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Η επίδραση των παραγώγων στις τρέχουσες μελλοντικές τιμές του πετρελαίου

Εμπειρική διερεύνηση της διαμόρφωσης των τιμών λόγω πραγματικής προσφοράς και ζήτησης ή κερδοσκοπικών στρατηγικών

ΜΕΤΑΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

ΣΤΑΘΟΠΟΥΛΟΣ ΦΩΤΙΟΣ

Επιβλέπων: Ιωάννης Λεβεντίδης

Απόστολος Χριστόπουλος

Αθήνα, Μάρτιος 2012

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Εγκρίθηκε από την τριμελή εξεταστική επιτροπή την

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Ιωάννης Λεβεντίδης	Απόστολος Χριστόπουλος	

Αθήνα, Μάρτιος 2012

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Φώτιος Π. Σταθόπουλος

Διπλωματούχος Ηλεκτρολόγος Μηχανικός και Μηχανικός Υπολογιστών Ε.Μ.Π.

Ευχαριστίες

Θα ήθελα να ευχαριστήσω την οικογένειά μου για την αμέριστη συμπαράσταση και υποστήριξη.

Θα ήθελα να ευχαριστήσω τους καθηγητές του Μεταπτυχιακού προγράμματος σπουδών για τα μαθήματά τους αλλά και τις συμβουλές τους.
Ειδική αναφορά θα ήθελα να κάνω στους κύριους Ιωάννη Λεβεντίδη και Απόστολο Χριστόπουλο για την συνεργασία κατά τη εκπόνηση της μεταπτυχιακής εργασίας.

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NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF APPLIED MATHEMATICS AND PHYSICS SCIENCE
MASTER IS SCIENCE:
MATHEMATICAL MODELLING IN FINANCIAL ENGINEERING

Impact of Futures on Spot Prices of Oil

Empirical examination of formation of the prices,
due to supply, demand or speculation.

MASTER THESIS

FOTIOS STATHOPOULOS

Supervisor: Ioannis Leventidis

Apostolos Xristopoulos

Athens, March 2012

Περίληψη

Η ερώτηση «πώς διαμορφώνονται οι τιμές» αποτελεί βασική ερώτηση στην οικονομική θεωρεία. Μια μέθοδος που είναι ικανή να προσδιορίσει τις τρέχουσες τιμές ενός αγαθού αποτελεί πολύτιμο εργαλείο στα χέρια των επενδυτών, που σκοπός τους είναι η μεγιστοποίηση του κέρδους. Η σωστή αποκωδικοποίηση του πως διαμορφώνονται οι τιμές μπορεί να προσφέρει υπεραποδόσεις στους επενδυτές

Σε αυτή τη μεταπτυχιακή εργασία εξετάσαμε τη σχέση των τρεχουσών τιμών ενός εκ των πιο δημοφιλή αγαθών, του πετρελαίου, σε συνάρτηση με τις τιμές των συμβολαίων μελλοντικής εκπλήρωσης (ΣΜΕ) του ίδιου αγαθού καθώς και με την παγκόσμια προσφορά και ζήτηση του αγαθού αυτού. Ακολουθώντας τις πηγές/αναφορές της εργασίας, εξετάζουμε την επίδραση κάθε μιάς από τις μεταβλητές που ορίσαμε ως παράγοντα που επιδρά στις τρέχουσες τιμές του πετρελαίου. Ένα από τα πλεονεκτήματα της μεθόδου που ακολουθήσαμε αποτελεί πως η ίδια μέθοδος μπορεί να εφαρμοστεί σε όλα τα αγαθά ανεξάρτητα από τον τύπο τους.

Ξεκινώντας την ανάλυση με βάση τις μηνιαίες τιμές για την περασμένη δεκαετία, παρατηρούμε πως μόνο οι τιμές των ΣΜΕ επιδρούν πάνω στις τρέχουσες τιμές του πετρελαίου. Συνεχίζουμε την ανάλυσή μας εξετάζοντας τις τριμηνιαίες τιμές παρατηρούμε την ύπαρξη του παράγοντα της προσφοράς. Η προσφορά μάλιστα έχει αντιστρόφως ανάλογη μεταβολή από τις τρέχουσες τιμές, επιβεβαιώνοντας την υπόθεση της αποτελεσματικής αγοράς. Αυτό διότι, φυσιολογικά, όταν μεγαλώνει η προσφορά, μειώνεται η τιμή και αντίστροφα. Τέλος εξετάσαμε αποκλειστικά το πρώτο μισό της περασμένης δεκαετίας, αποκλείοντας έτσι το «πετρελαϊκό σοκ» της διετίας 2007-2008, με την τεράσια αύξηση των τιμών του πετρελάιου

Τα αποτελέσματα της έρευνάς μας, για το πως οι παραπάνω παράγοντες επιδρούν στις τρέχουσες τιμές του πετρελαίου, παρουσιάζονται στο τέλος της εργασίας, παράλληλα με προτάσεις για μελλοντική συνέχιση της έρευνας σε αυτό το πεδίο.

Λέξεις κλειδιά

αποτελεσματικότητα αγοράς, αγορά αργού πετρελαίου, Brent, τρέχουσα τιμή, παράγωγα, ζήτηση

Abstract

The question: “how spot prices are formed” becomes from the roots of the economic science. A method that determines the spot prices of a commodity is a usefull tool for investors who want to maximize their profit. Thus the decoding of how the spot prices are formed can enable the investors to increase their returns.

