Oil Price Volatility and The Information Function of Speculation

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ملخص

تقلب أسعار النفط ودور المضاربة كمصدر للمعلومات عن السوق

الهدف الرئيس من هذه الورقة هو استكشاف أسباب تقلب أسعار النفط. فتدرس الورقة وظيفة الأسعار في أسواق النفط الآجلة كمصدر للمعلومات عن أسواق النفط. كما وتبحث الورقة في العلاقة على المدى القصير بين تغير أسعار النفط الآجلة وتغير أسعار النفط الجارية. وعلاوة على ذلك، تنتج الورقة نموذجا لسعر التوازن على المدى الطويل قادر على إنتاج تنبؤات موثوقة. تظهر النتائج أن التغير في مخزونات النفط تسبب التغير في أسعار النفط على المدى القصير. اما على المدى الطويل فان النتائج تثبت ان الطلب والعرض على النفط، مستوى مخزون النفط، المضاربات في سوق النفط الآجلة (بورصة نيويورك) وسعر صرف دولار/حقوق السحب الخاصة هي جميعا عوامل مرتبطة في علاقة توازن طويلة المدى.

Abstract

The aim of this paper is to explore the reasons of oil price volatility. It analyses the information function of oil future market and investigates the relation between speculation and spot oil price in the short run. Furthermore, the paper produces a model for long run equilibrium able to produce reliable and reasonable oil price forecasts. Findings prove that in the short run, changes in oil inventories Granger cause changes in oil price. In the long run however, findings prove that, the oil demand, the oil supply, the $/SDR exchange rate, the speculation in oil future market (New York Mercantile Exchange) and the oil inventories are associated in a long run relationship.

Key words: oil supply, open interest, spot oil price, oil demand, exchange rate, future oil markets, oil inventories

1. Introduction

Oil price fluctuations, their causes and consequences are one of the most popular focuses in energy economics. One of reasons behind concentrating on this topic is that oil is a vital energy source, an important factor for industry, for transportation and hence for economic growth. Therefore, understanding the factors influencing oil price volatility is important on both economic and welfare terms. On one hand, when households have to suddenly pay more for energy costs, there is less money available in household budgets for other competing demands. On the other hand, oil price volatility amounts to sudden and large shifts in international trade. Consequently, volatile prices can affect labor markets, increasing temporary layoffs or prompting surge hiring.

As any other commodity, the oil price serves to co-ordinate consumption and production decisions. However, the gap between global oil supply and demand explain partially the observed price changes, since this gap and oil price changes are not synchronous. The price of oil, for example, strongly amounted in the first half of 2009 without being warranted by the resumption of global activity. Which factors account thus for the oil price fluctuations? A widely accepted hypothesis would be that the financial aspect of the market, the influx of speculators and therefore the huge use of oil contracts as financial papers, determine significantly the dynamics of spot oil prices. Furthermore, the derivative instruments generate changes in oil inventories. These stocks increase, when the oil is cheap to be sold in futures markets when oil is expected to be expensive. Therefore, in addition to the variations in oil supply and demand, the variations in oil inventories may influence the oil prices. On the other hand, oil contracts are settled in dollar, an increase in dollar value against other currencies means everything being equal, an increase in oil value expressed in dollar. As consequences, the exchange value of the dollar against other currencies influences therefore the oil price.

We explore in this paper the relation between the speculation and oil spot price in the short run. We develop also a linear model where the oil price, the oil supply and demand, the activity in oil future market (New York Mercantile Exchange), the OECD oil inventories and the SDR[1]/$ exchange rate are associated in a long run relationship. Together, these factors allow the model to perform well and to have a satisfactory forecasting power.

The paper is organized as follows: Section 2 presents the empirical literature review. Section 3 presents the statistical characteristics of oil price series and models the oil price volatility. Section 4 analyses the physical and financial relationship between speculation and oil price changes tested for the short run by Granger causality test. Section 5 presents a model for oil price equilibrium in the long run. The sixth and last section concludes.

2. Empirical Literature Review.

A rich empirical literatures are designed to recognize the factors explaining oil prices. The researches on oil price determination could be classified according to their approach into three categories.

The first category of researches is founded on the Microeconomic theories which emphasis the role of the supply and demand in determining the oil price. In other terms, oil prices ups and downs arise to reestablish the equilibrium after an excess in demand or a surplus in supply. Zamani (2004), presented a forecasting model that accounts for both the OPEC oil supply and OECD stocks and non OECD demand. Kilian (2009) emphasized that fluctuations in global crude oil spot prices reflect global economic conditions. For their part, The US. Energy Information Administration (EIA) performed a model for oil price determination. This model is a mixture of structural and time series specifications, which includes the impact of past oil price as well as the oil demand and the OPEC supply but also non OPEC supply availability as the main factors driving oil prices. The EIA's model adopts the idea that higher oil prices can always stimulate future non-OPEC oil

[1] SDR: special drawing rights, these rates are the official rates used by the IMF to conduct operations with member countries. The rates are derived from the currency's representative exchange rate, as reported by the issuing central bank.

production. Sanders et al. (2009) investigated the empirical performance of the EIA model for oil price forecasting at different time horizons. The authors found that EIA three-quarter ahead oil price forecasts are particularly accurate.

