]	[-0.37356]
DHASE(-2)	0.039661	-136.2043	0.001798	-0.018284	-0.007229	0.004826	-0.012375	-0.548467	0.132934	525.1407
	[0.39783]	[-0.21871]	[0.27294]	[-0.17192]	[-0.07702]	[0.08973]	[-0.25269]	[-0.59593]	[0.20432]	[0.39405]
DHASE(-3)	-0.026314	-173.9461	0.005906	-0.091841	-0.135518	-0.017180	-0.033199	-0.265678	0.527684	667.9403
	[-0.26482]	[-0.28023]	[0.89939]	[-0.86640]	[-1.44862]	[-0.32051]	[-0.68014]	[-0.28961]	[0.81371]	[0.50284]
DHASE(-4)	0.022302	62.01574	0.006050	0.027308	-0.103330	0.028176	0.015278	0.491670	0.414630	602.0225
	[0.22888]	[0.10188]	[0.93954]	[0.26271]	[-1.12639]	[0.53605]	[0.31918]	[0.54656]	[0.65202]	[0.46218]
DSP350(-1)	0.171654	-2027.766	0.003835	0.251595	-0.286672	-0.021502	0.056645	-0.844018	0.936736	1282.201
	[0.73726]	[-1.39423]	[0.24922]	[1.01298]	[-1.30785]	[-0.17121]	[0.49528]	[-0.39267]	[0.61650]	[0.41197]

DSP350(-2)	0.117336	981.3321	-0.000113	0.178209	0.092580	-0.141386	-0.077669	-0.146850	-0.368538	-1419.163
	[0.50660]	[0.67827]	[-0.00740]	[0.72127]	[0.42458]	[-1.13165]	[-0.68266]	[-0.06868]	[-0.24382]	[-0.45836]
DSP350(-3)	-0.133581	72.28150	0.015724	-0.018305	0.027772	0.003446	-0.077818	4.556533	1.574597	-76.88560
	[-0.58293]	[0.05049]	[1.03836]	[-0.07488]	[0.12873]	[0.02787]	[-0.69131]	[2.15384]	[1.05290]	[-0.02510]
DSP350(-4)	0.278772	-570.9990	-0.009798	0.285805	-0.130460	-0.112865	-0.184857	2.368262	-0.903368	3585.789
	[1.29448]	[-0.42446]	[-0.68847]	[1.24408]	[-0.64347]	[-0.97157]	[-1.74745]	[1.19120]	[-0.64277]	[1.24558]
DSP500(-1)	-0.112887	902.3491	0.002176	-0.109859	0.055734	0.155796	-0.123607	3.802260	0.024623	1877.154
	[-0.46747]	[0.59818]	[0.13633]	[-0.42645]	[0.24515]	[1.19600]	[-1.04200]	[1.70551]	[0.01562]	[0.58149]
DSP500(-2)	-0.020963	240.2882	0.011908	0.243975	-0.110196	0.187022	0.021403	3.308479	1.107262	-370.3590
	[-0.08566]	[0.15719]	[0.73634]	[0.93460]	[-0.47833]	[1.41681]	[0.17805]	[1.46450]	[0.69334]	[-0.11322]
DSP500(-3)	0.301397	-764.7164	0.013466	0.179642	0.098008	0.078783	0.130964	-2.140708	1.556147	613.5237
	[1.23499]	[-0.50162]	[0.83494]	[0.69002]	[0.42657]	[0.59845]	[1.09245]	[-0.95015]	[0.97706]	[0.18806]
DSP500(-4)	-0.385816	-828.1977	0.020789	-0.353541	0.182608	0.128875	0.144547	-2.140306	2.391428	-3577.587
	[-1.61586]	[-0.55527]	[1.31751]	[-1.38801]	[0.81236]	[1.00060]	[1.23241]	[-0.97097]	[1.53471]	[-1.12086]
INDPREU(-1)	-0.008334	81.96040	0.000255	0.007217	0.007843	0.000930	0.002686	-0.309953	0.036280	60.79097
	[-1.09082]	[1.71733]	[0.50531]	[0.88544]	[1.09035]	[0.22571]	[0.71568]	[-4.39444]	[0.72764]	[0.59522]
INDPREU(-2)	-0.003268	7.204390	0.000158	0.002328	-0.009512	-0.003769	-0.004312	0.125249	0.025326	-219.6604
	[-0.42994]	[0.15173]	[0.31460]	[0.28714]	[-1.32927]	[-0.91928]	[-1.15490]	[1.78489]	[0.51055]	[-2.16182]
INDPREU(-3)	0.004067	82.22509	0.000656	-0.005311	-0.003386	-0.001272	-0.001595	0.305466	0.055145	1.522064
	[0.53919]	[1.74504]	[1.31673]	[-0.65999]	[-0.47677]	[-0.31270]	[-0.43041]	[4.38655]	[1.12022]	[0.01509]
INDPREU(-4)	0.001048	85.21004	0.001353	-0.018145	-0.013920	-0.003582	-0.002744	0.059422	0.128906	99.02539
	[0.14254]	[1.85492]	[2.78500]	[-2.31295]	[-2.01061]	[-0.90305]	[-0.75970]	[0.87526]	[2.68598]	[1.00733]
INDPRUSA(-1)	-0.051210	-936.5400	-0.005251	-0.072763	-0.051932	0.054632	0.047317	-0.224234	-0.204992	1702.477
	[-0.89500]	[-2.62023]	[-1.38864]	[-1.19208]	[-0.96406]	[1.77004]	[1.68345]	[-0.42450]	[-0.54897]	[2.22579]
INDPRUSA(-2)	0.093953	275.1476	-0.000318	0.174791	0.034933	0.024448	0.018860	0.200619	0.113964	-1930.111
	[1.54504]	[0.72434]	[-0.07906]	[2.69451]	[0.61020]	[0.74533]	[0.63137]	[0.35736]	[0.28717]	[-2.37439]
INDPRUSA(-3)	-0.071289	433.7202	0.000821	-0.043199	0.005315	-0.001266	-0.018930	-0.905549	0.239021	111.6881
	[-1.19742]	[1.16622]	[0.20868]	[-0.68018]	[0.09482]	[-0.03942]	[-0.64729]	[-1.64756]	[0.61518]	[0.14034]
INDPRUSA(-4)	0.020770	-69.83379	-0.003201	-0.037969	-0.034067	-0.056711	-0.017659	0.806302	-0.052916	270.1908
	[0.38280]	[-0.20604]	[-0.89281]	[-0.65600]	[-0.66693]	[-1.93766]	[-0.66257]	[1.60970]	[-0.14944]	[0.37252]
NIKK(-1)	-7.44E-06	0.010918	-2.68E-07	5.08E-06	3.63E-06	-1.14E-06	-1.61E-06	-3.52E-05	-2.82E-05	0.896656
	[-1.25547]	[0.29476]	[-0.68411]	[0.80260]	[0.65048]	[-0.35724]	[-0.55401]	[-0.64351]	[-0.72926]	[11.3120]
NIKK(-2)	1.30E-05	-0.041493	6.16E-07	-1.87E-06	-5.44E-06	-2.40E-06	1.60E-06	0.000154	7.98E-05	0.036643
	[1.61064]	[-0.82183]	[1.15334]	[-0.21637]	[-0.71490]	[-0.55021]	[0.40337]	[2.06919]	[1.51317]	[0.33915]
NIKK(-3)	-2.96E-06	0.055782	-1.63E-07	9.09E-06	1.07E-06	2.65E-06	-2.18E-06	-0.000143	-3.97E-05	-0.067484
	[-0.37446]	[1.13053]	[-0.31257]	[1.07821]	[0.14330]	[0.62311]	[-0.56088]	[-1.96780]	[-0.77012]	[-0.63911]
NIKK(-4)	-2.23E-06	-0.027045	-3.08E-07	-1.19E-05	2.28E-06	2.13E-07	1.68E-06	2.14E-05	-2.19E-05	0.067675
	[-0.40209]	[-0.77928]	[-0.84000]	[-2.00345]	[0.43608]	[0.07096]	[0.61391]	[0.41790]	[-0.60483]	[0.91121]
C	-0.002501	223.0687	0.004650	-0.008894	0.006795	0.014399	0.012500	0.230340	0.456976	1039.277
	[-0.10553]	[1.50681]	[2.96916]	[-0.35181]	[0.30456]	[1.12632]	[1.07373]	[1.05280]	[2.95467]	[3.28050]

We observe similar interdependencies to the previous two contracts. Fed's funds rate is affected positively by the second lag of the 3 months maturity oil future and its coefficient is 0,189. So if the returns of this certain future contract are up by one point, we will have an upward movement to FED' funds rate of 0,189 points.

S&P 350 and S&P 500 are affected negatively by the first lag of the oil future and their coefficients are -0,158 and -0,132 respectively meaning that one point increase in the returns of the oil future at the present month will result to a decline of 0,158 and 0,132 respectively for the two indices next month.

European union industrial production is affected positively by the first lag of the 3 months maturity future and has a coefficient of 2,105.

