Does speculation drive oil prices?

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Abstract

This paper aims to identify the various factors that affect the dynamics of West Texas Intermediate (WTI) crude oil spot prices and empirically assess their role. A relationship between the identified factors is investigated and the presence of the speculative component is also studied. For the empirical evaluation a VEC specification is estimated using as endogenous variables the Dollar/Euro exchange rate, the interest rate for the US Treasury constant maturities and other variables related to the US crude oil supply, in order to capture the influences and the size of the explanatory variables. The results of this exercise confirm the worries expressed by world consumers about the extreme volatility of the oil price induced by speculation and by the erratic trend of the dollar/euro exchange rate. Given the strong impact of oil price volatility on the global inflation and growth, it becomes necessary to think about the possibility to express the oil price in another numéraire or a basket of different currencies but also to start to consider oil as a "common" good requiring consequently an international surveillance policy finalized to reduce the impact of speculative financial behavior on its price.

1 Introduction

Crude oil prices have been showing an exceptional volatility which has led to an increase in uncertainty of the energy sector as a whole. In 2007 the price of a barrel of crude oil was traded at less than \$60. During the spring of 2008 the oil price had cross the threshold of \$100/bd for the first time, reaching a record of \$147/bd in July. At the end of August it remained very high (around \$115/bd) but only four months later it dropped back to US\$ 45/bd (on December 29, 2008). Through March and April 2009, oil was traded at about \$40 per barrel. By august 2009, prices returned to \$70 a barrel.

Oil price fluctuation really affects consumers, producers and marketers especially in terms of costs, incentives to invest in technology and trading strategies. At present the price of crude oil does not seem to be provided by the traditional relationship between supply and demand[1] but it is affected by others factors as a dynamic financial market and changing political forces (Stevans, Sessions (2008) [13]). We assume that active financial traders operating in the oil market may cause large deviations of prices from fundamentals. In particular some "speculator" (i.e., large banks and hedge funds) not directly interested in the delivery of oil, may strongly affect this market. The involvement of hedge funds, private speculators or public investors and the wide use of derivative instruments in commodity market (i.e., oil, gold and other raw materials) have led the oil spot price to rise far above the marginal cost of production. The recent rise in oil prices may be generated by both changes in market fundamentals and speculation (Kaufmann, Ullman (2009) [10]). Other economists (i.e., Krugman (2008) [11]) sustain that the "oil bubble" is not due to speculation but it may be a result of other variables linked to the growing consumption of emerging countries (i.e., China, India) and the increasing cost of exploration and drilling activities.

The relationship between oil price and the factors which affect its volatility over time has been largely investigated, using different set of historical data and different methodologies.

Links between spot and futures (for both near month and far month contracts) oil prices are investigated in [10]. This paper examines the causal relationship between prices of the different crude oil blends from North America, Europe, Africa and Middle East using a cointegration analysis in a VAR framework. Different data set periods are investigated averaging daily obser-

[1] The oil price evolution depends in part on the specific features of this sector. The sector is still oligopolistic with few countries which operate as a cartel (OPEC), so any OPEC decision (increasing or reducing production) may affect the oil price widely. In the short-run the demand and supply for crude oil are strongly inelastic (rigid) since there are no substitutes readily available and producers tend to work on a full capacity therefore they cannot adjust to take advantage of higher prices.

vations to weekly values. Their results suggest that the recent rise in oil prices is generated by both changes in market fundamentals and speculation. The increasing demand of non-OPEC countries (i.e., emerging countries) affects the supply/demand balance requiring higher prices. Hence these changes in fundamentals are recognized by speculators who take position accordingly. Increases of prices are anticipated on the futures market and then are transmitted to the spot market, which drives prices beyond levels justified by the existing supply/demand balance.

Relationship among the US real price of crude oil and factors which affect its movement over time (futures prices, the value of dollar, exploration, world demand and supply) is examined in [13], using different specification of the VEC model. The data set is monthly and the time period used is from January 1998 to March 2008. The authors verify that for model specification that includes shorter term futures contracts the spot oil prices are dominated by real supply, whereas for longer term contracts the crude oil price is dominated mainly by futures prices. From a policy perspective their conclusions show that if regulators really want to avoid speculation in the oil market they should limit the longer term futures contracts.