The rise of speculative activities in oil market and, in parallel the high increase in oil prices after year 2000, suggest that oil price and speculation activities are positively correlated. Thus another category of researches posits that oil market is generally efficient and holds the view that futures oil prices have the power to forecast realized spot prices. A widely supported approach was taken by Chinn, LeBlanc and Coition (2001), who postulated that the best predictor of future spot prices is futures prices. Taback (2003) also found similar results but found that the explanatory power of futures prices was low for changes in spot prices. Ghalayini (2011) found that speculation activity in oil market measured by the open interest on WTI three months does not Granger cause the variations in spot oil price but the relation goes from spot oil price to speculation activity. However, considering that the difference between the spot and future oil price is revealed in crude oil inventories, Kilian and Murphy (2013) have extended kilian (2009) model, identifying speculative demand shocks and including oil inventories as third variables explaining oil prices.

The third category of researches consider the combined impact of economic and financial variables on the variation of oil price. Chevalier (2010) highlighted a new articulation between the "physical" fundamentals of the oil market that prevailed until the beginning of the 2000s, and the emergence of new "financial" fundamentals following the reforms of the derivatives in the U.S. markets in 2003 and the rise of the "non-commercial" agents in this market. Merino and Ortiz (2005), extending the various works of Ye et al. investigated whether some explanatory variables can account for the fraction of oil price variations that is not explained by oil inventories. The authors acknowledge as possible sources of variation: the difference between spot and futures prices; speculation defined as the long-run positions held by non-commercials of oil, gasoline and heating oil in the NYMEX futures market; OPEC spare capacity along with the relative level of US commercial stocks, different long-run and short-run interest rates.

Exploiting causality and co integration tests, the authors identified the importance of the speculation variable which, among others appears to add systematic information to the model.

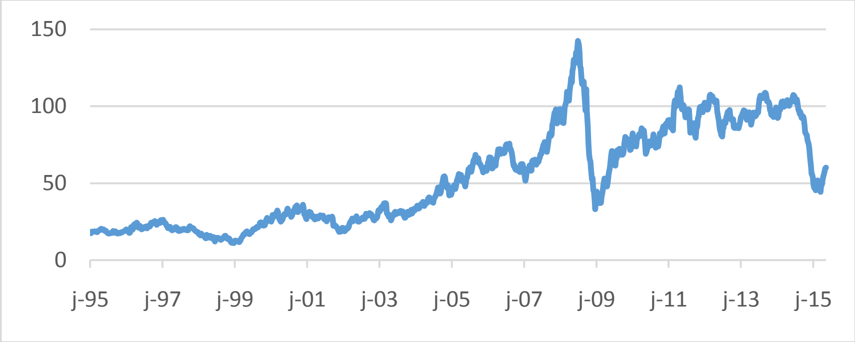
In this paper, we continue the work we did in 2012 and construct a model where financial and physical factors influence jointly the spot oil price. In this new model the oil price is determined by five explanatory variables. These variables are, in addition to the oil supply and demand, the OECD oil inventories and the $ exchange rate. Together, these factors allow the model to perform well and to have a strong forecasting power.

3. Oil price statistical characteristics and volatility

In general, the oil price symbolizes the spot price of a barrel of benchmark crude oil. West Texas Intermediate (WTI) for North American oil (a light, sweet crude) quoted since 1978 at the New York Mercantile Exchange (NYMEX) is One such benchmark oil. The other benchmarks are Brent Crude traded on the Intercontinental Exchange (ICE), Dubai for Middle East oil flowing to the Asia-pacific region; Tapis from Malaysia, used as a reference for light East Asia's oil; and Minas, from Indonesia, for heavy East Asia's oil. There is also the OPEC basket which is a mix of light and heavy crude and is therefore heavier than both Brent and WTI. We note however that due to arbitrage world oil prices move together.

We can graphically note (figure 1) that Oil prices experience wide swings in times. The WTI oil price fluctuates from less than 10 dollars per barrel during the Asian crisis of 1997-1999 to unprecedented highs of $142 per barrel in July 2008. From this pick, the oil price heavily decreases and reaches $ 40 per barrel in January 2009, to swing than after on either side of 100 during 2010-2013 and to crush to 50 dollars in the end of 2014. Throughout the year 2015, meanwhile the war in Yemen, Libya and Syria, the oil price remains under $ 40 per barrel.

Figure 1: Weekly WTI Spot Price (Dollars per Barrel) from January 7/ 1995, to May 15 /2015.



Source: Realized by author, based on data from U.S. Energy Information Administration (EIA).

3.1 Descriptive statistics

The descriptive statistics of real crude oil series (in Log) from January 2000 to the end of the year 2015provided in Table 1, display non-Gaussian characteristics with negative skewness. Moreover, the series is not normally distributed according to Jarque-Bera test results since the calculated probability is (0.0001) less than 5%.

Table 1: Descriptive Statistics of the weekly real oil price series considered in log from 2000-2015

	Log(P)		***Log(P)***
Mean	3.250692	Skewness	--0.252500
Median	3.316468	Kurtosis	1.835341
Maximum	2.934982	Jarque-Bera Stat. Probability	12.83832 0001630
Minimum	4.066257	observations	192

Source: calculated by author using Eviews based on Data collected from U.S. Energy Information Administration (EIA).

