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The Effect of Financial and Macroeconomic Factors on the Oil Market

Nikolaos Sariannidis[1]*, Georgios Galyfianakis[2,3], Evagelos Drimbetas[4]

[1]Department of Financial Applications, Technological Education Institute of West Macedonia, Kila, 50100 Kozani, Greece, [2]Department of Accounting and Finance, School of Management and Economics, Technological Education Institute of Crete, Estavromenos, Iraklio, 71004, Crete, Greece, [3]Department of Economics, University of Thrace, 69100, Komotini, Greece, [4]Department of Economics, Democritus University of Thrace, 69100, Komotini, Greece. *Email: sarn@hol.gr

ABSTRACT

Our objective in this paper is to contribute to the discussion and identify, in the short-run, the effects of basic financial indicators (equity, bonds, exchange rates, Baltic exchange dry index) and widely traded commodities (Gold, Wheat) on the crude oil market. A generalized autoregressive conditional heteroskedasticity model is employed to test the above hypothesis for the period of almost 10 years using daily data from June 1st, 2004 to May 30th, 2014. The results coming out of our investigation suggest that wheat and bonds markets have negative impact to the oil market. Also, the results indicate that the volatility of US $/Yen exchange rate and the volatility of Baltic exchange dry index influence significantly negatively the oil market. Lastly, our findings indicate that both, gold market as well as stock market, positively influence the oil market, confirming the relevant literature which was reviewed and summarized.

Keywords: Glosten–Jagannathan–Runkle-Generalized Autoregressive Conditional Heteroskedasticity Model, Crude Oil West Texas Intermediate, Gold, Equity Market, Exchange Rates, Bonds Market, Commodities, Baltic Exchange Index
JEL Classifications: G10, Q40

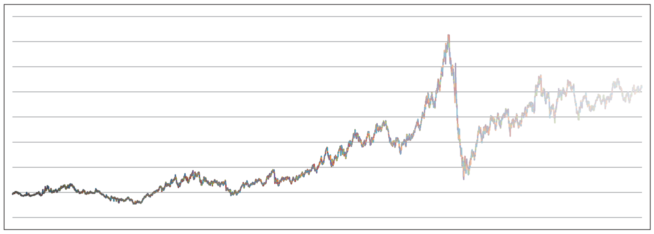
1. INTRODUCTION AND MOTIVATION

This paper examines in the short-run (day by day) the impact on oil prices in relation to financial indicators (equity, exchange rate, bonds, Baltic exchange dry index) and commodities (Gold, Wheat). More specifically, we proceed to analyze the implications of the generalized autoregressive conditional heteroskedasticity (GARCH) model developed by Glosten et al. (1993) to oil prices. The scope of this paper is to examine the relationship between oil prices and the above mention factors. Specifically, the contribution of this paper to the existing literature is two-fold. First, it uses recent data on the oil market and tests for the effect of specific financial determinants on oil's prices. Secondly, it contributes on the literature by imposing new parameters which are rarely been used to empirical investigation.

Oil market and oil itself has become a commodity that exhibits noticeable price volatility. Malik and Ewing (2013) mention that volatility in oil prices directly impacts both consumer behavior and financial markets and thus affects the performance of the overall economy. It is known that prior to the early 1970s crude oil prices were set up both by the major oil companies and OPEC[1]. Since the early 1980s the influence of OPEC has weakened and market forces have played an important role in the determination of oil prices. During the 1980s and 1990s oil prices remained relatively low and generally stable. Year 1983 marks the introduction by the New York Mercantile Exchange of crude oil futures contract trading (Plourde and Watkins, 1998). Since 2000s and especially since 2005 the upward movement trend of oil prices became more rapid reaching the unique highs of $145 per barrel in July 2008. After a fall in a very short period of $30 per barrel in December 2008 prices climbed again to $100 at the beginning of 2014 (Figure 1).

1 OPEC (Organization of the Petroleum Exporting Countries) is an International Organization and Economic Cartel of the oil-producing countries.

Figure 1: Crude oil West Texas Intermediate price $/Barrel



Source: Data Stream

Price changes in crude oil and other commodities markets are fundamentally determined by supply and demand imbalances. Those imbalances, according to the theory may originate from the business cycle, geopolitical events, unexpected weather patterns or catastrophes, etc. Next to that, and apart of the dynamics in financial markets, oil prices can be affected by the behavior of market participants that engage - at least in short-run - speculation (Fattcuh et al., 2013). Kaufmann (2011) supports the opinion that the large price changes of 2007-2008 are driven by changes in both market fundamentals and speculative pressures.

As crude oil is a commodity that economies relies on, then, oil related information such as prices, futures and financial indexes are among the most watched and interesting variables and indicators. Interestingly, the role of the other commodities and parameters taking into account in our paper and the linkages that exist between them in shaping oil prices, or influencing oil price volatility, has an intensive interest for the analysis dealing with the oil market.