The impact of exchange rates on commodities and vice versa is largely investigated (i.e, see Chen et al. (2008) [1]). Some authors highlight the role of the dollar as numéraire (see Geman (2005) [5], Cuaresma and Breitenfellner (2008) [3]) of standard commodities since a change in dollar exchange rate inevitably modifies the terms of trade among each couple of countries (i.e., see Schulmeister (2000) [12]). In a flexible exchange rate market, changes in commodities prices are affected by their numéraire. Cuaresma and Breitenfellner (2008) [3] perform a simple forecasting exercise using a vector correction model (VEC), in order to evaluate whether changes in dollar/euro exchange rate contain information about future changes in oil prices. They estimate different specification of this model using monthly data from January 1983 to December 1996 and showing that exchange rate provides information improves on oil price forecasting.

The physical (non financial) determinants of the real price of Brent crude oil are investigated in [2] using an equilibrium correction model over the last two decades. The paper examines, as exogenous variables, the demand for oil from the OECD[2] together with non-OECD (especially China and India)

[2]According to the International Energy Agency (EIA) the OECD countries still represent 60% of the world energy consumption.

demand and inventories. The frequency of data is quarterly and the data set refers to the period 1989-2005. They find two cointegrating relations which affect the change in oil prices. One cointegrating relation refers to OPEC's cartel behavior using its market power and quotas, the other is represented by the coverage rate of expected future demand by OECD using inventories behavior.

Our goal in this paper is to revisit some of the above mentioned issues. In particular using monthly data over the period 1986-2009, we examine the relationship among West Texas Intermediate (WTI) crude oil spot and the 5-year Treasury Constant Maturities, the exchange rate ($/€), the US imports of crude oil, the US oil ending stocks and the number of the US crude oil exploratory and developmental wells drilled. We perform a cointegration analysis in a VAR framework in order to examine the different factors which affect the dynamics of spot oil prices, distinguishing between the role of real and speculative components.

The remainder of the paper is organized as follows. Section 2 describes the data set and provides some standard statistics of energy data. In Section 3 the methodology and the empirical are presented and Section 4 draws some conclusions.

2 The dataset

The sample period is January 1986 - May 2009. The analysis is assessed using the following variables:

- O_t - WTI[3] crude oil spot prices (dollars per barrel $/bd)
- i_t - 5-year Constant Maturities
- E_t - dollar/euro exchange rates
- I_t - US imports of crude oil (thousand barrels)
- S_t - US ending stocks of crude oil (thousand barrels)
- W_t - number of the US crude oil exploratory and developmental wells drilled

[3]WTI is the benchmark for crude oil spot prices and the underlying commodity of the NYMEX's oil future contracts [5].