3.2. Volatility measure and formulation

A high volatile market is a market were prices tend to change a lot over relatively a short time. The volatility is associated with the risk, the unexpected and the uncertainty. It is considered as the difference between market price and economic fundamentals that rationally justify the valuation of the assets concerned.

Volatility measure of oil price series is based on the *returns* of the data ($R_t = logp_t - logp_{t-1}$.). Generalized Autoregressive Conditional Heteroskedasticity (GARCH) formulation which has been first proposed by Bollerslev (1986) and has become popular, particularly, due to its explanatory power for dependence in volatility tests whether the variance of returns is stationary and if price levels eventually revert back to the mean value. It tests then an equation specification for the mean of the return series (1) and an equation for the conditional variance (2) of the returns:

$$R_t = logp_t - logp_{t-1} = c + \varepsilon_t \quad (1)$$

$$\sigma^2_t = \omega + \alpha\varepsilon^2_{t-1} + \beta\, \sigma^2_{t-1} (2)$$

where $\varepsilon_t \sim N(0, \sigma^2_t)$ and $\sigma^2_t = E(\varepsilon^2_t)$.

This specification is often interpreted in a financial context, when an agent trader predicts this period's variance by forming a weighted average of a long term average (the constant), the forecasted variance from last period (the ARCH term: α), and information about volatility observed in the previous period (the GARCH term: β). If the asset return was unexpectedly large in either the upward or the downward direction, then the trader will increase the estimate of the variance for the next period.

3.3 Estimation Results

The prior step to estimate equation 1 and 2 is to test the stationarity of the real oil price series. The real oil price is calculated as the nominal WTI price divided by the US consumer price index (CPI) base year 1984. The monthly oil price data and the CPI are collected from the U.S. Energy Information Administration (EIA) database and cover the period January 2000 to the end of 2015.

The presence of a unit root in the real oil price series in log form is confirmed by the Augmented Dikey Fuller (ADF) and Phillips-Perron tests. ADF and Phillips- Perron test results shown in table 2 indicate that taking in differences, the oil price series become stationary. In other terms the series is integrated of order 1 (I(1)). The return series R_t is therefore stationary.

Table 2: ADF test results for monthly real oil price series in log, from January 2000, to May 2015.

ADF test	***Log(P)***
Probability Calculated ADF in levels	0.3738**
Probability Calculated ADF in first differences	0.0000*
Phillips- Perron test	**Log (P)**
Probability in Level	0.3411**
Probability in first difference	0.00000*

*Note: ** the series is not stationary since probability is more than 5%.*the series is stationary since probability is less than 5%..Source: Calculated by the author using Eviews.*

Equation (3) represents GARCH (1,1) model estimations for equation (2). The value in parentheses represent the coefficient probabilities.

$$\sigma^2_t = 0.001628 + 0.408993\varepsilon^2_{t-1} + 0.392587\sigma^2_{t-1} \quad (3)$$
$$(0.02) \qquad (0.01) \qquad (0.02)$$

According to probability values in equation (3), the ARCH and GHARCH coefficients (α and β) are significant since their respective probability is less than 5%. The sum of ARCH and GARCH (α + β) is 0.8, indicating that the volatility shocks are quite persistent. Thus why oil prices are volatile? In other terms, why oil market prices are different than fundamentals that rationally justify its valuation?

4. Factors influencing oil price

We explore in this section the physical factors influencing oil price as well as the informational function of oil price represented by the oil future markets.

4.1 Physical Fundamental Factors

4.1.1 The oil supply

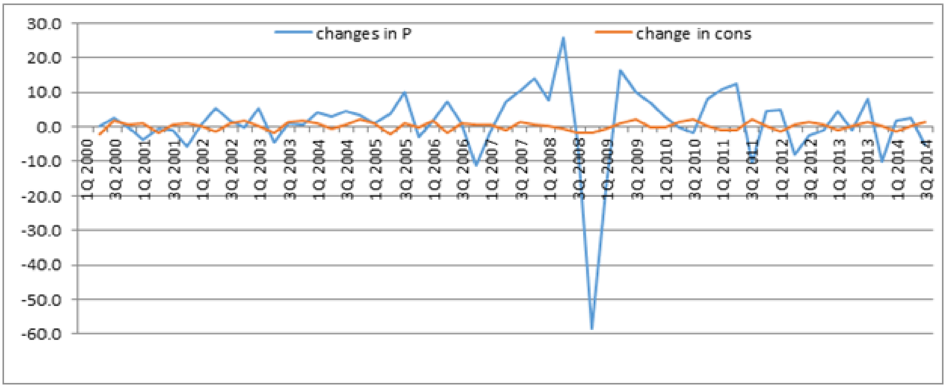
If oil were a normal product, competition would ultimately drive the price down to a level near to the current cost of production, which at the margin is probably somewhere between $20 and $30 a barrel. Certainly, the oil market is not a pure competitive market: The OPEC cartel controls 40 percent of the supply, and they retain about 78 per cent of the world's total proven crude oil reserves. This provide OPEC, when the cartel acts together to control production and balance the supply and demand, a clear influence on driving oil prices.