Table 17

WTI 6 months maturity future contract price and macroeconomic factors

	DCL6	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DCL6(-1)	0.142288	-418.5096	0.003242	0.112099	-0.090246	-0.182798	-0.162178	2.513477	0.266342	-1234.085
	[1.84022]	[-0.73928]	[0.53970]	[1.16160]	[-1.05529]	[-3.73565]	[-3.64631]	[2.99823]	[0.44899]	[-1.02018]
DCL6(-2)	-0.070136	180.3306	0.001023	0.259270	-0.058541	0.081106	0.058376	0.255637	0.249198	-950.8277
	[-0.87445]	[0.30709]	[0.16424]	[2.59003]	[-0.65994]	[1.59787]	[1.26528]	[0.29397]	[0.40498]	[-0.75776]
DCL6(-3)	-0.037471	-190.6885	-0.003304	0.030551	0.031260	-0.059598	-0.011137	1.302578	-0.441334	-60.03919
	[-0.46127]	[-0.32061]	[-0.52350]	[0.30132]	[0.34792]	[-1.15927]	[-0.23833]	[1.47893]	[-0.70814]	[-0.04724]
DCL6(-4)	-0.065662	-1172.895	-0.004206	-0.029477	-0.080153	-0.055014	-0.013905	1.149926	-0.493565	-1645.542
	[-0.82164]	[-2.00462]	[-0.67737]	[-0.29554]	[-0.90684]	[-1.08777]	[-0.30249]	[1.32717]	[-0.80502]	[-1.31616]
BDI(-1)	2.01E-05	1.361796	-5.30E-07	2.88E-05	2.40E-05	1.31E-05	1.86E-05	1.94E-05	-8.03E-05	0.069605
	[1.90054]	[17.5528]	[-0.64387]	[2.17857]	[2.04956]	[1.94775]	[3.05559]	[0.16909]	[-0.98787]	[0.41986]
BDI(-2)	-2.19E-05	-0.487752	1.35E-06	-3.01E-05	-1.44E-05	-9.16E-06	-1.62E-05	3.66E-05	0.000150	0.183540
	[-1.26589]	[-3.85730]	[1.00371]	[-1.39487]	[-0.75530]	[-0.83820]	[-1.63148]	[0.19519]	[1.13067]	[0.67927]
BDI(-3)	1.05E-05	0.013740	-1.80E-09	3.85E-05	-1.46E-05	-6.09E-06	-4.60E-07	1.06E-05	-6.67E-06	-0.343348
	[0.62079]	[0.11085]	[-0.00137]	[1.82193]	[-0.77742]	[-0.56844]	[-0.04726]	[0.05796]	[-0.05135]	[-1.29640]
BDI(-4)	-6.53E-06	0.055457	-1.56E-06	-4.35E-05	2.10E-06	1.14E-06	-3.20E-06	-0.000123	-0.000139	0.060510
	[-0.60033]	[0.69605]	[-1.84868]	[-3.20333]	[0.17484]	[0.16614]	[-0.51113]	[-1.04560]	[-1.66523]	[0.35542]
DCAPUT(-1)	7.381363	99601.69	0.352224	10.23993	7.278335	-5.005721	-3.650086	42.29296	6.689279	-145801.7
	[1.55922]	[2.87371]	[0.95771]	[1.73311]	[1.39011]	[-1.67084]	[-1.34040]	[0.82401]	[0.18418]	[-1.96865]
DCAPUT(-2)	-7.947018	-20547.83	0.137457	-18.37425	-2.660647	-1.184782	-0.760469	-39.92858	-1.480153	173427.5
	[-1.58454]	[-0.55959]	[0.35278]	[-2.93539]	[-0.47966]	[-0.37328]	[-0.26360]	[-0.73430]	[-0.03847]	[2.21029]
DCAPUT(-3)	6.916564	-33849.16	0.069505	7.479260	-0.514493	-1.030108	1.015438	91.37840	-11.07525	-8979.267
	[1.39070]	[-0.92960]	[0.17989]	[1.20492]	[-0.09353]	[-0.32728]	[0.35494]	[1.69464]	[-0.29026]	[-0.11540]
DCAPUT(-4)	-2.924119	-1848.916	0.366691	6.784612	1.903257	5.592562	1.668401	-87.79954	9.995053	-29731.47
	[-0.64962]	[-0.05610]	[1.04859]	[1.20766]	[0.38230]	[1.96322]	[0.64435]	[-1.79906]	[0.28943]	[-0.42219]
DFEDR(-1)	0.065436	-666.5515	0.004976	-0.185276	0.011228	0.039226	0.056057	1.249419	0.426108	508.2365
	[1.21560]	[-1.69127]	[1.18979]	[-2.75772]	[0.18859]	[1.15145]	[1.81036]	[2.14078]	[1.03179]	[0.60350]
DFEDR(-2)	0.006140	-109.1783	0.000947	0.256602	0.075021	0.119574	0.089335	0.952836	0.036833	905.1611
	[0.11130]	[-0.27032]	[0.22105]	[3.72693]	[1.22959]	[3.42505]	[2.81525]	[1.59309]	[0.08703]	[1.04880]
DFEDR(-3)	-0.049074	360.4087	0.000663	0.016156	0.086939	0.021639	-0.008280	-0.281931	0.118731	556.2542
	[-0.91355]	[0.91639]	[0.15893]	[0.24097]	[1.46332]	[0.63652]	[-0.26797]	[-0.48408]	[0.28810]	[0.66190]
DFEDR(-4)	-0.040559	-956.6112	-0.002615	-0.165488	-0.005075	-0.052369	-0.039756	-0.047015	0.042471	274.6903
	[-0.77613]	[-2.50028]	[-0.64400]	[-2.53730]	[-0.08780]	[-1.58350]	[-1.32256]	[-0.08298]	[0.10594]	[0.33599]
DHASE(-1)	0.009220	740.6001	-0.001833	-0.128878	0.059338	0.012937	0.065244	-0.162614	-0.227874	-475.9943
	[0.10803]	[1.18518]	[-0.27645]	[-1.20985]	[0.62860]	[0.23951]	[1.32891]	[-0.17573]	[-0.34801]	[-0.35648]
DHASE(-2)	0.070124	-142.3285	0.002110	-0.023829	-0.007539	0.001962	-0.014089	-0.510954	0.161020	405.5270
	[0.82664]	[-0.22916]	[0.32020]	[-0.22506]	[-0.08035]	[0.03655]	[-0.28872]	[-0.55555]	[0.24741]	[0.30556]
DHASE(-3)	-0.047640	-143.0935	0.005512	-0.096320	-0.128938	-0.010310	-0.025525	-0.319887	0.494340	876.9369
	[-0.56397]	[-0.23137]	[0.83992]	[-0.91361]	[-1.38010]	[-0.19287]	[-0.52531]	[-0.34928]	[0.76280]	[0.66357]
DHASE(-4)	0.006024	59.67056	0.005718	0.020017	-0.102243	0.024922	0.012788	0.538418	0.383689	719.8531
	[0.07247]	[0.09804]	[0.88543]	[0.19293]	[-1.11207]	[0.47372]	[0.26744]	[0.59739]	[0.60163]	[0.55352]
DSP350(-1)	0.198629	-2090.233	0.005012	0.225417	-0.279731	-0.022177	0.052759	-1.023788	1.007471	980.3600

	[1.00713]	[-1.44758]	[0.32711]	[0.91577]	[-1.28242]	[-0.17769]	[0.46505]	[-0.47879]	[0.66584]	[0.31773]
DSP350(-2)	0.080282	980.5104	-0.000888	0.203102	0.089372	-0.135800	-0.072362	-0.234891	-0.434044	-1124.818
	[0.40874]	[0.68185]	[-0.05821]	[0.82852]	[0.41141]	[-1.09252]	[-0.64048]	[-0.11030]	[-0.28805]	[-0.36606]
DSP350(-3)	-0.072383	108.9848	0.016733	-0.022618	0.022952	0.001677	-0.084230	4.458925	1.675253	-453.4978
	[-0.37339]	[0.07679]	[1.11106]	[-0.09348]	[0.10705]	[0.01367]	[-0.75536]	[2.12152]	[1.12643]	[-0.14953]
DSP350(-4)	0.249332	-569.6383	-0.009181	0.268962	-0.128096	-0.112724	-0.185168	2.297671	-0.850632	3386.991
	[1.36021]	[-0.42446]	[-0.64472]	[1.17565]	[-0.63184]	[-0.97172]	[-1.75612]	[1.15613]	[-0.60488]	[1.18107]
DSP500(-1)	-0.135763	974.8323	0.001729	-0.098658	0.065434	0.183785	-0.100740	3.506506	-0.004410	2239.096
	[-0.65787]	[0.64520]	[0.10782]	[-0.38304]	[0.28669]	[1.40723]	[-0.84864]	[1.56720]	[-0.00279]	[0.69353]
DSP500(-2)	-0.051297	255.1414	0.011388	0.240213	-0.108499	0.181709	0.015471	3.372893	1.056164	-211.9797
	[-0.24502]	[0.16646]	[0.70014]	[0.91932]	[-0.46858]	[1.37147]	[0.12847]	[1.48596]	[0.65757]	[-0.06472]
DSP500(-3)	0.237773	-856.4642	0.013646	0.197105	0.087111	0.075759	0.127930	-2.087607	1.564688	378.3281
	[1.14261]	[-0.56215]	[0.84409]	[0.75891]	[0.37849]	[0.57526]	[1.06873]	[-0.92529]	[0.98008]	[0.11621]
DSP500(-4)	-0.294793	-802.3537	0.020692	-0.320389	0.179018	0.121444	0.139715	-2.036370	2.384435	-3496.931
	[-1.45206]	[-0.53981]	[1.31191]	[-1.26446]	[0.79728]	[0.94524]	[1.19639]	[-0.92516]	[1.53091]	[-1.10100]
INDPREU(-1)	-0.007327	84.86761	0.000243	0.006811	0.007916	0.000705	0.002569	-0.304728	0.036004	67.19831
	[-1.12760]	[1.78388]	[0.48055]	[0.83979]	[1.10145]	[0.17135]	[0.68723]	[-4.32536]	[0.72222]	[0.66101]
INDPREU(-2)	-0.002095	8.066496	0.000165	0.001489	-0.009347	-0.003744	-0.004311	0.126253	0.026171	-219.1168
	[-0.32413]	[0.17048]	[0.32849]	[0.18460]	[-1.30771]	[-0.91552]	[-1.15965]	[1.80188]	[0.52785]	[-2.16723]
INDPREU(-3)	0.002751	83.00290	0.000637	-0.004978	-0.003096	-0.000597	-0.001008	0.298841	0.053344	12.67125
	[0.42796]	[1.76350]	[1.27621]	[-0.62038]	[-0.43542]	[-0.14678]	[-0.27256]	[4.28754]	[1.08159]	[0.12599]
INDPREU(-4)	0.001543	84.52327	0.001340	-0.017959	-0.013875	-0.003537	-0.002773	0.058076	0.127257	103.5875
	[0.24659]	[1.84501]	[2.75682]	[-2.29957]	[-2.00489]	[-0.89323]	[-0.77051]	[0.85606]	[2.65091]	[1.05818]
INDPRUSA(-1)	-0.048355	-936.4820	-0.005069	-0.078513	-0.049332	0.058740	0.050142	-0.274008	-0.191832	1653.184
	[-0.99974]	[-2.64453]	[-1.34891]	[-1.30060]	[-0.92218]	[1.91899]	[1.80223]	[-0.52251]	[-0.51697]	[2.18474]
INDPRUSA(-2)	0.093521	256.5712	-0.000653	0.177947	0.033948	0.020280	0.016629	0.265810	0.080168	-1837.152
	[1.81866]	[0.68148]	[-0.16355]	[2.77262]	[0.59690]	[0.62316]	[0.56216]	[0.47676]	[0.20321]	[-2.28360]
INDPRUSA(-3)	-0.066301	431.2529	0.000802	-0.036103	0.002087	0.002241	-0.016121	-0.942960	0.243131	58.01818
	[-1.30729]	[1.16142]	[0.20344]	[-0.57036]	[0.03720]	[0.06982]	[-0.55260]	[-1.71489]	[0.62487]	[0.07312]
INDPRUSA(-4)	0.013538	-57.86772	-0.003079	-0.043523	-0.032892	-0.060911	-0.021307	0.846035	-0.042116	265.4262
	[0.29223]	[-0.17061]	[-0.85564]	[-0.75274]	[-0.64195]	[-2.07758]	[-0.79954]	[1.68440]	[-0.11850]	[0.36622]
NIKK(-1)	-6.81E-06	0.011124	-2.84E-07	5.40E-06	3.52E-06	-8.37E-07	-1.36E-06	-3.78E-05	-2.93E-05	0.898371
	[-1.34912]	[0.30114]	[-0.72515]	[0.85690]	[0.63155]	[-0.26223]	[-0.46713]	[-0.69139]	[-0.75717]	[11.3815]
NIKK(-2)	1.26E-05	-0.042412	6.47E-07	-2.80E-06	-5.28E-06	-2.82E-06	1.18E-06	0.000156	8.18E-05	0.029050
	[1.82846]	[-0.84218]	[1.21026]	[-0.32608]	[-0.69367]	[-0.64685]	[0.29908]	[2.09451]	[1.55099]	[0.26996]
NIKK(-3)	-4.01E-06	0.055395	-1.82E-07	1.00E-05	1.03E-06	2.86E-06	-1.86E-06	-0.000145	-4.14E-05	-0.060122
	[-0.59594]	[1.12447]	[-0.34752]	[1.19438]	[0.13888]	[0.67154]	[-0.48149]	[-1.99073]	[-0.80130]	[-0.57114]
NIKK(-4)	-1.68E-06	-0.025881	-3.03E-07	-1.21E-05	2.23E-06	1.19E-07	1.51E-06	2.38E-05	-2.10E-05	0.065727
	[-0.35477]	[-0.74715]	[-0.82307]	[-2.05359]	[0.42700]	[0.03974]	[0.55556]	[0.46494]	[-0.57869]	[0.88797]
C	0.001318	221.7389	0.004641	-0.009540	0.006961	0.014183	0.012443	0.235339	0.455757	1040.279
	[0.06534]	[1.50187]	[2.96266]	[-0.37904]	[0.31208]	[1.11136]	[1.07272]	[1.07639]	[2.94588]	[3.29737]

We observe that S&P 350 and S&P 500 are affected negatively by the first lag of the 6 months future contract with coefficients of -0,183 and -0,162 respectively. European Union industrial production is affected positively by the first lag of the future contract with a coefficient of 2,513 and FED’s funds rate is affected positively by the second lag of the future contract.

The new element in this VAR is that the dry bulk index has a negative correlation to the fourth lag of the 6 months maturity future contract and has a coefficient of -1172,9. This translates to an increase of 1172,9 points in dry bulk index the current month if before 4 months the returns of the future contract had been decreased by one point.