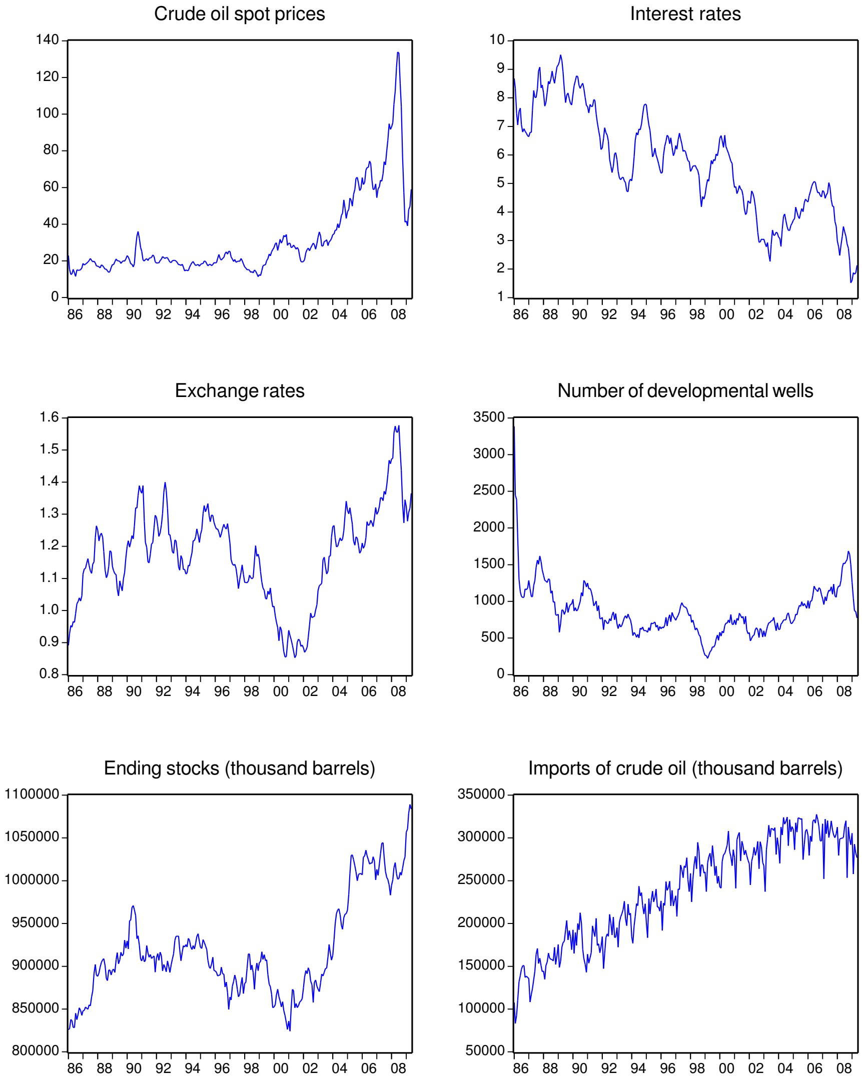

Figure 1: Data (2001-2009).

Table 1: Unit root test results for the logged time series.

Series	t_γ	τ_0	τ_1	τ_d	Decision
O_t	0.53 (1)	-1.67 (1)	-2.97 (1)	-12.88 (0)	I(1)
i_t	-1.19 (2)	-0.74 (2)	-3.33^{****} (15)	-20.4 (13)	I(1)
E_t	-0.77 (2)	-2.40 (1)	-2.41 (1)	-11.17 (1)	I(1)
W_t	-0.35 (6)	-3.65^{***} (3)	-3.63^{**} (3)	-8.07 (5)	I(I)
S_t	1.48 (0)	-0.74 (0)	-1.34 (0)	-15.39 (0)	I(1)
I_t	3.00 (12)	-3.04^{*} (12)	-0.65 (12)	-6.94 (11)	I(1)

All data is monthly. Following the recent literature, we convert all data in natural logarithmic units in order to interpret the estimated coefficients as elasticities.

A preliminary analysis is going to be performed on the stationarity of the time series. First we test the order of integration of the time series using the Augmented Dickey-Fuller (ADF) type regression:

$$\Delta y_t = \alpha_0 + \alpha_1 t + \gamma y_{t-1} + \sum_{j=1}^{k} \beta_j \Delta y_{t-j} + \epsilon_t \tag{1}$$

where $\Delta y_t = y_t - y_{t-1}$ and the lag length k is automatic based on Scharwz information criterion (SIC). The results of the unit root test are reported in Table 1 [4], respectively.

We run the test without any exogenous variable, with a constant and a constant plus a linear time trend as exogenous variables in Eq. (1). The reported t-statistics are t_γ, τ_0 and τ_1, respectively. τ_d is the t-statistic for the ADF tests in first-differenced data. For almost each case we reject the hypothesis in first-difference, hence we conclude that these variables are first-difference stationary (i.e. the series are $I(1)$) with the exception of i_t which is

[4] The 5% significance levels are -1.94 for ADF without exogenous variables, -2.86 for ADF with a constant, and -3.41 for ADF with a constant and trend. $(*)$ denotes acceptance of the null at the 3%, $(**)$ denotes acceptance of the null at the conventional test sizes, $(***)$ denotes rejection of the null at the conventional test sizes, $(****)$ denotes acceptance of the null at the 6%. The SIC-based optimum lag lengths are in parentheses. All the series are in logs.