In this thesis we have examined the relationship between the spot prices of one of the most popular commodities, the Brent Crude Oil, in comparison to the prices of the future prices of Brent crude oil, as well as the world oil supply and world oil demand. Following the literature we inquired the impact of factors such as the prices of future contracts, supply and demand on the formation of the spot prices of oil.

Starting our analysis on a monthly period, we notice that the spot prices are dominated only by the prices of future contracts. In the next step of our analysis, we apply the same method for quarterly results, of the same period of time. We also investigated the first, and more stable, half of the past decade, the years from 2000 to 2005.

The findings of our research present how each of the abovementioned factors, the prices of future contracts, the world oil supply and world oil demand, impact on the formation of the spot prices of oil. We also examine if the efficient market hypothesis is taking place in the oil market, or on the other hand whether speculation is a critical factor for the formation of the oil spot prices. In parallel we propose further steps for the expansion of the research in this topic.

Key words

market efficiency, crude oil market, Brent, spot price, futures, demand

Context

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1 Introduction

1. 1 Purpose of the Thesis

The purpose of this thesis is to find the factor that impacts more on the formation of the spot prices of oil. We will examine the relationship between the spot prices and the prices of future contracts, the demand and the supply of oil. We focus on the characteristics of the most popular oil-commodity, which is the Brent Crude Oil (BCO). More specifically we search on the relationship between the spot price of the Brent Crude Oil and (a) the price of the Brent Crude Oil future with the closest delivery day (b) the oil demand and (c) the oil supply worldwide. Here we have to note that we make the hypothesis that the demand of the Brent Crude Oil is in parallel with the oil demand.

1. 2 Encouragement of the Thesis

Energy is one of the most popular markets. The traditional part of the energy market is the oil market, while the Brent Crude Oil is the most popular commodity.

For this reason we focus on the Brent Crude Oil prices. Our purpose is to examine the efficiency of this market and observe if the spot price of the Brent Crude Oil is affected and formed by the demand, as it should be, or speculation with the future contracts is involved in the final spot price.

We introduce a mathematical model in order to examine the aforementioned questions. The greatest advantage of the proposed model is that it is a general model which can be applied and fitted in other markets and commodities, studying the efficiency of those markets under the same perspectives.

1. 3 Literature Review

Price discovery has been an area of extensive empirical examination. In this paper we introduce a model that determines the formation of the spot prices of a commodity and the impact of the future market on the spot prices. Several studies have dealt with the discovery of the major price factors of the spot oil market, focusing on the relationship between the spot and the futures market of oil.

Garbade and Silber (1983) presented a paper on price movements and price discovery in future and spot markets for storable commodities [1]. They examined and estimated the lead-lag relationship between spot and futures prices. Their findings included that while future markets dominate and lead the spot markets, spot markets do not merely echo future prices; but there are reverse information that flows from cash markets to future markets as well.

Silvapulle and Moosa (1999) examined the relationship between spot and future prices, with evidence from the Crude Oil Market [2]. Their findings, of a VAR representation, included that both markets reacted to new information simultaneously and that the pattern of leads and lags changes over time. It is also mentioned that spot prices will react with a lag because spot transactions cannot be executed so quickly. This study has also revealed more evidence for causality from future prices to spot prices than otherwise. They conclude that although the futures market may play a bigger role in the price discovery process, the spot market also plays a role in this respect.

Caporale et al. [5] based on the metrics proposed by Harris et al. (1995, 2002) [3-4], investigate the role of crude oil spot and futures prices in the process of price discovery by using a cost-of-carry model with an endogenous convenience yield and daily data, along the lines of Figuerola-Ferretti and Gonzalo (2008). Using a VEC representation, their findings suggest that indeed valuable information for forecasting spot crude oil prices is embedded in the long-run spot-futures relationship (see Coppola 2008, among others), but also that it is concentrated mainly in 1-month and 2-month future contracts.

Bekiros and Diks [6] investigated the relationship between crude oil spot and futures prices. They applied the conventional linear Granger test after controlling for cointegration. They also examined the nonlinear causal relationships of VECM filtered residuals and they investigated the hypothesis of nonlinear non-causality after controlling for conditional heteroskedasticity in the data using a GARCH-BEKK model. The study contributed to the literature on the lead–lag relationships between the spot and futures markets in several ways. The pair wise VECM modeling suggested a strong bidirectional Granger causality between spot and futures prices. The results imply that if nonlinear effects are accounted for, neither market leads or lags the other consistently, or in other words the pattern of leads and lags changes over time.

Stevans and Sessions (2010) focus on the Crude Oil Prices in the U.S. [7]. Using a Vector Autoregressive model (VAR) they find that for model specifications with short-term futures contracts, supply does indeed dominate price movements in the crude oil market. However, for specifications including longer-term contracts that are inherently more speculative, the real price of oil appears to be determined predominantly by the futures price.

M.French (2005) investigated why and when do spot prices of Crude Oil revert to Futures Prices levels [9]. He specifies a model that links returns to convenience yield (the adjusted spot-futures spread), inventory news, and revisions of expected production cost. The findings about the formation of the spot prices include that reversion of spot to futures prices only when backwardation is severe. Convenience yield behaves nonlinearly, but price response to convenience yield is

also nonlinear. Equivalently, futures are informative about future spot prices only when spot prices substantially exceed futures.

Hamilton paper (2009) of explores similarities and differences between the run-up of oil prices in 2007-08 and earlier oil price shocks, looking at what caused the price increase and what effects it had on the economy [8]. Whereas historical oil price shocks were primarily caused by physical disruptions of supply, the price run-up of 2007-08 was caused by strong demand confronting stagnating world production.