Table 18

WTI 9 months maturity future contract price and macroeconomic factors

	DCL9	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DCL9(-1)	0.146175	-518.7767	0.003626	0.094359	-0.105524	-0.202549	-0.185839	2.766390	0.296797	-1591.981
	[1.86491]	[-0.80290]	[0.52857]	[0.85849]	[-1.07965]	[-3.61430]	[-3.65714]	[2.88443]	[0.43815]	[-1.15485]
DCL9(-2)	-0.053059	129.1127	0.001541	0.321459	-0.060733	0.099297	0.073101	0.204879	0.286712	-1082.225
	[-0.65507]	[0.19337]	[0.21735]	[2.83021]	[-0.60131]	[1.71463]	[1.39210]	[0.20672]	[0.40959]	[-0.75971]
DCL9(-3)	-0.038207	-256.8851	-0.006306	0.075438	0.016985	-0.067856	-0.011752	1.703389	-0.722511	54.64560
	[-0.46595]	[-0.38004]	[-0.87870]	[0.65608]	[0.16612]	[-1.15744]	[-0.22107]	[1.69775]	[-1.01957]	[0.03789]
DCL9(-4)	-0.033434	-1408.034	-0.003680	-0.038127	-0.093434	-0.058991	-0.016413	1.077008	-0.490004	-2320.378
	[-0.41532]	[-2.12178]	[-0.52235]	[-0.33775]	[-0.93077]	[-1.02492]	[-0.31449]	[1.09339]	[-0.70432]	[-1.63891]
BDI(-1)	2.00E-05	1.362140	-5.42E-07	3.01E-05	2.42E-05	1.30E-05	1.89E-05	2.08E-05	-8.18E-05	0.075197
	[2.11509]	[17.4886]	[-0.65508]	[2.27023]	[2.05185]	[1.92578]	[3.08639]	[0.18003]	[-1.00166]	[0.45252]
BDI(-2)	-2.26E-05	-0.486849	1.34E-06	-3.30E-05	-1.46E-05	-9.30E-06	-1.66E-05	3.38E-05	0.000150	0.177415
	[-1.46952]	[-3.84515]	[0.99792]	[-1.53171]	[-0.76329]	[-0.84692]	[-1.66810]	[0.17962]	[1.13198]	[0.65678]
BDI(-3)	1.18E-05	0.013269	9.95E-08	3.82E-05	-1.40E-05	-6.25E-06	-6.97E-07	6.53E-06	1.76E-06	-0.346515
	[0.78155]	[0.10702]	[0.07558]	[1.81120]	[-0.74774]	[-0.58082]	[-0.07150]	[0.03548]	[0.01351]	[-1.30995]
BDI(-4)	-6.98E-06	0.057016	-1.64E-06	-4.20E-05	1.85E-06	1.61E-06	-2.74E-06	-0.000121	-0.000146	0.069929
	[-0.72209]	[0.71509]	[-1.93864]	[-3.09370]	[0.15323]	[0.23329]	[-0.43648]	[-1.02310]	[-1.74065]	[0.41108]
DCAPUT(-1)	7.090269	98845.63	0.332712	10.72240	7.011065	-5.264916	-3.802094	47.56948	5.115310	-144252.4
	[1.69844]	[2.87235]	[0.91059]	[1.83166]	[1.34684]	[-1.76396]	[-1.40485]	[0.93127]	[0.14179]	[-1.96477]
DCAPUT(-2)	-7.896967	-18524.58	0.158127	-18.61103	-2.410706	-0.771560	-0.487816	-47.56608	0.485207	172602.3
	[-1.78322]	[-0.50744]	[0.40796]	[-2.99695]	[-0.43655]	[-0.24368]	[-0.16991]	[-0.87781]	[0.01268]	[2.21611]
DCAPUT(-3)	5.949484	-33576.03	0.073226	6.753297	-0.400297	-1.319887	0.761287	93.65856	-10.81879	-7594.519
	[1.34434]	[-0.92035]	[0.18904]	[1.08821]	[-0.07254]	[-0.41713]	[0.26534]	[1.72957]	[-0.28287]	[-0.09757]
DCAPUT(-4)	-1.955049	-2338.073	0.369317	7.193159	1.900082	5.764836	1.821874	-89.24342	10.14724	-30113.24
	[-0.48842]	[-0.07086]	[1.05414]	[1.28149]	[0.38067]	[2.01432]	[0.70205]	[-1.82209]	[0.29333]	[-0.42775]
DFEDR(-1)	0.066414	-618.8404	0.005298	-0.187859	0.015047	0.042983	0.058587	1.183931	0.463967	577.0489
	[1.38053]	[-1.56047]	[1.25818]	[-2.78471]	[0.25082]	[1.24966]	[1.87846]	[2.01127]	[1.11595]	[0.68202]
DFEDR(-2)	-0.003660	-66.56458	0.000893	0.252875	0.079607	0.120335	0.090927	0.944590	0.037149	1031.757
	[-0.07426]	[-0.16383]	[0.20702]	[3.65876]	[1.29527]	[3.41478]	[2.84560]	[1.56627]	[0.08721]	[1.19026]
DFEDR(-3)	-0.056334	345.9585	0.000631	0.012310	0.085514	0.018129	-0.010745	-0.239916	0.115661	544.3398
	[-1.18377]	[0.88190]	[0.15158]	[0.18447]	[1.44106]	[0.53282]	[-0.34827]	[-0.41202]	[0.28123]	[0.65039]
DFEDR(-4)	-0.028770	-958.1907	-0.002432	-0.167689	-0.006255	-0.053952	-0.042208	-0.030400	0.061316	246.3396
	[-0.61772]	[-2.49574]	[-0.59671]	[-2.56757]	[-0.10770]	[-1.62021]	[-1.39789]	[-0.05334]	[0.15234]	[0.30074]
DHASE(-1)	0.001958	728.0131	-0.002275	-0.122923	0.054477	0.009641	0.063696	-0.063122	-0.263233	-475.4293
	[0.02593]	[1.16950]	[-0.34417]	[-1.16082]	[0.57853]	[0.17857]	[1.30107]	[-0.06831]	[-0.40335]	[-0.35798]
DHASE(-2)	0.080920	-142.1309	0.002471	-0.029318	-0.006311	0.001622	-0.014719	-0.537243	0.191629	336.6073
	[1.07696]	[-0.22947]	[0.37580]	[-0.27826]	[-0.06736]	[0.03019]	[-0.30217]	[-0.58435]	[0.29511]	[0.25472]
DHASE(-3)	-0.061525	-132.4648	0.005461	-0.098559	-0.125792	-0.008800	-0.022751	-0.324695	0.491146	949.2370
	[-0.82184]	[-0.21465]	[0.83349]	[-0.93885]	[-1.34752]	[-0.16441]	[-0.46876]	[-0.35446]	[0.75914]	[0.72096]
DHASE(-4)	-0.003243	61.64001	0.005464	0.015171	-0.103017	0.021172	0.009923	0.597341	0.363181	770.6951
	[-0.04388]	[0.10119]	[0.84477]	[0.14641]	[-1.11800]	[0.40074]	[0.20714]	[0.66064]	[0.56870]	[0.59302]
DSP350(-1)	0.192260	-2130.257	0.005807	0.196726	-0.272683	-0.021254	0.050990	-1.209895	1.055319	820.0821

	[1.10327]	[-1.48292]	[0.38071]	[0.80504]	[-1.25486]	[-0.17059]	[0.45133]	[-0.56741]	[0.70073]	[0.26758]
DSP350(-2)	0.084292	957.3108	-0.001390	0.223405	0.084607	-0.138111	-0.072598	-0.151910	-0.477222	-1008.594
	[0.48562]	[0.66905]	[-0.09150]	[0.91785]	[0.39090]	[-1.11289]	[-0.64515]	[-0.07153]	[-0.31813]	[-0.33039]
DSP350(-3)	-0.029821	181.3032	0.016772	-0.021714	0.024866	0.011646	-0.078934	4.282082	1.687854	-442.9887
	[-0.17418]	[0.12846]	[1.11926]	[-0.09044]	[0.11647]	[0.09514]	[-0.71113]	[2.04401]	[1.14071]	[-0.14712]
DSP350(-4)	0.206393	-559.3339	-0.008763	0.249018	-0.122258	-0.110484	-0.183742	2.161680	-0.820063	3339.547
	[1.27003]	[-0.41753]	[-0.61610]	[1.09274]	[-0.60332]	[-0.95089]	[-1.74401]	[1.08711]	[-0.58390]	[1.16845]
DSP500(-1)	-0.136216	1031.023	0.001925	-0.091651	0.074674	0.197041	-0.089084	3.357954	0.019844	2433.418
	[-0.74164]	[0.68097]	[0.11975]	[-0.35585]	[0.32605]	[1.50048]	[-0.74814]	[1.49417]	[0.01250]	[0.75333]
DSP500(-2)	-0.077071	278.8925	0.010349	0.239127	-0.109957	0.178621	0.013234	3.464794	0.968007	-38.90492
	[-0.41373]	[0.18162]	[0.63476]	[0.91542]	[-0.47336]	[1.34111]	[0.10958]	[1.52006]	[0.60128]	[-0.01187]
DSP500(-3)	0.190134	-919.3366	0.014015	0.206623	0.080665	0.073041	0.124034	-2.065414	1.590273	202.0600
	[1.02892]	[-0.60352]	[0.86651]	[0.79738]	[0.35007]	[0.55284]	[1.03534]	[-0.91346]	[0.99579]	[0.06217]
DSP500(-4)	-0.231897	-781.0963	0.020458	-0.285145	0.173369	0.115788	0.135197	-1.862530	2.369862	-3427.820
	[-1.28896]	[-0.52667]	[1.29917]	[-1.13025]	[0.77279]	[0.90015]	[1.15913]	[-0.84607]	[1.52419]	[-1.08334]
INDPREU(-1)	-0.006260	87.73837	0.000241	0.006668	0.007936	0.000671	0.002536	-0.303219	0.036631	71.81831
	[-1.08678]	[1.84771]	[0.47714]	[0.82549]	[1.10485]	[0.16303]	[0.67904]	[-4.30197]	[0.73583]	[0.70890]
INDPREU(-2)	-0.001737	9.585786	0.000184	0.000608	-0.009120	-0.003700	-0.004329	0.123348	0.028075	-218.5985
	[-0.30306]	[0.20289]	[0.36649]	[0.07566]	[-1.27611]	[-0.90288]	[-1.16507]	[1.75884]	[0.56679]	[-2.16861]
INDPREU(-3)	0.002687	83.17903	0.000639	-0.004795	-0.002909	-0.000335	-0.000752	0.296394	0.053463	16.60233
	[0.47068]	[1.76768]	[1.27932]	[-0.59908]	[-0.40868]	[-0.08199]	[-0.20323]	[4.24353]	[1.08375]	[0.16537]
INDPREU(-4)	0.001229	85.01065	0.001313	-0.017738	-0.013811	-0.003358	-0.002607	0.057588	0.124787	108.8589
	[0.22136]	[1.85753]	[2.70211]	[-2.27847]	[-1.99502]	[-0.84592]	[-0.72425]	[0.84774]	[2.60085]	[1.11490]
INDPRUSA(-1)	-0.046981	-930.9919	-0.004867	-0.083443	-0.046824	0.061466	0.051771	-0.328409	-0.175624	1630.706
	[-1.10111]	[-2.64693]	[-1.30331]	[-1.39462]	[-0.88007]	[2.01489]	[1.87159]	[-0.62904]	[-0.47628]	[2.17310]
INDPRUSA(-2)	0.091807	235.6460	-0.000874	0.181081	0.031399	0.015957	0.013918	0.346559	0.059093	-1826.185
	[2.02362]	[0.63010]	[-0.22001]	[2.84638]	[0.55502]	[0.49193]	[0.47319]	[0.62430]	[0.15072]	[-2.28876]
INDPRUSA(-3)	-0.058263	430.3692	0.000761	-0.028773	0.000846	0.005084	-0.013557	-0.964821	0.240902	45.26943
	[-1.29137]	[1.15716]	[0.19273]	[-0.45480]	[0.01504]	[0.15761]	[-0.46348]	[-1.74770]	[0.61783]	[0.05705]
INDPRUSA(-4)	0.004644	-52.52232	-0.003071	-0.048907	-0.032552	-0.062964	-0.023159	0.859619	-0.040899	266.8887
	[0.11270]	[-0.15461]	[-0.85151]	[-0.84631]	[-0.63346]	[-2.13694]	[-0.86684]	[1.70475]	[-0.11484]	[0.36823]
NIKK(-1)	-6.06E-06	0.012242	-2.99E-07	5.94E-06	3.51E-06	-5.48E-07	-1.09E-06	-3.92E-05	-3.03E-05	0.901641
	[-1.35362]	[0.33146]	[-0.76310]	[0.94483]	[0.62902]	[-0.17108]	[-0.37477]	[-0.71499]	[-0.78377]	[11.4422]
NIKK(-2)	1.11E-05	-0.043982	6.60E-07	-3.90E-06	-5.20E-06	-3.13E-06	8.74E-07	0.000156	8.24E-05	0.023908
	[1.81843]	[-0.87319]	[1.23403]	[-0.45526]	[-0.68258]	[-0.71687]	[0.22067]	[2.08700]	[1.56111]	[0.22247]
NIKK(-3)	-4.03E-06	0.053928	-1.75E-07	1.07E-05	9.22E-07	2.80E-06	-1.84E-06	-0.000143	-4.09E-05	-0.060188
	[-0.67479]	[1.09601]	[-0.33502]	[1.28320]	[0.12382]	[0.65592]	[-0.47655]	[-1.96474]	[-0.79249]	[-0.57334]
NIKK(-4)	-1.05E-06	-0.024000	-3.07E-07	-1.22E-05	2.27E-06	2.10E-07	1.54E-06	2.38E-05	-2.10E-05	0.067449
	[-0.25038]	[-0.69373]	[-0.83674]	[-2.07384]	[0.43311]	[0.06999]	[0.56493]	[0.46297]	[-0.58008]	[0.91382]
C	0.003158	222.3700	0.004658	-0.010465	0.007140	0.014064	0.012293	0.233543	0.457242	1041.137
	[0.17657]	[1.50805]	[2.97513]	[-0.41721]	[0.32009]	[1.09966]	[1.06000]	[1.06702]	[2.95778]	[3.30945]