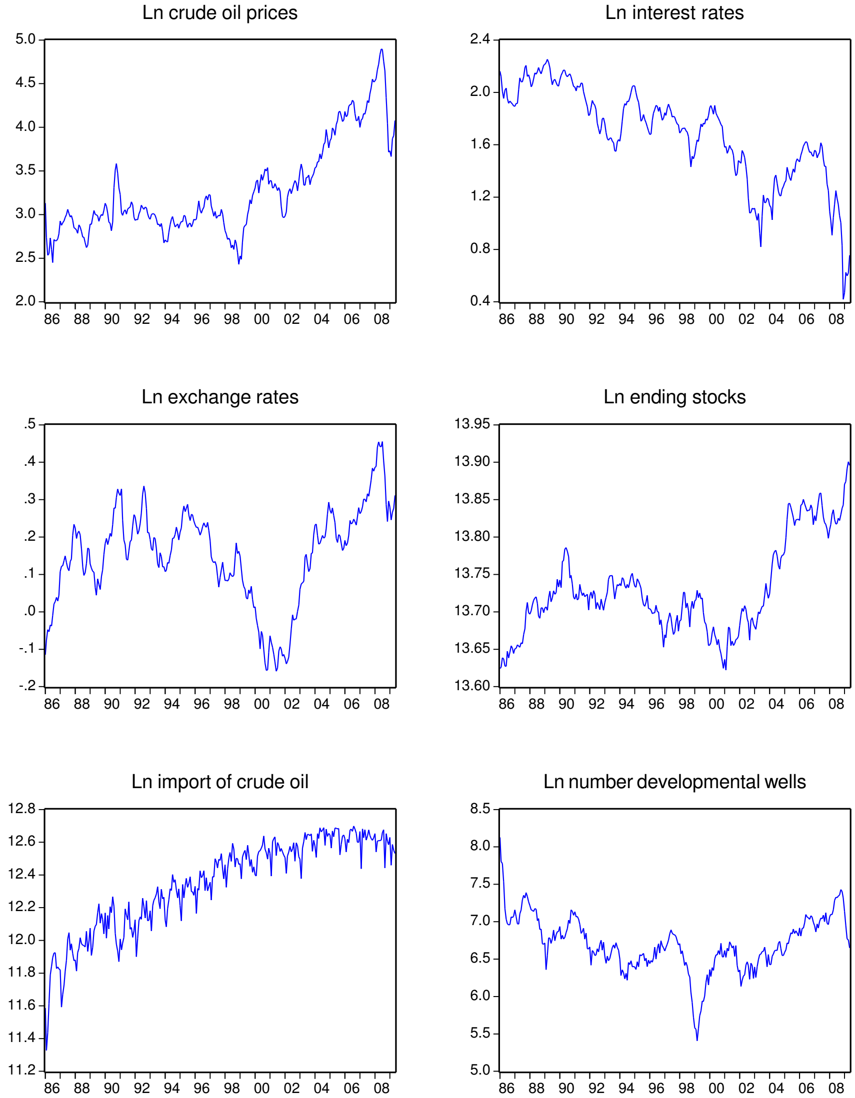

Figure 2: Financial and real logged data (2001-2009).

integrated of order two ($I(2)$)[5], so this variable is excluded from the analysis of the following section (3).

3 The cointegration analysis

The cointegration analysis is used to investigate the relationship between different time series. Cointegration means that one or more linear combinations of two or more variables are stationary even though individually they are not. From an economic point of view, cointegration implies that variables can drift apart in the short run, but they will show a long run equilibrium to which the system converges over time. In other words the series are drifting together at roughly the same rate, they have the same long wave or stochastic trend.

We estimate a cointegration analysis using the approach due to Johansen [6, 7] and Stock and Watson [14], based on VAR, which finds all possible cointegrating relationships.

To examine the number of cointegrating vectors we estimate four separate specifications of vector error correction model (VECM)[6], one for each successive futures contracts' maturity. Assume that the n-vector of non-stationary I(1) variables Y_t follows a vector autoregressive (VAR) process of order p,

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \epsilon_t \tag{2}$$

with ϵ_t as the corresponding n-dimensional white noise, and $n \times n$ A_i, $i = 1, \ldots, p$ matrices of coefficients[7]. Eq. (2) is equivalently written in a VECM framework,

$$\Delta Y_t = D_1 \Delta Y_{t-1} + D_2 \Delta Y_{t-2} + \ldots + D_p \Delta Y_{t-p+1} + D Y_{t-1} + \epsilon_t \tag{3}$$

where $D_i = -(A_{i+1} + .. + A_p)$, $i = 1, 2, \ldots, p-1$ and $D = (A_1 + .. + A_p - I_n)$. The Granger's representation theorem [4] asserts that if D has reduced rank $r \in (0, n)$, then $n \times r$ matrices Γ and B exist, each with rank r, such that

[5] For the variable i_t we run the unit root test also on second-differenced data. The related t-statistic $\tau_d 2$ is -8.931088 with a Lag Length of 8). We reject the null hypothesis of unit root at the conventional test sizes.

[6] VECM is based on the so-called reduced rank regression method (see [8]).

[7] In the following, for the VAR(p) model we exclude the presence of exogenous variables.

Table 2: Cointegration rank test for logged prices.