Singleton's analysis (2011) [10] is part of a growing literature documenting the "financialization" of commodity markets: as retail, institutional, and hedge-fund investors have increased the weights on commodities in their portfolio allocations, there have been significant changes in the behavior of commodity prices. "When futures market positions can be perfectly inferred by market participants, trades will only take place to satisfy hedging needs. If, however, the futures market positions of individual agents are not perfectly observable, strategic and manipulative motives for trade are also possible. In the case of strategic trading, the monopolist profits by hiding behind the trades of agents without market power. In the case of manipulation, agents without market power profit from hiding behind the trades of the monopolist." says Singleton, showing the margins for speculation and manipulation of the markets.

All the above literature in not only showing the path of the models that we will examine, but also creating the questions for a stimulation analysis on how the spot prices of oil are formed; what is the impact of the future prices on the formation of the spot prices of oil; and how supply and demand interfere with the spot prices of oil.

1. 4 Synopsis of the Thesis

The thesis is divided in two parts. At first we present the theoretical part of the proposed model, in order to examine the efficiency of the Brent Crude Oil market. The second part refers to the results of the model and the findings about the Brent Crude Oil market.

Chapter 1: In chapter one, we have an introduction of the thesis. We analyze the purpose of the thesis and present its goals.

Chapter 2: In the second chapter we present the mathematical model that is proposed in order to test the Brent Crude Oil market efficiency. We also show the data of the variables we will use.

Chapter 3: The third chapter we develop the mathematical method and calculate the relationship of the Brent Crude Oil spot price to the Brent Crude Oil future price and the worldwide oil supply and demand.

Chapter 4: As the conclusion of this master thesis, in the forth and last chapter, there are presented the findings of the thesis, in parallel with proposals for future research on this field.

2 The Proposed Model

The objective of the thesis is to find out the parameter that is critical for the formation of oil spot prices. In this chapter we are going to introduce the method we will use in order to examine whether the futures prices are can be considered as benchmarks for the spot prices or prices are determined only due to the corresponding supply and demand. Those are going to be the variables we use in the analysis.

2. 1 Research Methodology

As mentioned above, our purpose is to find out the parameter that is affecting more the formation of spot prices. For this reason we have gathered time-series for the aforementioned parameters and we will use regression to find out the correlation between them. The equation we use is:

$$SP = a \cdot FP + b \cdot De + c \cdot Su + e \quad (1)$$

Where: *SP* are the Spot Prices, *FP* are the Future Prices, *De* is the World Oil Demand, *Su* is the World Oil Supply and e stands for the errors of the regression.

Before starting the analysis, we have to test the data for the presence of unit root. We are going to examine the data with the unit root test. If there is a unit root, we age going to use the differences of the data.

After observing the correlograms of the data-series, we might add lags in the equations, and watch if the regression result is improved. Thus the final equation can be written :

$$D\left(SP_t\right) = D\left(A\left(l\right)FP_t\right) + D\left(B\left(l\right)Su_t\right) + D\left(C\left(l\right)De_t\right) + e_{D(SP),t} \qquad (2)$$

where *A(l), B(l), C(l)* are all polynomials in the lag operator with all roots outside the unit circle, and *D(..)* is the first order difference.

2. 2 Data

The variables will be utilized in this analysis are the spot price of Brent *(SP)*, the price of oil futures *(FP)*, and the world oil demand *(D)* and supply *(Su)*. In the following paragraphs we are going to present the data we have collected in order to perform the analysis. The data have been retrieved by the U.S Energy Information Administration (EIA) and the International Energy Agency (IAE). Here we have to notice that all the data do not have the same frequency; spot and future prices are daily, world supply is monthly while world demand is quarterly (3 months). For this reason we have done some statistical analysis, in order to have the same frequency on the data. In the first runs of the model we work in 3-months period, while we have decreased this period to monthly depending on the variables we use in the model.

A. Spot Price of Brent Oil

We have the daily prices of BCO since 2000. In Figure 2.1 is depicted the spot price variation during the past decade. During this period we can observe the continuous increase, with a rapid rhythm (after a short fall) in 2007, with the highest peak in 2008 with price more than 140 dollars per barrel. It has been the highest price of oil ever. The fall after 2008 is following the economic crisis, starting from the US economic bubbles, before it has turned to a worldwide crisis. In the beginning of 2009 the oil prices has fallen to the early ’00 level, while the last two years, 2009 and 2010 they have almost reached the level of 80dollars per barrel.

Figure 2.1 Spot price of Brent since 2000 on daily basis.

B. Price of Brent Oil Futures

As mentioned above about the prices of futures, we have the daily prices of Brent crude oil futures, since 2000. Comparing Figure 2.1 and Figure 2.2 we can easily depict that the diagrams of the future and spot prices are similar. A first observation about the results can be made, that there is correlation between the futures prices and the spot ones. Even though, this is something to be shown in the following analysis. We can have a more detailed observation of the spot and futures prices of Brent in Figure 2. 3 to Figure 2.13.

Figure 2.2 Price of Brent futures, from NYMEX, on daily basis since 2000.