WTI 9 months future contract first lag affects negatively S&P 350 and S&P 500 with coefficients -0,202 and -0,186 respectively and affects positively European Union industrial production (first lag) and FED's funds rate (second lag) with coefficients of 2,726 and 0,321. As in the previous VAR its fourth lag also affects negatively dry bulk index with a coefficient of -1408.

A new element in this VAR is the effect that the second lag of US industrial production has on the 9 months future contract. We observe a positive coefficient of 0,092 which means that if US industrial production increased by one point the returns of the 9 months future contract will increase, after two months, by 0,092 and vice versa if US industrial production decreased. Also the first lag of dry bulk index affects positively the future contract with a very small coefficient due to the fact that we didn't take logarithmic returns because it was already stationary.

Table 19

WTI 12 months maturity future contract price and macroeconomic factors

	DCL12	BDI	DCAPUT	DFEDR	DHASE	DSP350	DSP500	INDPREU	INDPRUSA	NIKK
DCL12(-1)	0.132598	-589.7164	0.002928	0.076358	-0.116410	-0.204283	-0.190444	2.953274	0.213532	-2062.737
	[1.67585]	[-0.83489]	[0.39072]	[0.63657]	[-1.08899]	[-3.31537]	[-3.41101]	[2.81189]	[0.28862]	[-1.37122]
DCL12(-2)	-0.036884	41.50212	0.003462	0.372235	-0.063417	0.107483	0.077028	0.210704	0.459503	-1014.792
	[-0.45444]	[0.05728]	[0.45031]	[3.02515]	[-0.57833]	[1.70049]	[1.34493]	[0.19557]	[0.60546]	[-0.65762]
DCL12(-3)	-0.023867	-271.6720	-0.009684	0.113113	0.008239	-0.073427	-0.010125	1.942904	-1.030746	153.3629
	[-0.29101]	[-0.37105]	[-1.24662]	[0.90974]	[0.07436]	[-1.14965]	[-0.17496]	[1.78465]	[-1.34407]	[0.09835]
DCL12(-4)	-0.024470	-1601.050	-0.003655	-0.032039	-0.113126	-0.060326	-0.021229	1.038555	-0.528159	-2834.833
	[-0.30315]	[-2.22186]	[-0.47803]	[-0.26182]	[-1.03734]	[-0.95968]	[-0.37272]	[0.96928]	[-0.69977]	[-1.84721]
BDI(-1)	2.00E-05	1.362681	-5.23E-07	3.13E-05	2.42E-05	1.24E-05	1.85E-05	2.29E-05	-7.97E-05	0.087799
	[2.28241]	[17.4530]	[-0.63104]	[2.36441]	[2.04829]	[1.82418]	[3.00131]	[0.19767]	[-0.97467]	[0.52801]
BDI(-2)	-2.26E-05	-0.486161	1.26E-06	-3.54E-05	-1.48E-05	-8.73E-06	-1.62E-05	2.96E-05	0.000143	0.156905
	[-1.59559]	[-3.83892]	[0.94129]	[-1.64621]	[-0.77283]	[-0.79057]	[-1.61556]	[0.15706]	[1.07794]	[0.58176]
BDI(-3)	1.10E-05	0.013065	2.33E-07	3.80E-05	-1.35E-05	-6.34E-06	-9.13E-07	5.78E-06	1.36E-05	-0.340546
	[0.79230]	[0.10552]	[0.17772]	[1.80527]	[-0.71954]	[-0.58681]	[-0.09333]	[0.03139]	[0.10509]	[-1.29145]
BDI(-4)	-6.05E-06	0.057787	-1.71E-06	-4.10E-05	1.69E-06	1.76E-06	-2.52E-06	-0.000121	-0.000151	0.076245
	[-0.67799]	[0.72580]	[-2.02150]	[-3.02877]	[0.14048]	[0.25357]	[-0.40060]	[-1.01894]	[-1.81039]	[0.44965]
DCAPUT(-1)	6.928441	98332.53	0.319412	10.92402	6.877785	-5.500392	-3.948559	49.63869	4.109350	-143004.6
	[1.80475]	[2.86921]	[0.87844]	[1.87697]	[1.32606]	[-1.83981]	[-1.45759]	[0.97408]	[0.11448]	[-1.95927]
DCAPUT(-2)	-7.576056	-17346.24	0.171120	-18.73367	-2.308174	-0.515947	-0.344971	-52.05092	1.661742	172650.0
	[-1.85794]	[-0.47652]	[0.44307]	[-3.03043]	[-0.41897]	[-0.16248]	[-0.11989]	[-0.96164]	[0.04358]	[2.22698]
DCAPUT(-3)	4.618348	-32586.99	0.066304	6.207935	-0.246089	-1.285125	0.820356	94.06942	-11.47562	-7745.224
	[1.12897]	[-0.89233]	[0.17113]	[1.00101]	[-0.04453]	[-0.40340]	[0.28419]	[1.73236]	[-0.30001]	[-0.09958]
DCAPUT(-4)	-1.001626	-3123.775	0.386029	7.524363	1.864249	5.703699	1.745746	-88.62023	11.63598	-29170.10
	[-0.27112]	[-0.09471]	[1.10320]	[1.34343]	[0.37350]	[1.98247]	[0.66965]	[-1.80709]	[0.33684]	[-0.41529]
DFEDR(-1)	0.066040	-591.5725	0.005697	-0.189560	0.018026	0.044651	0.059866	1.150966	0.506594	626.3542
	[1.48073]	[-1.48581]	[1.34868]	[-2.80358]	[0.29916]	[1.28560]	[1.90224]	[1.94415]	[1.21477]	[0.73868]
DFEDR(-2)	-0.004678	-35.74825	0.000879	0.249831	0.083771	0.119604	0.091772	0.949553	0.041064	1126.927
	[-0.10241]	[-0.08766]	[0.20304]	[3.60746]	[1.35734]	[3.36207]	[2.84700]	[1.56594]	[0.09614]	[1.29754]
DFEDR(-3)	-0.057210	336.0490	0.000575	0.008159	0.084909	0.016394	-0.011676	-0.222998	0.109643	518.6175
	[-1.30367]	[0.85779]	[0.13844]	[0.12264]	[1.43212]	[0.47971]	[-0.37705]	[-0.38281]	[0.26720]	[0.62159]
DFEDR(-4)	-0.025182	-960.3440	-0.002340	-0.172560	-0.006037	-0.053588	-0.042274	-0.029066	0.068816	214.3715
	[-0.58444]	[-2.49666]	[-0.57336]	[-2.64169]	[-0.10370]	[-1.59702]	[-1.39039]	[-0.05082]	[0.17080]	[0.26168]
DHASE(-1)	0.002432	731.1015	-0.002678	-0.116516	0.051416	0.007921	0.062982	-0.011198	-0.294684	-496.6986
	[0.03502]	[1.17960]	[-0.40724]	[-1.10702]	[0.54816]	[0.14651]	[1.28560]	[-0.01215]	[-0.45393]	[-0.37629]
DHASE(-2)	0.080348	-143.0479	0.002634	-0.029416	-0.006679	0.002379	-0.014501	-0.538432	0.203628	281.6103
	[1.16166]	[-0.23167]	[0.40214]	[-0.28054]	[-0.07148]	[0.04417]	[-0.29711]	[-0.58645]	[0.31485]	[0.21415]
DHASE(-3)	-0.073534	-139.1869	0.005581	-0.100430	-0.123698	-0.010363	-0.022431	-0.301336	0.502404	989.8929
	[-1.06684]	[-0.22620]	[0.85487]	[-0.96110]	[-1.32832]	[-0.19306]	[-0.46119]	[-0.32935]	[0.77952]	[0.75537]
DHASE(-4)	0.003507	56.44574	0.005133	0.011091	-0.104013	0.017981	0.008248	0.658459	0.333393	745.0334
	[0.05140]	[0.09267]	[0.79434]	[0.10722]	[-1.12835]	[0.33841]	[0.17132]	[0.72702]	[0.52257]	[0.57433]
DSP350(-1)	0.182364	-2168.202	0.006126	0.176855	-0.271002	-0.017486	0.051843	-1.311880	1.062179	697.2698