Moreover, two characteristics give the power to producer counties. In one hand, oil production is not labor intensive and, therefore, the oil supply can be controlled easily by reducing depletion rates without affecting the labor market. In other hand, producers incur no storage costs, since petroleum is simply left in the ground while consuming countries has to cover the technical costs of building storage facilities, interest on the value of oil stocks and various risks.

4.1.2 The oil demand

Oil demand is linked, in addition to demographic factors, to the levels of economic activity. Consumers and industrial users, tend to pick up their oil demand when growth rates of gross domestic product increase pushing up oil price and, slow down reducing oil price when those growth rates decline. Therefore, oil price tends to be volatile, at least partly due to variations in the business cycle. However, figure 3 where changes in oil consumption and changes in oil prices are drawn for the period Q1.2000- Q.3 2014, shows smooth changes in oil consumption and severe fluctuations in oil price. This implies that changes in oil consumption are not able to explain all changes in oil prices.

Figure 2: Changes in oil consumption (Million barrels/day) series and changes in oil price series from the Q1 2000 to the Q3 2014.



Source: Realized by the author based on data gathered from EIA. Gov database.

4.1.3. The oil inventories

Inventories of crude oil are held at various points in the petroleum distribution network. A small amount is held by oil lease holders at the oil field. Almost 50 percent of total stocks are held by the federal government in the Strategic Petroleum Reserve (SPR). The SPR was established to provide a buffer against a physical disruption in the delivery of imported crude oil. These inventories aim to compensate the gap between the oil supply and demand. Private stocks are also held to insure the efficient operation of refineries in the face of shifting seasonal product demand and potential disruptions in crude oil supply. Therefore, a decrease in oil inventories indicates a shortage in oil production and constitutes a supplemental supply.

$$\textit{Inventories level changes} = \textit{Demand} - \textit{Supply} \qquad (5)$$

However, if inventories of crude oil are low relative to the past average, or in the perception of market traders, this is considered as indication that the market is tight, implying that demand is nearly equal to, or might even exceed, potential supply at current price levels. As a result, upward pressure on spot price occurs, even if there is no physical shortage observable.

4.2 The impact of the dollar exchange rate

Oil is priced and contracts are settled in dollars. An increase in the dollar value against other currencies, everything being equal is therefore, interpreted as an oil price increase and inversely. The exchange rate variations of the U.S. dollar may affect the level and distribution of world oil demand and the oil price as consequences.

On the other hand, the oil financial assets became an attractive investment. A common speculation strategy during a falling US dollar is, for speculators and ordinary investment funds, to take futures positions selling the dollar "short" and oil "long". The increase in the speculative demand for dollar increases its value and makes oil price and dollar exchange rate more related.

4.3. Speculation factor and the information function of future oil price

The information content of prices was considered by economists as early as the 1940's. In 'the use of knowledge in society' Hayek (1945) writes: 'we must look at the price system as such a mechanism for communicating information if we want to understand its real function… The most significant fact about this system is the economy of knowledge with which it operates, or how little the individual participants need to know in order to take the right action'. This clearly states the relationship between information, prices, individual's decisions and market equilibrium.

However, since futures contracts are standardized in all details other than prices, futures markets are perfect for aggregating a diversity of thoughts about the predictable price of a goods at different period in time. A shared opinion on price forecasting is regularly easier to emerge at a futures market than among spot market where producers and consumers of a physical commodity are dispersed. We may think therefore that Futures markets are an important source of price information. In other terms, prices are usually said to be "realized" in futures markets and then transferred to spot markets. Progress in the usage of tools clearly related to oil has helped in price detection by carrying openly manageable, readily available information about current and anticipated future market situations into the spot market price.

4.3.1 Financial impact of speculation

Activity in crude oil futures and options contracts has been increasing since 2004 as interest in oil as an investment grew. During that period, the number of contracts outstanding (known as "open interest[1]") has more than tripled, and the number of traders has almost doubled. A widely accepted hypothesis would be that the financial aspect of the market, the influx of speculators and therefore the use of oil contracts as financial papers, determine significantly the dynamics of spot oil prices.

The large purchases of crude oil futures contracts by speculators have, in effect, created an additional demand for oil, driving up the price of oil for future delivery in the same manner that additional demand for contracts for the delivery of a physical barrel today drives up the oil price on the spot market. As far as the market is concerned, the demand for a barrel of oil that results from the purchase of a futures contract by a speculator is just as real as the demand for a barrel that results from the purchase of a futures contract by a refiner or other user of petroleum. Given that only about 5 percent of futures contracts are ever delivered as a physical product, increased uncertainty can encourage speculative behavior in the futures market and push up futures prices beyond that warranted by future market fundamentals. This, in turn, may impact the oil inventories level and constitutes a physical impact of speculation.