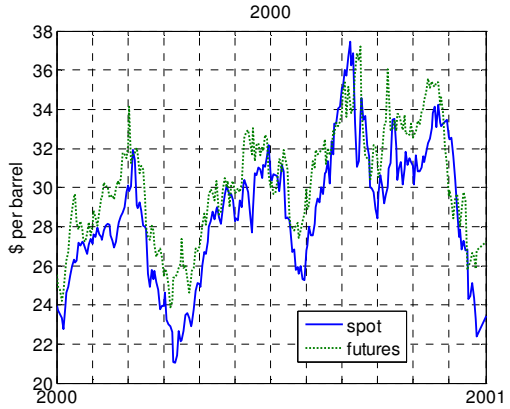

Figure 2. 3 Spot and Futures prices for 2000

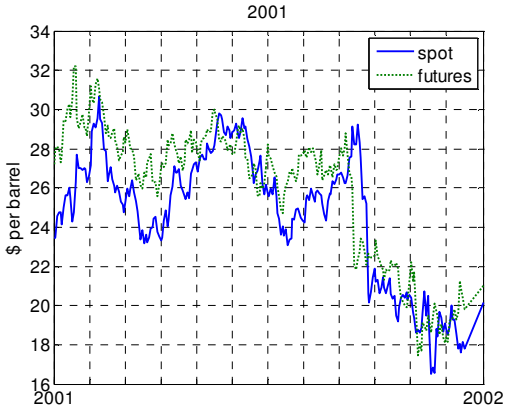

Figure 2. 4 Spot and Futures prices for 2001

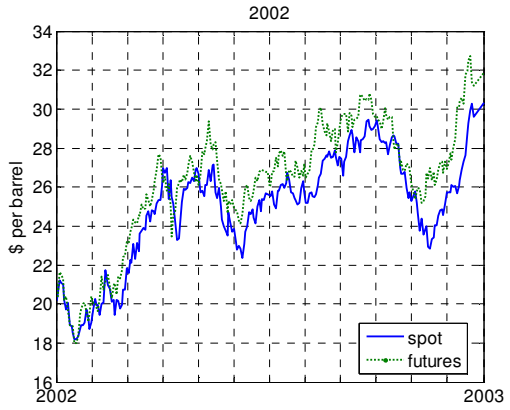

Figure 2. 5 Spot and Futures prices for 2002

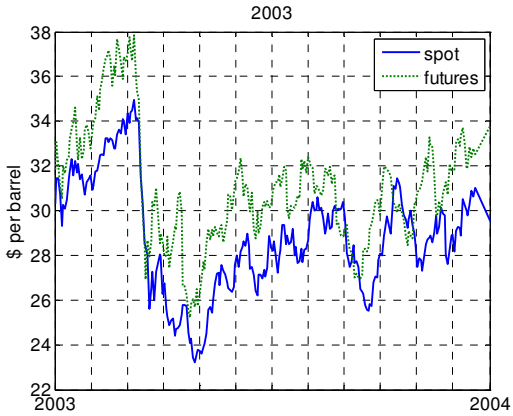

Figure 2. 6 Spot and Futures prices for 2003

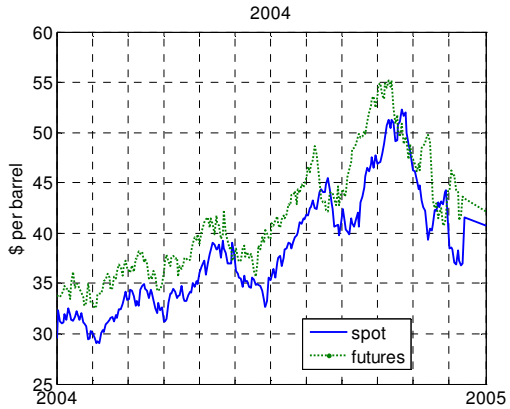

Figure 2. 7 Spot and Futures prices for 2004

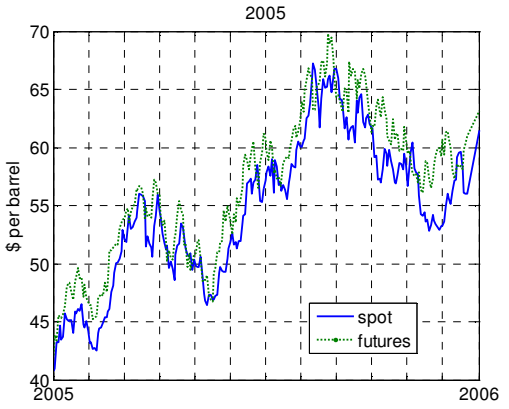

Figure 2. 8 Spot and Futures prices for 2005

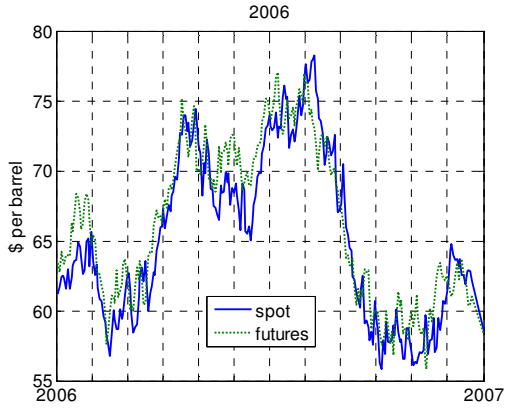

Figure 2. 9 Spot and Futures prices for 2006

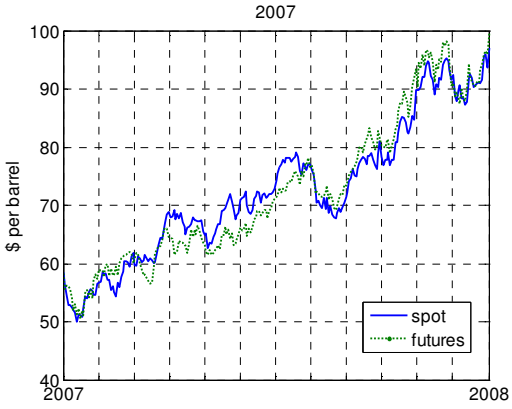

Figure 2. 10 Spot and Futures prices for 2007

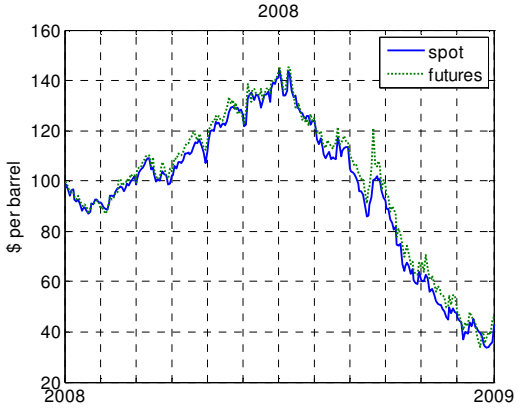

Figure 2.11 Spot and Futures prices for 2008

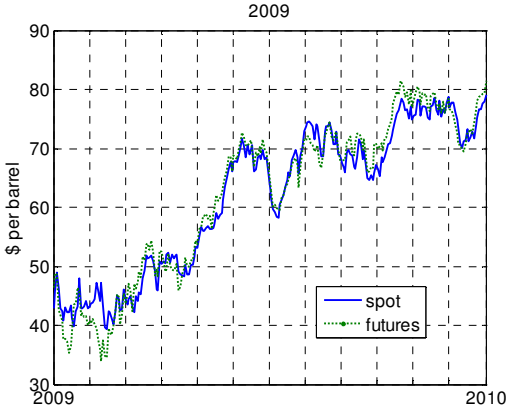

Figure 2. 12 Spot and Futures prices for 2009

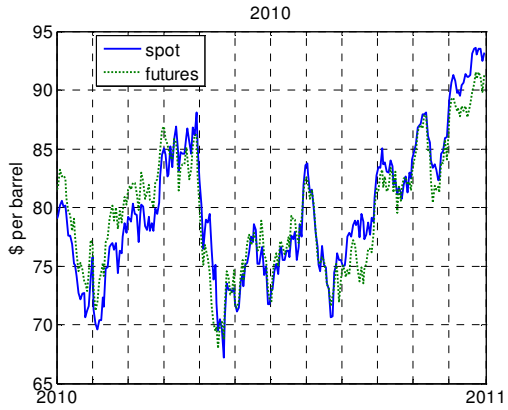

Figure 2.13 Spot and Futures prices for 2010

C. World Oil Demand

The data of world oil production since 2000 are in quarterly basis in Figure 2.14. This is the fact that, when we include the demand in our analysis we will work on this period. We have also