	[1.13788]	[-1.51545]	[0.40357]	[0.72790]	[-1.25160]	[-0.14010]	[0.45842]	[-0.61666]	[0.70879]	[0.22883]
DSP350(-2)	0.102266	947.0188	-0.001082	0.231775	0.084179	-0.143306	-0.076731	-0.145191	-0.439955	-854.6272
	[0.64019]	[0.66408]	[-0.07151]	[0.95706]	[0.39004]	[-1.15196]	[-0.68071]	[-0.06847]	[-0.29454]	[-0.28139]
DSP350(-3)	-0.009972	260.7383	0.016257	-0.020679	0.027106	0.020596	-0.073563	4.123967	1.647695	-374.8925
	[-0.06328]	[0.18536]	[1.08930]	[-0.08656]	[0.12733]	[0.16784]	[-0.66159]	[1.97163]	[1.11830]	[-0.12514]
DSP350(-4)	0.158743	-541.2262	-0.008683	0.234626	-0.119543	-0.109903	-0.184172	2.088768	-0.819535	3320.708
	[1.05911]	[-0.40449]	[-0.61167]	[1.03256]	[-0.59033]	[-0.94157]	[-1.74134]	[1.04985]	[-0.58476]	[1.16530]
DSP500(-1)	-0.128306	1034.058	0.002674	-0.097157	0.083497	0.197369	-0.087167	3.307459	0.089258	2640.441
	[-0.75745]	[0.68381]	[0.16665]	[-0.37833]	[0.36485]	[1.49618]	[-0.72924]	[1.47095]	[0.05635]	[0.81987]
DSP500(-2)	-0.106526	308.7518	0.009248	0.232968	-0.109401	0.180301	0.016001	3.461102	0.875041	22.43315
	[-0.62025]	[0.20137]	[0.56848]	[0.89475]	[-0.47148]	[1.34805]	[0.13203]	[1.51817]	[0.54488]	[0.00687]
DSP500(-3)	0.160633	-948.9703	0.014658	0.213503	0.075525	0.068123	0.116408	-2.018403	1.644469	116.8120
	[0.94239]	[-0.62364]	[0.90792]	[0.82622]	[0.32796]	[0.51320]	[0.96782]	[-0.89207]	[1.03178]	[0.03605]
DSP500(-4)	-0.188323	-766.8641	0.020620	-0.257679	0.169648	0.111363	0.130749	-1.768268	2.397660	-3334.782
	[-1.13490]	[-0.51767]	[1.31195]	[-1.02430]	[0.75672]	[0.86178]	[1.11662]	[-0.80278]	[1.54527]	[-1.05702]
INDPREU(-1)	-0.005480	89.65377	0.000229	0.006481	0.007985	0.000578	0.002513	-0.301438	0.036084	72.63441
	[-1.03211]	[1.89141]	[0.45623]	[0.80513]	[1.11312]	[0.13981]	[0.67066]	[-4.27687]	[0.72679]	[0.71951]
INDPREU(-2)	-0.001928	10.34729	0.000189	-5.09E-06	-0.008985	-0.003569	-0.004213	0.122302	0.028513	-221.0001
	[-0.36475]	[0.21925]	[0.37794]	[-0.00063]	[-1.25800]	[-0.86703]	[-1.12949]	[1.74283]	[0.57681]	[-2.19878]
INDPREU(-3)	0.002835	82.80090	0.000667	-0.004680	-0.002751	-0.000290	-0.000701	0.295823	0.056101	20.76978
	[0.53796]	[1.75980]	[1.33644]	[-0.58576]	[-0.38635]	[-0.07058]	[-0.18850]	[4.22835]	[1.13835]	[0.20727]
INDPREU(-4)	0.001209	85.75367	0.001292	-0.017565	-0.013698	-0.003180	-0.002416	0.056417	0.123035	113.4898
	[0.23607]	[1.87502]	[2.66310]	[-2.26155]	[-1.97899]	[-0.79707]	[-0.66823]	[0.82961]	[2.56839]	[1.16517]
INDPRUSA(-1)	-0.046743	-928.0451	-0.004719	-0.085269	-0.045751	0.064152	0.053444	-0.352416	-0.164300	1610.327
	[-1.19078]	[-2.64832]	[-1.26936]	[-1.43286]	[-0.86267]	[2.09857]	[1.92944]	[-0.67634]	[-0.44763]	[2.15771]
INDPRUSA(-2)	0.087628	224.6963	-0.001002	0.182976	0.030459	0.013029	0.012266	0.394680	0.047652	-1818.385
	[2.09785]	[0.60258]	[-0.25336]	[2.88949]	[0.53973]	[0.40052]	[0.41616]	[0.71182]	[0.12200]	[-2.28971]
INDPRUSA(-3)	-0.045196	420.7263	0.000820	-0.023155	-0.000943	0.004463	-0.014341	-0.966930	0.246932	43.82604
	[-1.08381]	[1.13014]	[0.20768]	[-0.36625]	[-0.01673]	[0.13744]	[-0.48735]	[-1.74677]	[0.63327]	[0.05528]
INDPRUSA(-4)	-0.004205	-43.93711	-0.003229	-0.053169	-0.031978	-0.062357	-0.022400	0.852879	-0.055329	254.7973
	[-0.11051]	[-0.12936]	[-0.89608]	[-0.92180]	[-0.62211]	[-2.10458]	[-0.83436]	[1.68876]	[-0.15553]	[0.35224]
NIKK(-1)	-5.54E-06	0.013363	-2.97E-07	6.61E-06	3.48E-06	-3.46E-07	-9.42E-07	-4.08E-05	-2.96E-05	0.904490
	[-1.33931]	[0.36199]	[-0.75786]	[1.05424]	[0.62330]	[-0.10731]	[-0.32287]	[-0.74279]	[-0.76565]	[11.5045]
NIKK(-2)	1.00E-05	-0.044691	6.35E-07	-4.72E-06	-5.14E-06	-3.28E-06	7.92E-07	0.000158	7.93E-05	0.019517
	[1.77820]	[-0.88758]	[1.18849]	[-0.55187]	[-0.67403]	[-0.74709]	[0.19890]	[2.11161]	[1.50434]	[0.18200]
NIKK(-3)	-3.74E-06	0.050857	-1.35E-07	1.11E-05	7.40E-07	2.59E-06	-2.03E-06	-0.000143	-3.73E-05	-0.060506
	[-0.67801]	[1.03322]	[-0.25901]	[1.32632]	[0.09931]	[0.60314]	[-0.52277]	[-1.95562]	[-0.72256]	[-0.57719]
NIKK(-4)	-8.60E-07	-0.021449	-3.24E-07	-1.23E-05	2.40E-06	3.66E-07	1.66E-06	2.30E-05	-2.23E-05	0.069188
	[-0.22162]	[-0.61950]	[-0.88274]	[-2.09903]	[0.45794]	[0.12126]	[0.60684]	[0.44759]	[-0.61480]	[0.93832]
C	0.003991	224.2440	0.004669	-0.011475	0.007411	0.014074	0.012264	0.231000	0.458269	1042.837
	[0.24180]	[1.52188]	[2.98675]	[-0.45857]	[0.33236]	[1.09492]	[1.05295]	[1.05434]	[2.96933]	[3.32317]

We observe that S&P 350 and S&P 500 are affected by the first lag of the 12 months future contract negatively with coefficients -0,204 and -0,190 while European Union industrial production (first lag) and FED's funds rate (second lag) are affected positively with coefficients 2,953 and 0,372 respectively. Dry bulk index is affected negatively with coefficient -1601 and affects positively dcl12. Also as in the previous VAR, the second lag of US industrial production affects the WTI contract positively and has a coefficient of 0,087.

3.3 Impulse response results

In appendix B we present analytically the results of impulse response analysis. The returns of S&P 500 and S&P 350 have almost identical impulse responses. They react negatively contemporaneously and in the first lag to an oil price increase, until the 3 months maturity contract. From the 6 months maturity contract and on, they react positively contemporaneously and negatively in the first lag. They revert to their mean non monotonically in about 8 periods.

Federal reserve funds rate reacts positively contemporaneously and for the first two lags for all maturities. We observe a higher responsiveness as maturity of the futures contracts increases. This is consistent with the idea that FED uses long maturity oil contracts as predictors of real economic activity. It returns to each mean non monotonically in about 12 periods.

European union industrial production is affected positively contemporaneously and at the first lag by oil price shocks at all futures contracts maturities. Then it reverts to each mean monotonically after about 12 periods.

3.4 Variance decomposition results

In order to avoid quoting too many variance decomposition tables we present a concise table below which shows the variance of S&P 500, S&P 350, FED's funds rate and EU industrial production, that is caused by the oil spot and futures prices variance after 10 periods. In other words the values of the table are the contribution of the oil variables to the total variance of these four macroeconomic factors after an innovation shock on the relative equations. They are expressed in percentage points. Note that we also quote the variance of S&P 500 which caused by FED's funds rate in order to conclude about the effect of oil price changes to the four macroeconomic variables, relatively to the effect of FED's funds rate changes and compare our results with other studies.

The first observation which also confirms the results of impulse response analysis is that the contribution of oil variance to the total variance of FED's rate increases as maturity of oil variables increases. This is consistent, as we also note in impulse response analysis, with the fact that FED uses long maturity oil futures as predictors of future economic activity and adapt its monetary policy accordingly. The variance of the 12 months maturity contract is 9.22 which is quite high. The same happens in EU industrial production but we can't be sure about the reasons.

The variance of oil variables to the total variance of S&P 500 and S&P 350 is also significant and it ranges from 4.26 to 5.94. Also from table 18 we can see that the effect of oil price changes in S&P 500 is bigger than the effect of interest rates changes which is in agreement with the studies of Park and Ratti (2007). Cong, Wei, Jiao and Fan (2008) found that the same is true for Chinese stock market returns.

The variance decomposition of the oil variables in the six VAR models shows that the greater percentage change in total variance comes from the oil variables themselves and that none of the macroeconomic factors has a great contribution except from the dry bulk index which reaches 5.52% and capacity utilization which reaches 5.22%, in the 9 and 12 months maturity contracts.

Table 20

Variance decomposition

	S&P 500		*S&P 350*	*FED's interest rate*	*EU industrial production*
	oil	FED's interest rate			
spot	4.49	2.87	5.49	4.60	6.09
1 month	4.26	2.90	5.63	4.68	6.24
3 months	5.13	2.78	5.85	5.16	6.89
6 months	5.59	3.07	5.47	6.65	7.84
9 months	5.94	3.40	5.11	8.17	8.27
12 months	5.59	3.67	4.59	9.22	8.54

3.5 Vector Autoregression Conclusions-Remarks

According to the VAR estimations WTI spot and futures prices are affecting positively the Federal Funds rate and European industrial production and negatively S&P 500 and S&P 350 but without bidirectional interactions. The last three future contracts (6,9,12 months) affect also negatively the dry bulk index. The 9 and 12 contracts are affected by the second lag of US industrial production. Below is a concise table of the aforementioned results.

Table 21

VAR results with statistical significant lags

dfedr	*is affected by* →	dspot(-2)	dcl1(-2)	dcl3(-2)	dcl6(-2)	dcl9(-2)	dcl12(-2)	
coefficient		0.147	0.152	0.189	0.259	0.321	0.372	
dsp350	*is affected by* →	dspot(-1)	dcl1(-1)	dcl3(-1)	dcl6(-1)	dcl9(-1)	dcl12(-1)	
coefficient		-0.128	-0.131	-0.158	-0.183	-0.202	-0.204	
dsp500	*is affected by* →	dspot(-1)	dcl1(-1)	dcl3(-1)	dcl6(-1)	dcl9(-1)	dcl12(-1)	
coefficient		-0.105	-0.105	-0.132	-0.162	-0.186	-0.190	
indpreu	*is affected by* →	dspot(-1)	dcl1(-1)	dcl3(-1)	dcl6(-1)	dcl9(-1)	dcl12(-1)	
coefficient		1.817	1.854	2.105	2.513	2.726	2.953	
bdi	*is affected by* →				dcl6(-4)	dcl9(-4)	dcl12(-4)	
coefficient					-1172.9	-1408	-1601	
dcl9	*is affected by* →						bdi(-1)	indprusa(-2)
coefficient							0.00002	0.092
dcl12	*is affected by* →						bdi(-1)	indprusa(-2)
coefficient							0.00002	0.087

We can see a solid correlation among these variables which gets stronger as the maturity increases relatively to FED's funds rate. This is also evident at the impulse response analysis in appendix B. We observe that 1 standard deviation shock at the variable causes a relative small disturbance at short maturities which is gradually increases as we approach the 12 months maturity contract and after about 12 periods the variable returns to its mean value.

Regarding FED's funds rate and European industrial production the positive correlation denotes that in upward or downward economic cycles these move in tandem with oil prices. In an anodic cycle world economy consumes more and more oil and the higher oil prices seem to precede EU industrial production by one month which is not according to our expectations. We would expect a decline in EU industrial production due to higher input costs. Maybe this is a result of late responsiveness of EU industrial production to oil prices but there is no proof for this. On the other hand FED rises interest rates in order to cool down the overheating economy and avoid bubbles and these result is in full accordance to the results of Park and Ratti (2007) and Sadorsky (1999), not only relatively to the positive sign of correlation but also relatively to the lags.