Nr. of coint. vec.	Eigenvalue	λ_{trace}	$\lambda^{0.05}_{\text{trace}}$	$\lambda_{\max}$	$\lambda^{0.05}_{\max}$
$r = 0$	0.21	119.1	95.75	65.11	40.07
$r \leq 1$	0.07	54.01	69.81	21.94	33.87
$r \leq 2$	0.05	32.06	47.85	16.02	27.58
$r \leq 3$	0.03	16.03	29.79	9.92	21.13
$r \leq 4$	0.2	6.11	15.49	6.09	14.26
$r \leq 5$	4.04E-05	0.01	3.84	0.01	3.84

$D = -\Gamma B'$ and $B'Y_t$ is $I(0)$. r is the number of cointegrating relations and the coefficients of the cointegrating vectors are reported in the columns of B. If the matrix D has full rank ($r = n$) the starting variables are all I_0 and not I_1. On the other hand, if $r = 0$ the number of common stochastic trends is equal to to the number of variables n, which meas that the variables are dominated by different stochastic trends. If $r < n$, there are $n - r$ common trends among the variables and r linear combinations (stationary cointegrating relations). Note that the cointegrating vector $B'Y_t$ is not unique unless for $r = 1$. If the cointegrating relation is only one ($r = 1$) we can rewrite $B'Y_t$ in this form,

$$v_t = B_1 + B_2 O_t + B_3 F_{it} + B_4 i_t + B_5 E_t + B_6 P_t + B_7 S_t + B_8 W_t + B_9 I_t \quad (4)$$

In order to better interpret the estimated coefficients a normalization (see Johansen (2005) [9]) rule needs. We choose to normalize equation 4 with respect to B_2,

$$O_t = \theta_1 + \theta_2 F_{it} + \theta_3 i_t + \theta_4 E_t + \theta_5 P_t + \theta_6 S_t + \theta_7 W_t + \theta_8 I_t + \eta i \quad (5)$$

where $\theta i = -\frac{\theta_i}{\theta_2}$ and $\eta_i = -\frac{v_i}{\theta_2}$.

The cointegration results are shown in Tables 2.

A rejection of the null 'no cointegrated' relationship in favor of 'r at most 1' at the 5% significance level is provided. This provides evidence of the existence of one cointegrating relationship among the variables.

Table 3 shows the estimated coefficients in the cointegrated relation (eq. 4). Interpreting these coefficients (θ) as the long run effect of each variable

Table 3: VEC results (t statistics in parenthesis).

Series	Estimated coefficients (B)
O_t	1
i_t	0.58 (4.25)
E_t	0.92 (2.51)
W_t	-0.91 (-8.48)
S_t	-3.79 (-3.97)
I_t	-0.59 (-2.70)

as the long-run effect of each variable on WTI crude oil spot price (O_t) (see Johansen (2005 [9]) the results of the model shows that concerning the real variables dynamics there is strong evidence of a negative relation between oil price and both the number of drilling and developmental wells of curde oil and the US imports of crude oil. The development of new oil resources and the conjunctural cycle of the US economy play, as it is quite expectable, an important role in influencing oil price trend, but financial variables are also very important in the oil market. Long term interest rate, which reflects the expectation on inflation and consequently the direction of the speculation behavior, as well as the dollar/euro exchange rate seem to have a heavy impact in the determination of oil price. As many authors observe the oil price is particularly affected by the evolution of the dollar/euro exchange rate which, as we know, it is on its turn strongly influenced by unpredictable variables. It follows, consequently, that in a very consistent way the price of one of the most important commodity for the global economy depends on variables that only in a limited size can be linked to the real market.

4 Conclusion

This paper analyzes the relationship between WTI crude oil spot prices and the 5-year Treasury Constant Maturities, the exchange rate ($/€), the US imports of crude oil, the US oil ending stocks and the number of the US crude oil exploratory and developmental wells drilled using a VEC model. The results of this exercise confirm the worries expressed by consumers about the extreme volatility of the oil price induced by speculation and by the erratic trend of the dollar/euro exchange rate. The analysis on these relations should be more investigated focusing the attention on a policy perspective. Given the strong impact of oil price volatility on the global inflation and growth, it becomes necessary to think about the possibility to reduce the influence of speculation on the oil market, especially introducing a new numéraire or a basket of different currencies to price oil. A further possibility to avoid the influence of non-real variables on oil market would be to start to consider oil as a "common" good and to introduce at the international governance level a special surveillance and monitoring policy to keep oil prices, as much as possible, in line with the market-driven values.

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