retrieved the monthly variation of the world oil demand after statistical analysis and following the variation of the oil demand of the OECD. We also present the world oil demand since 1970 on annual basis (Figure 2.15), in order to see the increase of oil demand through the past decades. We can see a fall in mid 80's, and this is mainly due to the crisis in the USA during those years. Since then, and only during 1991, the year of the Gulf-War the oil demand is increasing. This trend is interrupted in 2009 when we can see a fall of the oil demand, but in 2010 despite the current economic crisis we can depict a recovery in the demand levels.

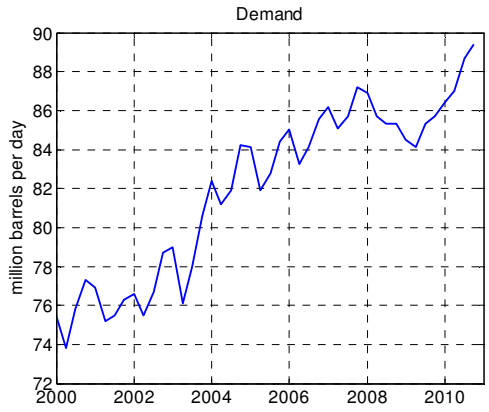

Figure 2.14 World Oid Demand in quarterly basis.

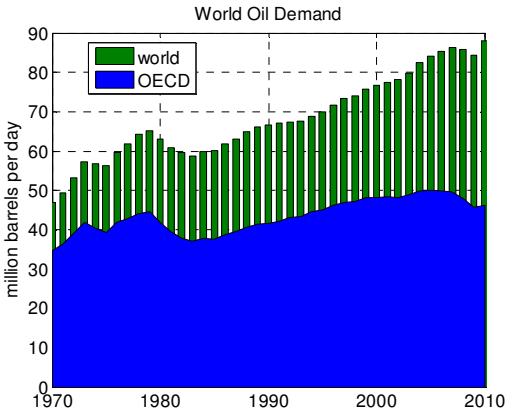

Figure 2.15 World and OECD Oil Demand since 1970.

D. World Oil Supply

Like the world oil demand, the world oil supply has almost the same performance. Our data have a monthly period, thus we can see more details in the data. From Figure 2. 16 we can depict that supply is increasing in average through the years. There is a break in this rise in 2009 while it can be explained from the economic crisis.