In accordance to our expectations and relative literature the negative coefficients of S&P 500 and S&P 350 can be attributed to the negative effects that rising oil prices have in the production procedure due to higher production input costs and generally GDP. We have already referred to some studies that examine the exact decrease in GDP which caused by a rise in oil prices. Our VAR results for these two indices are also coincide to those of Park and Ratti (2007) regarding the sign of the relation and the lags.

The negative coefficient of the effect of oil price to dry bulk index was more or less expected because as it has been said rising oil prices cause decline in world GDP and that is transformed into lower demand for cargo transfers and accordingly freights. Dry bulk index is affected only by 6, 9 and 12 months maturity futures contracts and this suggests, that the relationship between them incorporates expectations about future oil prices. The expectations about the opposite direction are confirmed and we conclude that a rise in dry bulk index precedes a rise in 9 and 12 months maturity oil contracts with one month lag.

From the aspect of the impact of macroeconomic factors to oil variables we observe that the second lag of US industrial production precedes rising prices in future contracts of 9 and 12 months maturity. This at first glance can be attributed to increased oil consumption and demand from industrial companies but maybe it is also a result of hedging in order to anticipate higher oil price in the future.

Relatively to Hang Seng, we find no evidence of interaction with oil variables. Maybe this is a result of inefficiencies in the Chinese stock market due to Government interference which causes non-responsiveness. One field of interference might be the exchange rate policy which doesn’t allow yen to revaluate relatively to the dollar. So without revaluation the capacity of Chinese economy to import more oil is confined. The lack of interaction between the Chinese stock market and oil price changes is in agreement with the study of Cong, Wei, Jiao and Fan (2008).

Nikkei also shows unresponsiveness to change in oil prices and maybe this can be attributed to the stagnancy of the Japanese economy from the ‘90s and onwards. In econometric analysis it is very rare to find a stock exchange index to be stationary but this is the case for Nikkei. So an index that doesn’t present high movability for almost two decades maybe is less responsive to oil price changes.

Another finding that we came across in this thesis and was unexpected, is that the explicative power of WTI oil futures, at least relatively to the certain macroeconomic variables, is increasing as the maturity of contracts increasing. We observe from table 18 that the statistical significant coefficients between the variables are increasing following maturity. There are explicit graphic depictions of this finding in appendix C. A possible explanation is that greater maturities of WTI futures are better predictors of macroeconomic variables than earlier maturities but this is something that needs further investigation.

References

O. Blanchard-J. Gali (2007). The macroeconomic effects of oil price shocks: why are 2000s so different from the 1970?

Jianjun Cui (2007). Analysis on the oil price mechanism and its fluctuation.

Demirer Riza-Kutan Ali (2010). The behavior of crude oil spot and futures prices around OPEC and SPR announcements: An event study perspective.

Bahram Adranzi, Arjun Chatrath, Kanwalroop Kathy Dhanda, Kambiz Raffiee (2001). Chaos in oil prices? Evidence from futures markets, *energy economics 23(2001) 405-425.*

Mikael Hook, Robert Hirsch, Kjell Aleklett (2008). Giant oil field decline rates and their influence in world oil production.

Ferdinand E. Banks (1991). 'Paper' oil, 'real' oil and the price of oil, *energy policy July/August 1991.*

International Energy Agency, May 2004. Analysis of the impact of high oil prices on the global economy.

Nick A. Owen, Oliver R. Inderwildi, David A. King (2010). The status of conventional oil reserves-Hype or cause for concern, *energy policy 38 (2010) 4743-4729.*

Kjell Aleklett, Mikael Hook, Kristofer Jakobsson, Michael Lardelli, Simon Snowden, Bengt Soderbergh (2009). The peak oil age-Analyzing the world oil production reference scenario in world energy outlook 2008, *energy policy 38 (2010) 1398-1414.*

Sharon Xiaowen Lin, Michael N. Tamvakis (2001). Spillover effects in energy futures markets, *energy economics 23 (2001) 43-56.*

Sveltlana Maslyuk, Russel Smyth (2007). Unit root properties of crude oil spot and futures prices, *energy policy 36 (2008) 2591-2600.*

Kevin L. Kliesen (2008). Oil & US macroeconomy: An update and a simple forecasting exercise, *Federal Reserve Bank of St. Louis review September/October 2008 pp. 505-516.*

J. Isaac Miller, Ronald S. Ratti (2008). Crude oil and stock markets: Stability, instability and bubbles, *energy economics 36 (2009) 559-568.*

George Filis (2009). Macroeconomy, stock market and oil prices: Do meaningful relationships exist among their cyclical fluctuations? *Energy economics 32 (2010) 877-886.*

William E. Shambora, Rosemary Rossiter (2007). Are there exploitable inefficiencies in the futures market for oil? *Energy economics 29 (2007) 18-27.*

Thalia Chanziara, George Skiadopoulos (2006). Can the dynamics of the term structure of petroleum futures be forecasted? Evidence from major markets.

Sveltlana Maslyuk, Russell Smyth (2008). Cointegration between oil spot and futures prices of the same and different grades in the presence of structural change, energy policy 37 (2009) 1687-1693.

S. Gurcan Gulen (1998). Efficiency in the crude oil futures market.

Alessandro Lanza, Matteo Manera, Michael Mc Aleer (2006). Modeling dynamic conditional correlations in WTI oil forward and futures returns, *finance research letters 3 (2006) 114-132.*

Robert Kaufmann, Ben Ullman (2008). Oil prices, speculation and fundamentals: Interpreting causal relations among spot and futures prices, *energy economics 31 (2009) 550-558.*

Salah Abosedra, Hamid Baghestani (2004). On the predictive accuracy of crude oil futures prices, energy *policy 32 (2004) 1389-1393.*

Stelios Bekiros, Cees Diks (2007). The relationship between crude oil spot and futures prices: Cointegration, linear and nonlinear causality, *energy economics 30 (2008) 2673-2685.*

Gonzalo Cortazar, Eduardo Schwartz (2002). Implementing a stochastic model for oil futures prices.

Ron Alquist, Lutz Kilian (2008). What do we learn from the price of crude oil futures?

Cetin Ciner (2001). Information content of volume: An investigation of Tokyo commodity futures markets, Pacific-*basin finance journal 10 (2002) 201-215.*

Ronald Ripple, Imad Moosa (2007). The effect of maturity, trading volume and open interest on crude oil futures price range-based volatility.

Perry Sadorsky (2000). The empirical relationship between energy futures prices and exchange rates, *energy economics 22 (2000) 253-266.*

Cong R.G., Wei Y.M., Jiao J.L., Fan Y. (2008). Relationships between oil price shocks and stock market. An empirical analysis from China, *energy policy 36 (2008) 3544-3553.*

Gogineni S. (2010). Oil and stock market: An industry level analysis.

Park J., Ratti R. (2007). Oil price shocks and stock markets in the US and 13 European countries.

Samuel Imarhiagbe (2010). Impact of oil prices on stock markets: Empirical evidence from selected major oil producing and consuming countries, *global journal of finance and banking issues Vol. 4 (2010).*

Perry Sadorsky (1999). Oil price shocks and stock market activity, *energy economics 21 (1999) 449-469.*

Shawkat Hammoudeh, Eisa Aleisa (2002). Dynamic relationships among GCC stock markets and NYMEX oil futures.

William E. Shambora, Rosemary Rossiter (2004). Are there exploitable inefficiencies in the futures market for oil? *Energy economics 29 (2007) 18-27.*

Appendix A

Unit root test for EU industrial production

Null Hypothesis: INDPREU has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-4.657159	0.0001
Test critical values:	1% level	-3.457286	
	5% level	-2.873289	
	10% level	-2.573106	

Unit root test for US industrial production

Null Hypothesis: INDPRUSA has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-5.179960	0.0000
Test critical values:	1% level	-3.457286	
	5% level	-2.873289	
	10% level	-2.573106	

Unit root test for Nikkei index

Null Hypothesis: NIKK has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-3.949814	0.0020
Test critical values:	1% level	-3.457061	
	5% level	-2.873190	
	10% level	-2.573054	

Unit root test for Dry Bulk index

Null Hypothesis: BDI has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-3.168715	0.0231
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI future 1 month maturity

Null Hypothesis: CL1 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.811255	0.3745
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI future 3 months maturity

Null Hypothesis: CL3 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.720107	0.4199
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI future 6 months maturity

Null Hypothesis: CL6 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.630197	0.4656
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI future 9 months maturity

Null Hypothesis: CL9 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.536655	0.5135
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI future 12 months maturity

Null Hypothesis: CL12 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.445769	0.5595
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for WTI spot price

Null Hypothesis: SPOT has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.804083	0.3780
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for US capacity utilization

Null Hypothesis: CAPUT has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-2.300324	0.1727
Test critical values:	1% level	-3.457515	
	5% level	-2.873390	
	10% level	-2.573160	

Unit root test for FED's funds rate

Null Hypothesis: FEDR has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-2.452849	0.1285
Test critical values:	1% level	-3.457400	
	5% level	-2.873339	
	10% level	-2.573133	

Unit root test for Hang Seng index

Null Hypothesis: HASE has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.686958	0.4366
Test critical values:	1% level	-3.457061	
	5% level	-2.873190	
	10% level	-2.573054	

Unit root test for S&P 350 index

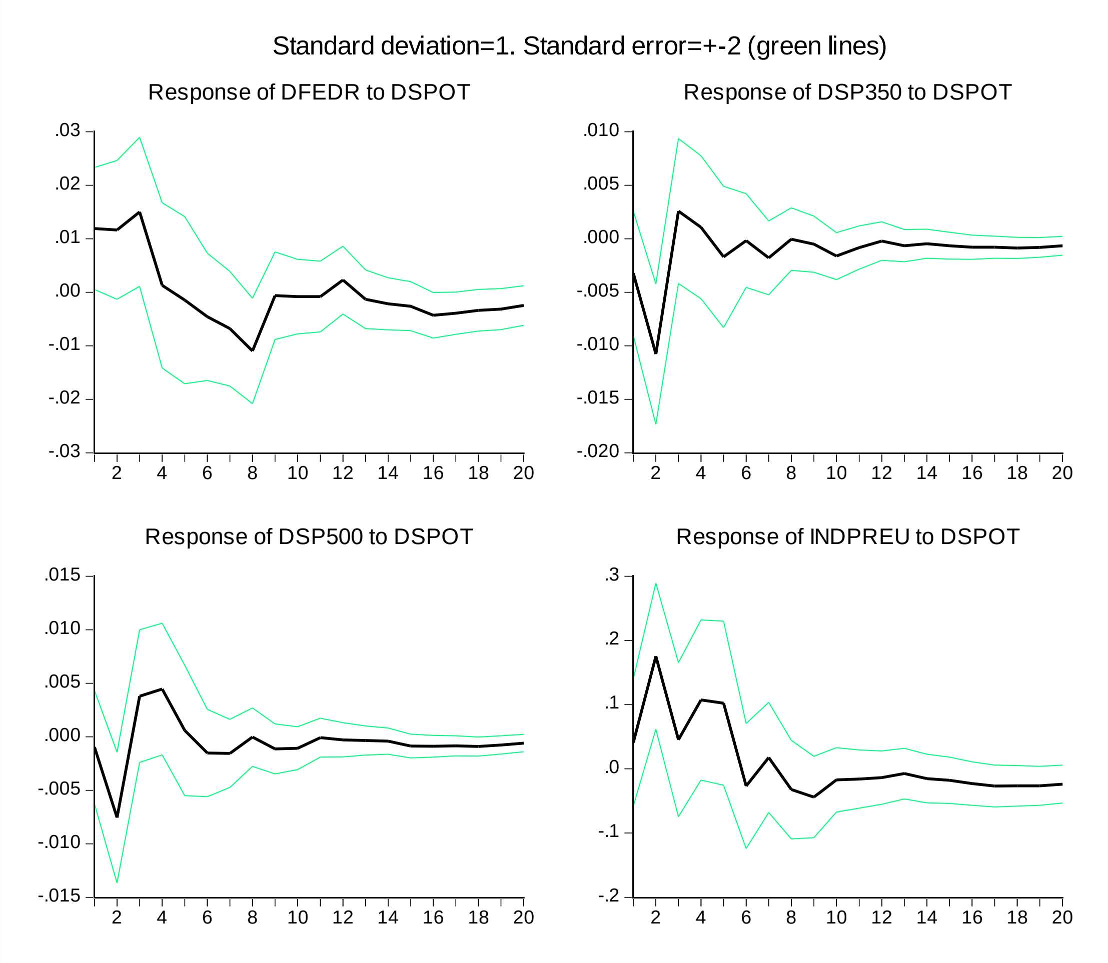
Null Hypothesis: SP350 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.546768	0.5083
Test critical values:	1% level	-3.457173	
	5% level	-2.873240	
	10% level	-2.573080	