4.3.2 Physical impact of speculation

By purchasing large numbers of futures contracts, and thereby pushing up futures prices to even higher levels than current prices, speculators have provided a financial incentive for oil companies to buy more oil and place it in storage. A refiner will purchase extra oil today, if the futures price is higher than spot price. Changes in stocks levels are therefore related to the difference between spot and future oil price. In other terms, oil stocks (inventories) increase, when oil is cheap to be sold future when oil is expected to be expensive linking markets for physical petroleum products with financial markets. Therefore, changes in oil

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[1] The total number of futures contracts long or short in a delivery month or market that has been entered into and not yet liquidated by an offsetting transaction or fulfilled by delivery. Also called open contracts or open commitments

stocks level represent, as the oil future price, an information vehicle for oil price.

4.3.3 Testing the speculation as information vehicle

We investigate in the following the information function of the financial and physical dimension of speculation in the short run. We test therefore, a bi-directional causality relationship between the spot oil price monthly series and the monthly future price series of each future WTI contract (one, two, three and four months). However, to study the relation between oil price changes and the physical dimension of speculation, we test a bi-directional causality relation between spot oil price and OECD stocks level.

The spot and future oil price series are collected from the U.S. Energy Information Administration (EIA) monthly database. The monthly oil stocks series are collected from the database of OECD. The series cover the period from January 2000 to September 2014 194 observations for each variable.

4.3.3 A Methodology

A recognized way to statistically test for whether one variable leads another or inversely, are known as Granger Causality test. Granger (1969) proposed a bi-directional test. In the Granger-sense X does cause Y if it is suitable in forecasting Y. In this context "suitable" involves that X is able to rise the precision of the prediction of Y with respect to a forecast, considering only past values of Y.

In Granger sense, testing causality, entails utilizing *F* tests to test whether lagged information on a variable *Y* delivers any statistically significant information about a variable *X* in the existence of lagged *X*. If not, then "*Y* does not Granger-cause *X*".

$$X_j = c_1 + \sum \alpha_j X_{t-1} + \sum \beta_J .\ Y_{t-1} + u_t \qquad (6) \text{ where } j = 1 \text{ to } p$$

Another caution is that Granger-causality tests are very sensitive to the selection of lag length and to the methods engaged in dealing with any non-stationarity of the time series. Thus, the prior step is to analysis whether individual series are stationary. The standard test for the presence of a unit root is the "Augmented Dickey Fuller test" identified by Dickey, D.A. and W.A. Fuller (1981).

4.3.3 B Test results

Stationary Test Results:

The ADF test results reported in table 3 indicate that all the series for log spot price and future price are integrated of order 1. The results indicate also that the monthly series of OECDE stocks is I(1).

Table 3: Unit Root Tests for individual series in Log

Variables	Models	Lag	Calculated ADF in levels	Lag	Calculated ADF in Differences
LogPt:	*Intercept*	*1*	*-2.1295*	*0*	*-9.016****
	Trend & Intercept	*1*	*-2.0442*	*0*	*-9.0659***p*
	None	*1*	*-0.868*	*0*	*-9.039****
LogF1t:	*Intercept*	*1*	*-2.1264*	*0*	*-8.971****
	Trend & Intercept	*1*	*-2.045*	*0*	*-9.020****
	None	*1*	*-0.864*	*0*	*-8.994****
LogF2t:	*Intercept*	*1*	*-2.1261*	*0*	*-8.818****
	Trend & Intercept	*1*	*-2.050*	*0*	*-8.169****
	None	*1*	*-0.836*	*0*	*-8.841****
LogF3t:	*Intercept*	*1*	*-2.123*	*0*	*-8.718****
	Trend & Intercept	*1*	*-2.052*	*0*	*-8.771****
	None	*1*	*-0.812*	*0*	*-8.741****
LogF4t:	*Intercept*	*1*	*-2.116*	*0*	*-8.647****
	Trend & Intercept	*1*	*-2.044*	*0*	*-8.701****
	None	*1*	*-0.793*	*0*	*-8.669****
Log Inventories:	*Intercept*	*1*	*-1.965*	*0*	*-13.88****
	Trend & Intercept	*1*	*-2.707*	*0*	*-13.88****
	None	*1*	*1.088*	*0*	*-13.79****

Significant at the 1% level, **Significant at 5% level, *Significant at10% level.* ***Source:* *Author calculation.*

Causality Test Results

Since all series are I(1), we consider the series in difference in order to run the Granger test. We consider also for each equation, the lag length which minimize the Akaike and Schwarz information criterion. The Granger causality test results reported in table 4 indicate that the future oil price, for the four contracts, does not cause the spot oil price. On the other hand, results indicate that changes in oil inventories level cause changes in spot oil price in the short run.