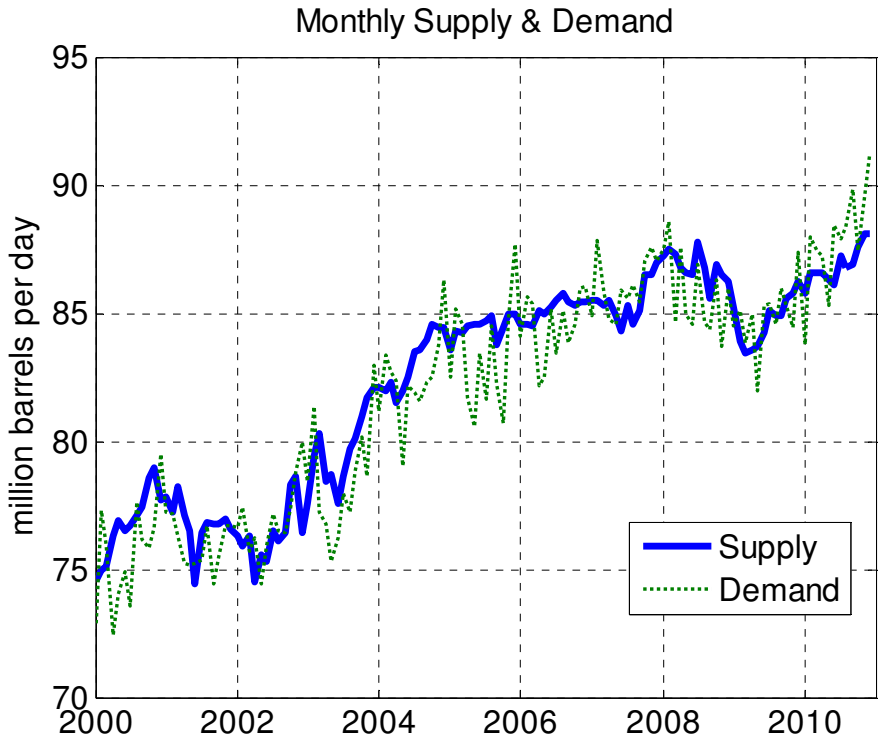

Figure 2. 16 Monthly World Oil Supply since 2000. The variation of the World Oil Demand is form by the monthly OECD Demand and the quarterly World Oil Demand.

3. Analysis

3.1 Results

In the following paragraphs we present the analysis of the proposed model, on monthly and quarterly basis. In order to find the correlation between variables we have considered, we apply the model introduced in paragraph 2.1. As it is mentioned firstly we are going to test the variables for the existence of unit root. In case of unit root existence we use in the model the first differential order.

A. MONTHLY DATA

In this paragraph we are going to examine the correlation of the variables on a monthly basis. As abovementioned, the world oil demand has been given in quarterly periods, thus we used the OECD demand that has been given in monthly basis and we have extracted the monthly values of the world oil demand. Firstly we

apply the unit root test. Since the probability of unit root existence is high for all variables, while for the first differential order is null, then we will use the first differential order of the variables, since their t-statistic values are below the 1% trust level threshold (Table 3.2).

variable	t-statistic	probability
spot	-1,65	0,48
future	-1,77	0,43
demand	-1,14	0,68
supply	-1,31	0,79
D(spot)	-5,48	0
D(future)	-4,98	0
D(demand)	-13,19	0
D(supply)	-9,27	0

Table 3. 1 Unit root test results

1% level	5% level	10% level
-3,48	-2,88	-2,58

Table 3. 2 Trust levels

At this point we will present the results of the regressions we have applied in order to find the model that best fits to the time series of the given variables. In Table 3.3 it is shown that the future prices are correlated to the spot prices of oil, while the probability of demand and supply cannot to be correlated with the spot prices.

Dependent Variable		Independent Variables			
D(SPOT)		D(FUTURE)	D(DEMAND)	D(SUPPLY)	C
	Coefficient	0,99	0,03	-0,03	0,03
	Std. Error	0,02	0,06	0,17	0,12
	t-Statistic	4421552	0,43	-0,20	0,26
	Prob.	0,00	0,67	0,84	0,80
	R-squared	0,94			
	Adj. R-squared	0,94			

Table 3. 3 Regression: Spot Prices vs Futures Prices, Demand, Supply, Constant

We also add in the model first order lags, but also their probability of not being correlated with the spot prices is high, as presented in Table 3.4. This is the reason that in the next regressions we eliminate the variables demand and supply, as well as the lags.

Dependent Variable		Independent Variables			
D(SPOT)		D(FUTURE)	D(DEMAND)	D(SUPPLY)	C
	Coefficient	0,99	0,05	-0,03	0,02
	Std. Error	0,03	0,08	0,18	0,13
	t-Statistic	3886466	0,60	-0,16	0,18
	Prob.	0,00	0,55	0,88	0,86
		D(SPOT(-1))	D(FUTURE(-1))	D(DEMAND(-1))	D(SUPPLY(-1))
	Coefficient	-0,01	0,00	0,04	0,05
	Std. Error	0,09	0,10	0,08	0,18
	t-Statistic	-0,07	-0,02	0,50	0,29
	Prob.	0,95	0,98	0,62	0,77
	R-squared	0,94	Adj. R-squared	0,94	

Table 3. 4 Regression: Spot Prices vs Futures Prices, Demand, Supply, Constant and first order Lags

We apply the regression with only one independent variable, the prices of futures. In Table 3.5 we also include a constant variable, but it is shown that it has to be eliminated too.