Unit root test for S&P 500 index

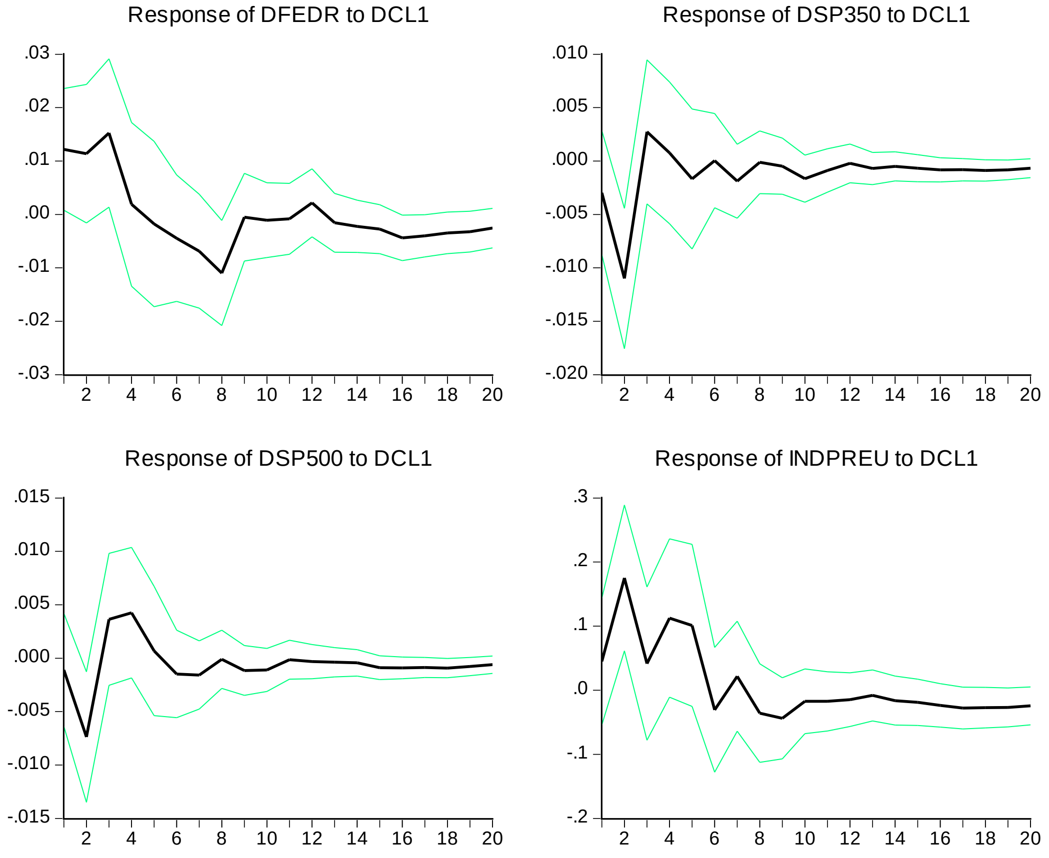
Null Hypothesis: SP500 has a unit root			
		t-Statistic	Prob.
Augmented Dickey-Fuller test statistic		-1.563256	0.4999
Test critical values:	1% level	-3.457061	
	5% level	-2.873190	
	10% level	-2.573054	

Appendix B

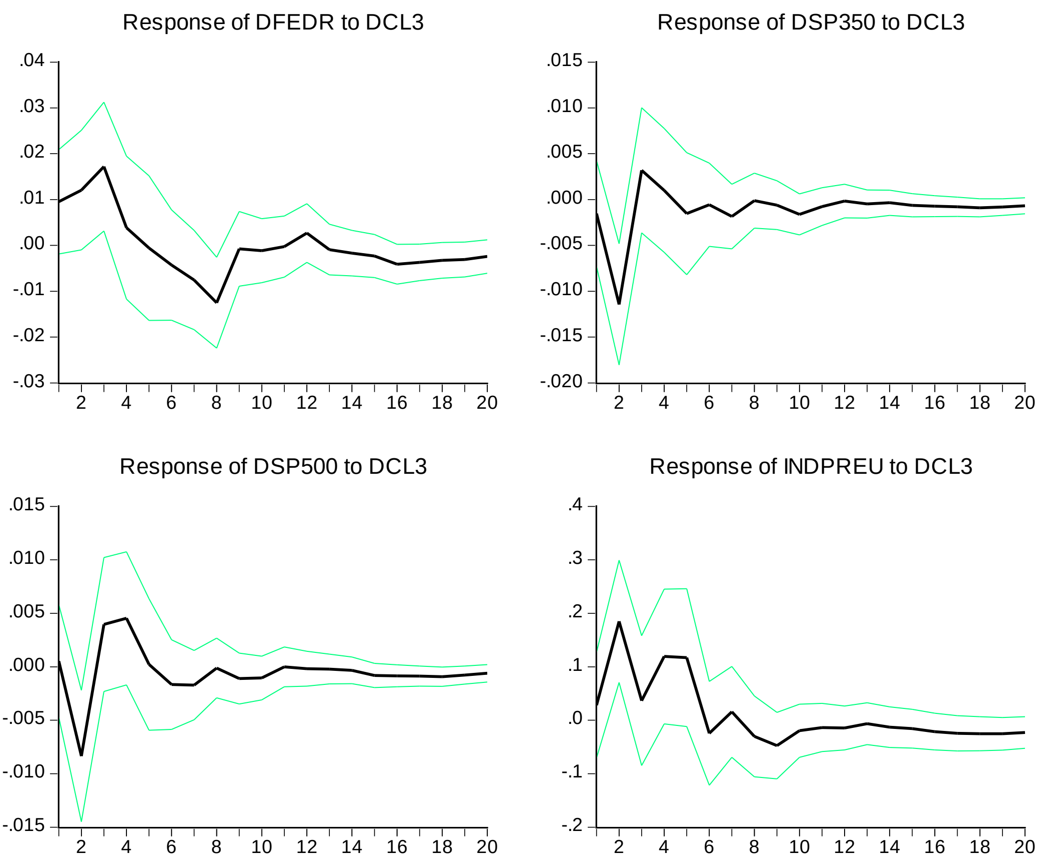
Response of macroeconomic variables to spot oil price



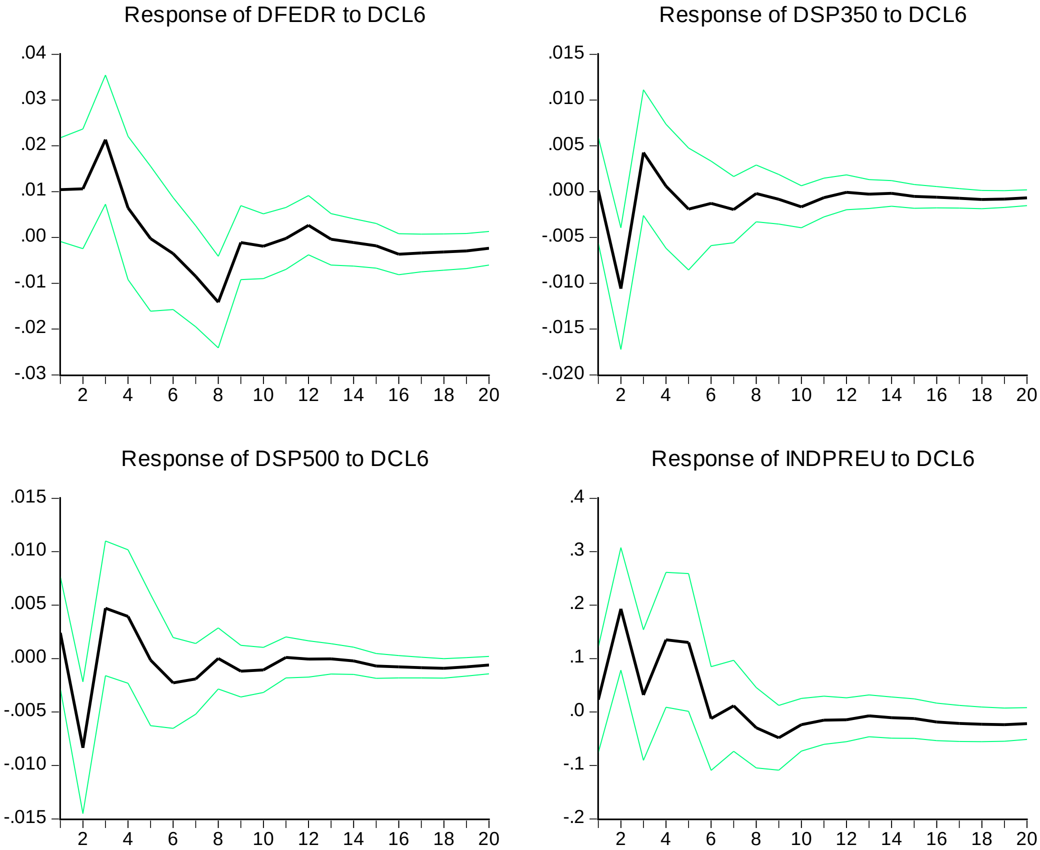
Response of macroeconomic variables to 1 month maturity future



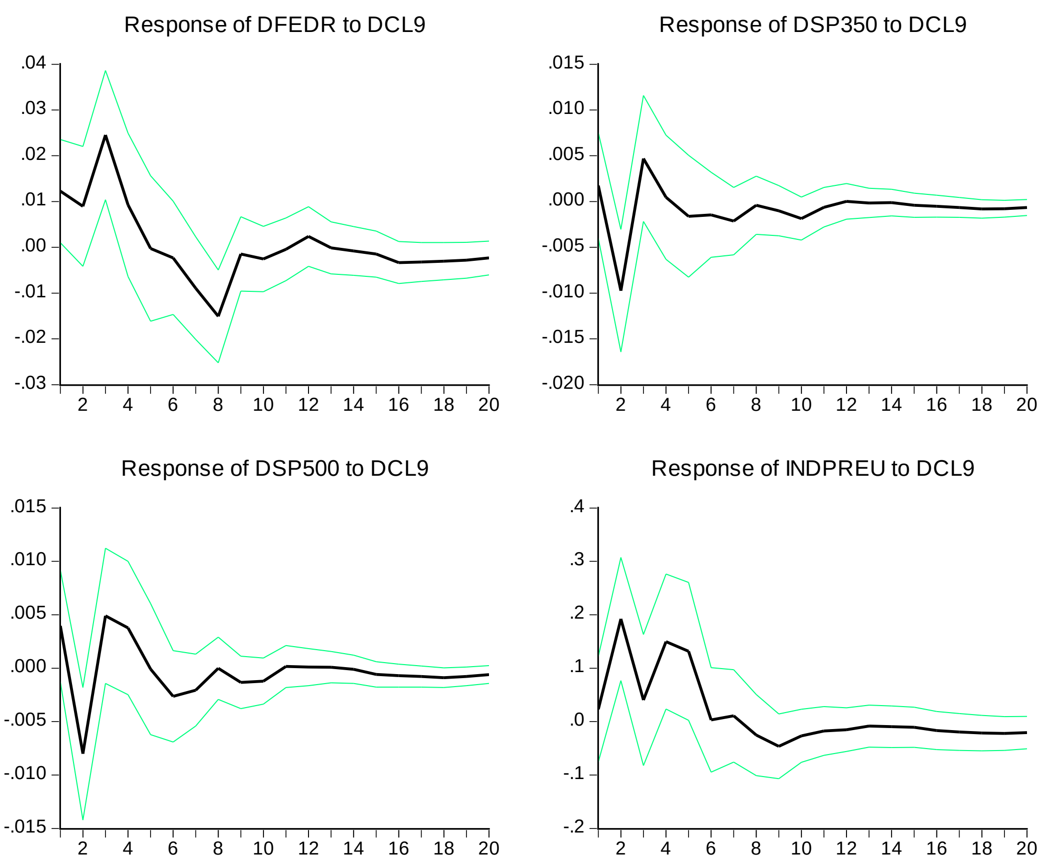
Response of macroeconomic variables to 3 months maturity future