Table 4: Granger Causality Tests

Null Hypothesis	Observations	Lags	F-Statistic	Probability	Results
D(logF1) does not Granger Cause D(logP) *D(logP) does not Granger Cause D(logF1)*	*192*	*1*	*0.54* *0.02*	*0.45* *0.86*	*Accepted* *Accepted*
D(logF2) does not Granger Cause D(logP) *D(logP) does not Granger Cause D(logF2)*	*191*	*2*	*1.22* *0.27*	*0.29* *0.75*	*Accepted* *Accepted*
D(logF3) does not Granger Cause D(logP) *D(logP) does not Granger Cause D(logF3)*	*192*	*1*	*2.29* *0.57*	*0.41* *0.09*	*Accepted* *Accepted* *éù*
D(logF4) does not Granger Cause D(logP) *D(logP) does not Granger Cause D(logF4)*	*192*	*1*	*3.05* *0.67*	*0.08* *0.41*	*Accepted* *Accepted*
D(logP) does not Granger Cause D(logINV) *D(logINV) does not Granger Cause D(logP)*	*192*	*1*	*1.33* *5.78*	*0.265* *0.003*	*Accepted* *Rejected*

Source: *Author calculation*

Results Analysis

The tests result indicate that the effects of financial speculation shocks diminish within the period of one month contributing little to low-frequency in spot oil price movements. However, speculation in oil futures markets generate volatility in physical crude oil inventories and, in turn, in spot oil price volatility. Oil stocks increase, when the oil is cheap to be sold future when the oil is expected be expensive. In other terms, the impact of future price on spot price is moderated by the variations in oil stocks. The impact of speculation in oil future market in the short run is therefore reflected by the variations in oil stocks.

Section 5: Oil Price Equilibrium model

This section models the oil price determination process with crude oil price as dependent variable.

5.1 Model explanation

In order to model the oil price, we consider five explanatory variables: the world oil production as proxy of the oil supply, the world oil consumption as proxy of the oil demand, the open interest on the WTI contract as proxy of the speculation on oil contracts, OECD oil inventories and the US/SDR exchange rate as proxy of the exchange rate value of the dollar against other currencies. The following equation represents our model for oil price determination:

$$Price_t = b_0 + b_1 Supply_t + b_2 Demand_t + b_3 \$Exchange_t + b_4 speculation_t + b_5 Inventories_t + u_t \quad (7)$$

In which U_t = noise disturbance term at time t, Price is the nominal crude oil price. Supply is the world oil production. Demand is the world oil consumption which is considered as proxy for the world oil demand. Exchange is the value of one $ terms of SDR. Inventory is the OECD oil stocks considered as proxy for world oil inventories and Speculation is the oil open interest on WTI contract in NYMEX considered as proxy speculation in oil market.

According to Microeconomic theory, an increase in oil consumption rises oil prices, while an increase in oil supply reduces it. We expect therefore, the regression coefficient associated with the consumption to be positive, while the coefficient associated with the Supply to be negative.

We also expect a negative relationship between $/SDR exchange rate and crude oil prices. A decrease in the dollar value against other currencies is everything being equal, a decrease in the value of oil price, since the latter is priced in dollar. The oil price will then rise to offset the impact of the diminution in the dollar value. The sign of speculation coefficient is expected to be positive. An increase in speculation is an increase in future oil demand and therefore in future oil prices creating tension on the spot oil market increasing the spot oil price.

Finally, we expect oil inventories coefficient to be negative. Since oil inventories is an information vehicle, a decrease in oil inventories indicates shortage oil market thus the oil price rise.

We note however, that political and historical events are omitted from the model. We assume that this does not create an endogeneity problem since the turmoil Middle East Countries didn't imply an increase in future or spot oil price. In other terms, we may assume that the variable speculation and the error term U_t are not correlated.

5.2 Data sources

The data cover the period, first quarter of 2000 to the third quarter of 2014. Spot and future oil price, the open interest the oil production and consumption are collected from the EIA quarterly database. The stocks level data are collected from the quarterly OECD database while the dollar/SDR exchange rate data are collected from the International Monetary Fund (IMF) database.

5.3. Econometric methodology

The used methodology is based on the Johansen co-integration test (1988) and the estimation of the error correction model by the Vector Autoregression method (VEC).

The co-integration notion, introduced by Granger (1988) is relevant to the problem of the determination of long-run or "equilibrium" relationship in economics. From a statistical point of view, a long-term relationship means that the variables move together over time so that short term disturbances from the long-term trend will be corrected. The VEC restricts the long-run behavior of the endogenous variables to converge to their co integrating relationships while allowing for short-run adjustment dynamic.

A prior step is to conduct a unit root test on each variable to find the order of integration. If all variables are integrated of the same order, we can then test for co-integration.

5.4. Results and Discussion

5.4.1 Stationary test

The ADF test results presented in table 4 indicate that all the series are not stationary in level. Taking in differences, all the series become stationary. In other term all the series are integrated of order 1 (I(1)).

Table 5: Unit Root Test Results for individual series

Variables	Lag	Probability Calculated ADF in levels	Lag	Probability Calculated ADF in first Differences
P	0	0.729	0	0.0000*
S	0	0.6642	0	0.0000*
CONS	4	0.7899	3	0.0445*
O	0	0.8110	0	0.0000*
I	2	-0.8341	1	0.0000*
X	0	0.6374	0	0.0000*

*Note: *the series is stationary since probability is less than 5%. Source: Author calculation*

5.4.2 Co integration test

Since All the series of the model are first order integrated I(1), we proceed to test for co integration. We should carry out the Johansen test with correct number of lags to eliminate serial correlation. Based on minimizing the information criterion, Schwarz information criterion (SC) and Akaike information criterion (AIC), 2 lags are found as the most parsimonious lag length for the variables. Thus, we perform the co-integration test including 2 lags with intercept and linear deterministic trend. The Johansen co integration tests are based on the Maximum Eigenvalue of the stochastic matrix as well as the Likelihood ratio test which is in turn based on the Trace of the stochastic matrix. In the Johansen test we exploit that the number of non-zero eigenvalues is at most the rank (r) of the matrix π, meaning that we can interpret the number of significant Eigenvalues as the number of co-integration relations. Table 5 shows the summary results of the two Johansen tests Maximum Eigenvalue and Trace test Likelihood co-integration tests. Both the trace test and the maximum Eigenvalue test indicate 1 co-integrating equation as the null hypothesis of r = 1 is rejected. Thus, it may be concluded that there is 1 long-run equilibrium relationship between the variables.