Dependent Variable		Independent Variables	
D(SPOT)		D(FUTURE)	C
	Coefficient	0,99	0,03
	Std. Error	0,02	0,12
	t-Statistic	4474545	0,27
	Prob.	0,00	0,79
	R-squared	0,94	
	Adj. R-squared	0,94	

Table 3. 5 Regression: Spot Prices vs Futures Prices, Constant

We conclude to the final equation, that only the prices of the futures have to be included in the model and explains 94% of the data set.

$$D(SP) = 0.99 \cdot D(FP) \tag{3}$$

Dependent Variable	Independent Variable	
D(SPOT)		D(FUTURE)
	Coefficient	0,99
	Std. Error	0,02
	t-Statistic	4509610
	Prob.	0,00
	R-squared	0,94
	Adj. R-squared	0,94

Table 3. 6 Regression: Spot Prices vs Futures Prices

B. QUARTERLY DATA

In this paragraph we investigate the data on a quarterly basis. We firstly examine the existence of unit root. As presented in Table 3.7, the existence of unit root in the variables leads to use in the analysis the first order differences, while the t-statistic value is below the 1% trust level threshold (Table 3.8).

variable	t-statistic	probability
qspot	-1,81	0,48
qfuture	-1,99	0,43
qdemand	-1,23	0,68
qsupply	-0,91	0,79
D(qspot)	-5,97	0
D(qfuture)	-6,13	0
D(qdemand)	-9,04	0
D(qsupply)	-5,44	0

Table 3. 7 Unit root test results

1% level	5% level	10% level
-3,59	-2,93	-2,60

Table 3. 8 Trust levels

In the first iteration we include as independent variables the prices of futures, as well as the world oil demand and supply and the constant variable. In Table 3.9 we observe that the oil demand should be eliminated from the variables, so we continue to the next regression. The values of R-square and R-square adjusted are quite high, so the model tends to be satisfying.

Dependent Variable		Independent Variables			
D(SPOT)		D(FUTURE)	D(DEMAND)	D(SUPPLY)	C
	Coefficient	0,98	-0,06	-0,55	0,28
	Std, Error	0,02	0,22	0,32	0,25
	t-Statistic	4697495	-0,26	-1730404,00	1125174,00
	Prob,	0,00	0,80	0,09	0,27
	R-squared	0,98			
	Adj, R-squared	0,98			

Table 3. 9 Regression: Spot Prices vs Futures Prices, Demand, Supply, Constant

After eliminating the world oil demand and the constant variable, we proceed to the regression with prices of futures, the world oil supply and a constant as the independent variables. In Table 3.10 we observe that the constant variable should not be included in the regressions.

Dependent Variable		Independent Variables		
D(SPOT)		D(FUTURE)	D(SUPPLY)	C
	Coefficient	0,98	-0,59	0,28
	Std, Error	0,02	0,26	0,25
	t-Statistic	4794701	-2278598	1119739
	Prob,	0,00	0,03	0,27
	R-squared	0,98		
	Adj, R-squared	0,98		

Table 3. 10 Regression: Spot Prices vs Futures Prices, Supply, Constant

Eventually we proceed to the last regression where only the prices of future contracts and the world oil supply are included in the regression. The final equation becomes:

$$D(SP) = 0.98 \cdot D(FP) - 0.5 \cdot D(Su) \quad (4)$$

The values of R-square as well as the adjusted R-square are both 98%, while the probabilities for both independent variables not to conform with the spot prices are below 5% for both variables.

Dependent Variable		Independent Variables	
D(QSPOT)		D(QFUTURE)	D(QSUPPLY)
	Coefficient	0,98	-0,50
	Std, Error	0,02	0,25
	t-Statistic	4789336	-2032051
	Prob,	0,00	0,05
	R-squared	0,98	
	Adj, R-squared	0,98	

Table 3. 11 Regression: Spot Prices vs Futures Prices, Supply

C. DATA UP TO 2005

In the above paragraphs we have noticed that when we examine the monthly spot prices, only the prices of future contracts are considered. On the other hand when we examine the quarterly data the world oil supply should also be considered to form the spot prices of oil. In this paragraph we will examine a stable economic period for the world economy, during the first half of the past decade, just before the "oil shock" of 2007-2008 [8], that as it is mentioned:

"whereas historical oil price shocks were primarily caused by physical disruptions of supply, the price run-up of 2007-08 was caused by strong demand confronting stagnating world production".

We begin with the unit root test, and again we will work the first order differences of all variables, comparing the results with the trust levels of Table 3.13.

variable	t-statistic	probability
spot	-0,28	0,92
future	-0,06	0,94
demand	-0,92	0,77
supply	-0,84	0,80
D(spot)	-3,2	0,01
D(future)	-3,02	0,03
D(demand)	-9,66	0

D(supply)	-12,45	0

Table 3. 12 Unit root test results

1% level	5% level	10% level
-3,50	-2,89	-2,58

Table 3. 13 Trust levels

In the first regression we include all variables, the prices of future contracts, the world oil supply and the world oil demand, as well as the constant variable. In Table 3.14 we observe that demand and the constant variable should be excluded from the equation.

Dependent Variable		Independent Variables			
D(SPOT)		D(FUTURE)	D(SUPPLY)	D(DEMAND)	C
	Coefficient	1,04	-0,21	0	0
	Std, Error	0,04	0,12	0,05	0,1
	t-Statistic	2938876	-1796784	-0,06	-0,04
	Prob,	0,00	0,08	0,95	0,96
	R-squared	0,92			
	Adj, R-squared	0,92			

Table 3. 14 Regression: Spot Prices vs Futures Prices, Demand, Supply

In the next regression we include only the prices of futures and the world oil supply. The probability of non conformance to the model is very low for both variables thus the final equation becomes:

$$D(SP) = 1.04 \cdot D(F) - 0.21 \cdot D(Su) \tag{5}$$

Dependent Variable		Independent Variables	
D(SPOT)		D(FUTURE)	D(SUPPLY)
	Coefficient	1,04	-0,21
	Std, Error	0,04	0,12
	t-Statistic	2960358	-1812835
	Prob,	0,00	0,07
	R-squared	0,93	
	Adj, R-squared	0,92	

Table 3. 15 Regression: Spot Prices vs Futures Prices, Demand, Supply, Constant

3.2 Interpretation of Findings

The question: "how spot prices are formed" becomes from the roots of the economic science. A method for price discovery of a commodity is always a useful tool for investors who want to maximize their profit. Thus we are focusing our research on decoding the formation spot prices of oil.