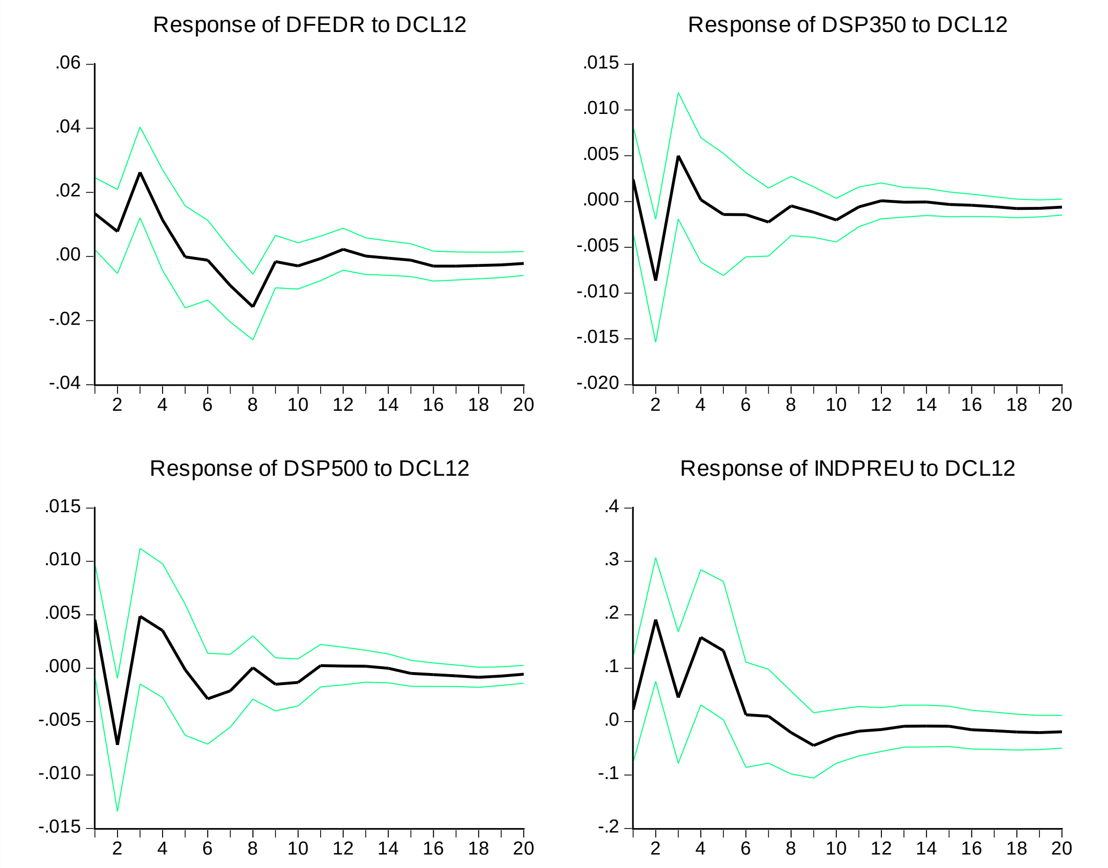
Response of macroeconomic variables to 6 months maturity future



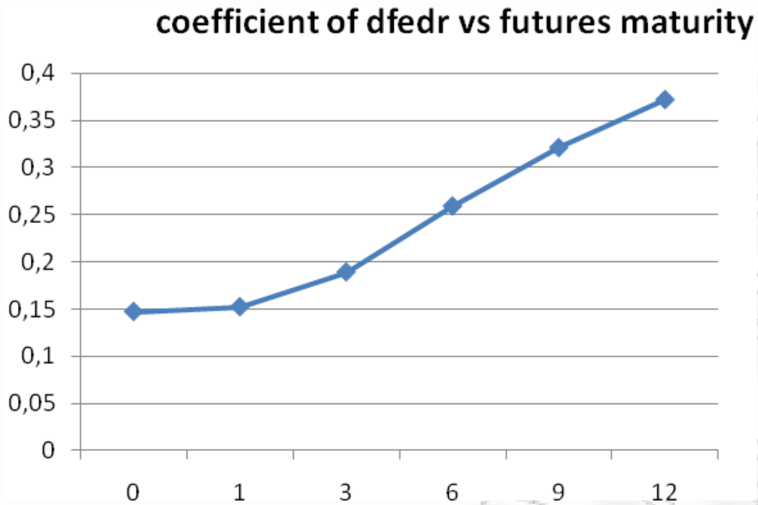
Response of macroeconomic variables to 9 months maturity future

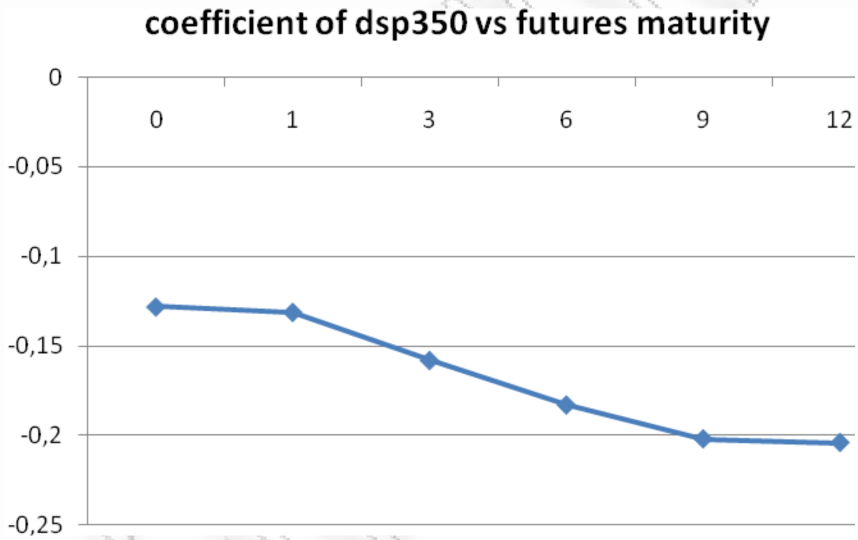


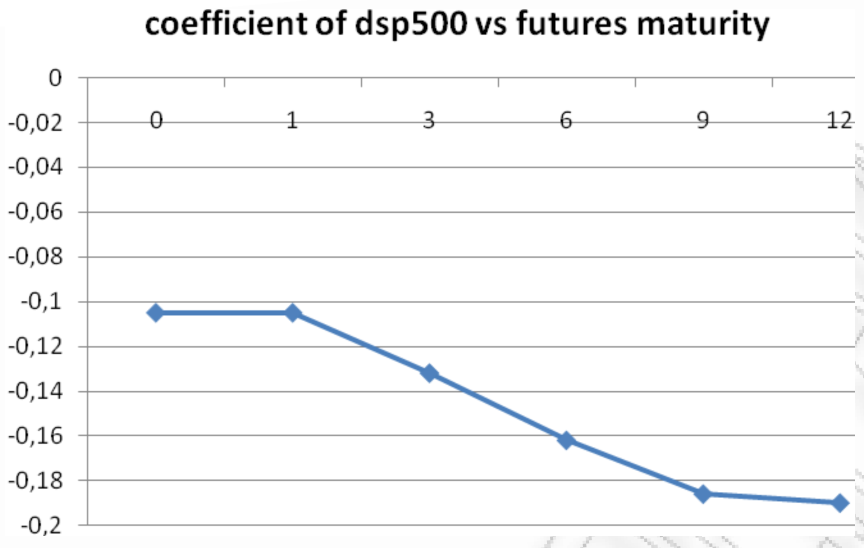
Response of macroeconomic variables to 12 month maturity future

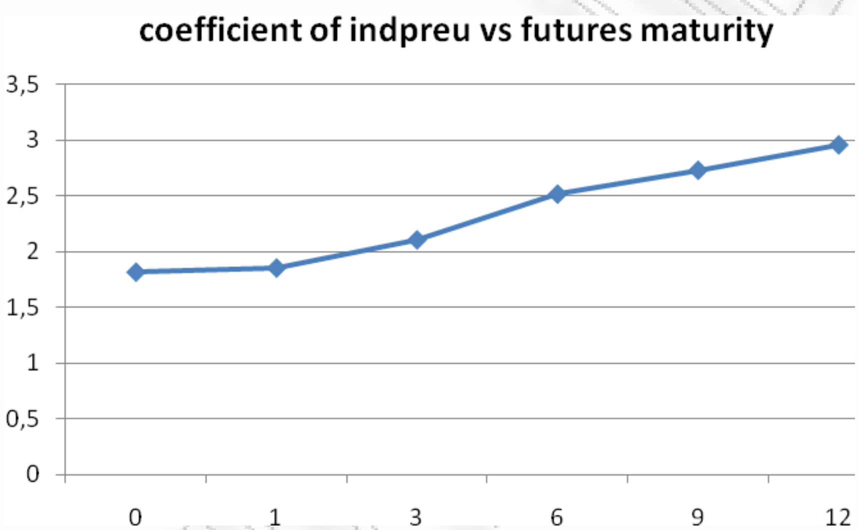


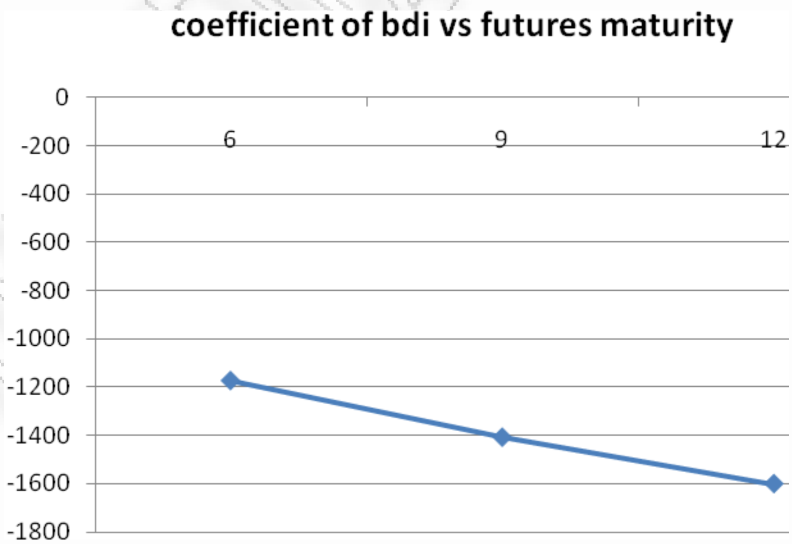
Appendix C


coefficient of dfedr vs futures maturity
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
0
1
3
6
9
12


coefficient of dsp350 vs futures maturity
0
-0,05
-0,1
-0,15
-0,2
-0,25
0
1
3
6
9
12


coefficient of dsp500 vs futures maturity
0
-0,02
-0,04
-0,06
-0,08
-0,1
-0,12
-0,14
-0,16
-0,18
-0,2
0
1
3
6
9
12


coefficient of indpreu vs futures maturity
3,5
3
2,5
2
1,5
1
0,5
0
0
1
3
6
9
12


coefficient of bdi vs futures maturity
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
6
9
12