Table 6: Co-integration test results

Null Hypothesis	Alternative Hypothesis	Calculated value	0.05 Critical Value	Probability
		λ_{trace} value		
r=0	r=0	98.05357	95.75366	0.0344
r<=1	r>1	54.51647	69.81889	0.4393
r<=2	r>2	23.90954	47.85613	0.9444
r<=3	r>3	13.05605	29.79707	0.8890
r<=4	r>4	4.432180	15.49471	0.8657
r<=5	r>5	0.526067	3.841466	0.4683
		λ_{max} tests		
r=0	r=1	43.53709	40.07751	0.0196
r=1	r=2	30.60694	33.87687	0.1170
r=2	r=3	10.85348	27.58434	0.9690
r=3	r=4	8.62387	21.13162	0.8615
r=4	r=5	3.906113	14.26460	0.8691
r=5	r=5	0.526067	3.841466	0.4683

Source: Author calculation

5.4.3 Vector error correction model

The VEC estimations, include the short and long run estimates and shows that the error correction coefficient (-0.589712) which measures the speed of adjustment towards long-run equilibrium carries the expected negative sign and it is highly significant at the 1% level. I note however, that the model fits well the observed data as indicated by the R^2 (57%). In other terms, the model explains 57% of the oil price changes. Moreover, the model estimations by the Minimum least square methods indicate that the F-statistic is equal to 4.3 and its probability (0.000139) is less than 5%. This means that, considered together, the used dependent variables have significant impact on the oil price variations.

5.4.4 Model estimations

The long Run

The Vector Error Correlation Model (VECM) estimation of parameters in the long run and their relative t-statistics are presented in the table 7. The model estimations in long run:

P(-1)=-7.3*S(-1) + 9.4*CONS(-1) +0.4*O(-1) -1.1*I(-1) -3.4*X(-1) +2.3.(8)

Table 7: Vector Error Correction Estimates in the long run

Variable	Coefficient	Std. Error	T-statistic	Significant or non-significant
S(-1)	7.297290	2.63862	2.76557	Significant
CONS(-1)	-9.387415	2.46138	-3.81388	Significant
O(-1)	-0.430149	0.22354	-1.92426	Non-Significant
I(-1)	1.126570	1.42330	0.79152	Non-Significant
X(-1)	3.432259	1.01304	3.38809	Significant
C	-2.332837			

Source: Author calculation

The adjustment dynamic

The short-run adjustment dynamic indicates how the endogenous variable, the oil price, converge to the co integrating relationships. It shows how the oil price returns to its equilibrium value of long term. In other terms it shows the d(P) model which allows to rich the long run equilibrium. Akaike and Schwarz criterions, indicate that it is better to take the model in lag 2. The VECM estimates and their relative t-statistics in the short run are presented in the table 8. The adjustment dynamic is therefore:

Table 8: The adjustment dynamic estimation

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Significant or non-significant*
Equation (7)	*-0.589712*	*0.159984*	*-3.68606*	Significant
D(P(-1))	*0.407917*	*0.158388*	*2.575436*	Significant
D(P(-2))	*-0.049868*	*0.180599*	*-0.276126*	Non-Significant
D(S(-1))	2.151600	2.312181	0.930550	Non-Significant
D(S(-2))	0.830398	2.149441	0.386332	Non-Significant
D(CONS(-1))	0.239481	1.881161	0.127305	Non-Significant
D(CONS(-2))	0.893642	1.631005	0.547909	Non-Significant
D(O(-1))	-0.157592	0.263794	-0.597407	Non-Significant
D(O(-2))	-0.203457	0.284910	-0.714109	Non-Significant
D(I(-1))	1.866887	1.549812	1.204589	Non-Significant
D(I(-2))	-2.154854	1.316753	-1.636490	Non-Significant
D(X(-1))	2.885887	1.748943	1.650075	Non-Significant
D(X(-2))	1.597168	1.619624	0.986135	Non-Significant
C	0.018550	0.019761	0.938712	Non-Significant

Source: Author calculation

The adjustment dynamic is therefore:

D(P) = -0.6*P(-1) – 4.4*S(-1) + 5.6*CONS(-1) +0.2*O(-1) – 0.6*I(-1) - 2*X(-1) + 0.4*D(P(-1)) - 0.05*D(P(-2)) + 2.1*D(S(-1)) + 0.8*D(S(-2)) + 0.24*D(CONS(-1)) + 0.9*D(CONS(-2)) - 0.1*D(O(-1)) - 0.2*D(O(-2)) + 1.8*D(I(-1)) - 2.1*D(I(-2)) + 2.9*D(X(-1)) + 1.6*D(X(-2)) –2. (9)

5.4.5 Residuals diagnostics

The estimated model has no serial correlation in the residuals as the Breusch-Godfrey Serial Correlation LM Test (table 7) results indicate that the probability of Obs*R-squared is equal to 0.1890 (more than 5%.). Furthermore, the model has no heterosdasticity as the Arch test results presented in table 8 below indicate that the probability of Obs*R-squared is 0.1852 (more than 5%). Therefore, the model can be used for forecasting. This is confirmed by the low value of the Root Mean Squared Error.