In this thesis we have examined the relationship between the spot prices of one of the most popular commodities, the Brent Crude Oil, in comparison to the prices of the future prices of Brent crude oil, as well as the world oil supply and world oil demand. Following the literature (as presented in Paragraph 1.3) we inquired the impact of factors such as the prices of future contracts, supply and demand on the formation of the spot prices of oil.

Starting our analysis on a monthly period on the past decade (2000 - 2010), we notice that the spot prices are dominated only by the prices of future contracts. We have noticed that the prices of futures lead the spot prices according to Garbade-and-Silber, and Silvapulle-and-Moosa. In our model we are using the 1-month futures contracts and we are able to forecast the spot prices complying with the findings of Caporale et al..

In the next step of our analysis, we apply the same method for quarterly periods, of the same period of time. Here the spot prices of oil are formed by two factors. As abovementioned for the monthly periods, the price of the futures is the principal factor for the formation of the spot prices of oil. In addition there is a second factor which is the oil supply. We notice that the negative coefficient of the world oil supply is proving the efficient market hypothesis, since in that case the relationship between spot prices and supply is inverse. This means that when supply is increasing the oil price is reducing, as it is expected from the efficient market hypothesis.

These findings lead us search for the reason that supply does not take place in the monthly period analysis. A possible explanation is the "oil-shock" of 2007-2008. We observe that while the first half of the past decade regarding the oil market can be considered economically stable, the most recent half of the past decade, 2006 – 2010, includes the "oil-shock" period [8, 10]. For this reason we also investigated the first, and more stable, half of the past decade, the years from 2000 to 2005. As we

notice in the results, supply is again considered in the formation of the spot prices, proving again the efficient market hypothesis. In other words it is the oil shock of 2007-2008 that eliminates the oil supply as a factor that forms the spot prices of oil. During the oil shock the prices of futures, still dominate the spot prices; on the contrary investors will try to hedge theis positions [10]. Thus speculation and manipulation of the market is possible to take place. This finding is partially in against Stevans and Sessions that claim that model specifications with short-term futures contracts, supply does indeed dominate price movements in the crude oil market. We have shown that it is depending on other exogenous factors (oil shock) mostly related with speculation, whether supply can be considered or not as a factor.

Concluding, in this thesis we have found that the prices of oil futures are dominating the spot prices, in accordance to the literature; but the world oil supply is also forming the spot prices under certain circumstances. The world oil demand does not impact on the formation of the spot prices of oil in any case. Hence it can be safely concluded that, although the oil futures market may play a bigger role in the price discovery process, the oil supply also plays a role in this respect, under certain circumstances.

4 Conclusion

4. 1 Results

From the above analysis we have interesting findings about the factors that form the spot prices of oil:

- We have found that the future contracts of oil dominate the spot price of the oil.
- On the other hand the world oil demand does not impact on the formation of the spot prices of oil.
- The world oil supply has a twofold performance:

  For longer-term periods (i.e. quarterly) or during "stable" economic periods, the world oil supply is considered as a factor that forms the spot prices of oil. This is proving in addition the hypothesis of efficient markets, from the inverse relationship between the spot prices and world supply. When supply is increasing the spot prices are reduced and the opposite, which is supposed to happen in an efficient market.

On the contrary the volume of oil supply cannot be used for useful findings in order to forecast the spot price of oil, as it can be done with the prices of future contracts in shorter-term periods, especially when the closing date of the future contract is reaching.

4. 2 Further Research

As next steps in this topic, there could be plenty of issues. Firstly we can add in the model more variables, such as the variation of the prices of future contracts with longer closing date (2, 4, or 6 months), the world inflation, and the variation over time of dollar or euro currency. In this way the model would examine more parameters and deepen the study. In parallel we could also examine different oil products such as WTI, and try to define if their behavior is similar to Brent or their prices are formed independently.

Additionally we could expand this research in other commodities, examining if speculation is taking place only in other markets. As a result we can have very interesting results on how the prices are formed and whether all the exchanges are legal or policies are needed to regulate those markets. Of course this issue is not something simple and a lot of research and discussions should be done in order to have such a conclusion.

Furthermore we can compare the spot prices of oil to the prices of commodities of sustainable energy, and try to retrieve result on the interactivity of those commodities. We could also work for a longer period (i.e. twenty years long) of try to retrieve more detailed data for the oil supply and demand.

Finally it would be very interesting to connect this kind of analysis to behavioural economics and finance, in order to understand better the behaviour of the markets and their trends.

All aforementioned ideas can be included in future works, in order to complete the analysis of the relationship between the spot prices of a commodity and the prices of future contracts, in parallel with parameters such as demand, supply, etc.

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Abbreviations

BCO	Brent Crude Oil
D	Demand
FP	Futures prices
NYMEX	New York Mercantile Exchange
SP	Spot prices
Su	Supply