Table 9: Breusch-Godfrey Serial Correlation LM T including 2 lags

F-statistic	1.265490	Prob. F(2,40)	0.2932
Obs*R-squared	3.332508	Prob. Chi-Square(2)	0.1890

Source: *Author calculation*

Table 10: Heteroskedasticity test

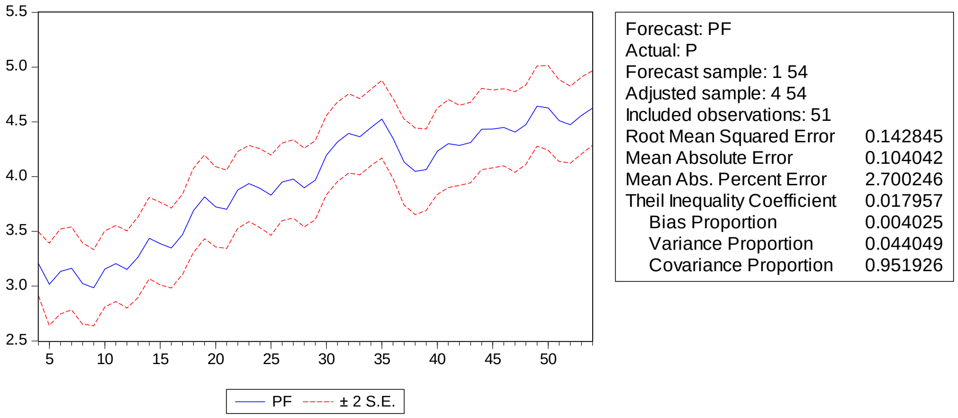
F-statistic	1.698494	Prob. F(2,51))	0.1931
Obs*R-squared	3.372197	Prob. Chi-Square(1)	0.1852

Source: *Author calculation*

5.4.6. Forecasting

As shown in figure 6 the estimated model lays between 2 standard deviations. In other hand, the gap between actual price and forecasted price represented by the Root Mean Squared Error = 0.14 is quite small. Thus, the predictive power of our regression model is satisfactory.

Figure 3: Dynamic forecasting



Source: Realized by the author using Eviews

5.4.7 Results and Analysis

The long run model estimations validate our expectations related to the sign of the variable coefficients. The findings show as in Hamilton (2008) that the variables oil supply and oil demand are significant for oil price determination. The estimates indicate that an increase in oil production by 1%, everything being equal, reduces oil price by 7%, while an increase in oil consumption by 1%, increases the oil price by 9 %.

As Chen and Chen (2007),. Throop (1993), Zhou (1995)[1] and Dibooglu (1995) [2] who found that there is a link between oil prices and exchange rates, the results show that an increase in dollar/SDR exchange rate which means an appreciation in the dollar value against major currencies by 1% implies a decrease of oil price by 3.4 %. In other terms, an appreciation of the dollar value indicates an increase in oil price value, and implies a market oil price reduction to maintain the market equilibrium of long term.

Relatively to the oil inventories, the estimates indicate a positive relation between oil inventory level and oil price in the long run. A decrease in oil inventories is a supplemental oil supply and therefore a decrease in oil price. Yet the findings indicate, by contrast with Zamani (2004), Ye et al. (2002, 2005 and 2006) that changes in oil inventories are not significant for changes in oil price.

Finally, the findings show a positive correlation between oil spot price and future oil market activity. However, the estimates indicate as in Taback (2003) that the explanatory power of futures activity was low for changes in spot prices.

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[1] Different sources of real shocks have been investigated in Zhou (1995). Among many sources of real disturbances, such as oil prices, fiscal policy, and productivity shocks, it has been shown that oil price fluctuations play a major role in explaining real exchange rate movements.

[2] In the case of the dollar, the link is generally found to be positive, which means that an increase in oil price goes with a dollar appreciation.

6. Conclusion

We explore in this study the information function of future oil price in the short run. The bi-direction Granger causality test results for monthly time series data prove that there is no causality relationship between spot and future oil price. However, test results indicate that changes in the OECD inventories Granger cause changes in oil spot price. We conclude that changes in oil future price impact is moderated by changes in oil inventories which impact spot oil price.

We consider, the joint impact of economic and financial factors on oil price to construct an oil price determination model which accounts for economic and financial factors. The findings prove that the oil price, the world oil production, the world oil consumption, the open interest on the WTI contracts, the OECD oil inventories and the US/SDR exchange rate are related in a long run relationship and that the oil supply and demand are the main factors influencing the changes in oil price in the long run. The descriptive statistics of the estimated model indicate however, that the latter is reliable for forecasting.

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