The structured of this paper is as follows: Section 2 presents an overview of the existing relevant literature. In Section 3 are displayed the methodological considerations. Section 4 describes analytically the data used. Section 5 describes the econometric methodology and presents the empirical results. Finally the last section poses the main conclusions deduced by this paper.

2. THEORY AND LITERATURE REVIEW

Price changes in commodity markets are mainly caused by supply and demand imbalances, so called "the fundamental price variables." In oil market, real prices, especially during the last decade, cannot be explained only by economic fundamentals. Globalization of the economies and financialization of the future markets make speculation to become a major determinant in the spot price of crude oil (Kilian, 2009). A large number of studies illustrate that oil prices are generated by both changes in market fundamentals and speculation (Kaufmann, 2011). According to Ciffarelli and Paladino (2009) speculation plays a significant role in the oil market, which is consistent with the observed large daily upward and downward shifts in prices. The importance of speculation is disputed by other researchers like Hamilton (2009) that argues against an important role of speculation and Kaufmann (2011) argues that the large price changes of 2007-2008 were driven by changes in both market fundamentals and speculative pressures.

The relationship between oil prices and some other factors that affect oil prices over time has been largely investigated. Killian et al. (2012) argues that there is no consensus in the literature on how to model the global market for crude oil. Co-integration of financial markets and internationalization of economies have made all the markets to become more and more popular and easily accessed. Malik and Ewing (2013) support the idea of sharing of common information by financial market participants. Financial liberalization and opening of economies has generated increasing interest in the analysis of commodity markets. Commodity markets face a rapid growth in liquidity and investors are attracted to commodities purely as investments (Managi et al., 2013).

Gold market functions as a mobilization factor of hedge against portfolio and geopolitical risks and - According to the literature - A hedge against inflation (Malik and Ewing, 2013). Many other studies have shown that gold is used as a hedge in investment portfolios (Jaffe, 1989; Ciner, 2001; Capie et al., 2005). Furthermore, gold plays an important role as a store of value and as a safe haven investment especially in times of political and economic uncertainty (Baur and McDermott, 2010). Finally, the oil and gold prices are often considered interconnected in a cause and effect relationship through their link to inflation (Sariannidis and Kiohos, 2010).

Another body of related literature is devoted to the interactions between financial markets and interactions across different sectors (Malik and Ewing, 2013; Sadorsky, 2012). Dynamic interaction between commodity markets make investors to use progressively in their portfolios most of the parameters under investigation in our study. Managi et al. (2013) argues that the relationship between oil and commodity prices is complicated and suggest the need to take stock, energy, metal and agricultural markets integration into account. Related to that, Du et al. (2011) using data from 1998 to 2009 examine the volatility of crude oil prices and the relationship between oil and agricultural commodity markets. They found evidence of volatility spillover among crude oil, corn, and wheat markets.

Agricultural commodity prices seem to respond rapidly to actual and anticipated changes in financial and energy conditions. Agricultural commodities are used to produce energy (Piesse and Thirtle, 2009). Biofuel production has expanded rapidly in recent years affecting the prices of other grains like wheat. In the present research wheat market obviously is a significant determinant that affects energy market and global economy. Wheat is the most important food staple entering world trade. Over the years it has attracted many price supports or controls. Uncertainties, such as climate, affecting crop yields encouraged the developments of wheat future markets (Plourde and Watkins, 1998). Wheat may related with food security risk increasing uncertainty and global economic stability (Sariannidis, 2011). In that way, upward pressure of its price tent to have negative effect on oil prices due to the uncertainty to the economic development.

Regarding the determinant factor of the stock markets, Dow Jones (DJ) Industrial Average Index is used due to investigate its influence on the oil price. The theoretical link about stock market and consumption and thus the price of crude oil, can be based on using stock market as a proxy of economic wealth and as an element that stabilizes economy. The "wealth effect" of the stock market is identified as a significant determinant of oil consumption and hence oil price as well (Sariannidis, 2010). A lot of studies investigate the effect of oil prices on the stock markets. Some authors verify that there is no relationship between oil price shocks and stock market returns (Jammazi and Aloui, 2010). A negative relationship between oil prices and stock returns has been documented by Filis (2010) for the Greek stock market. For the same market Sariannidis et al. (2006) argues that Greek stock market has become less volatile for investors after the Greece introduction to Economic and Monetary Union creating a more stable economic environment.

The importance of bonds in the formation of oil prices could be explained not only by their involvement in the modern portfolio management but also through the role of interest rates in the economy. More specifically, interest rates affect the level of investments in the economy when the trend of interest rates is increasing the financial environment is more insecure. Although, to our knowledge, there is scarce literature explaining the role of long dated US Treasuries on oil prices, international liquidity seems to play an important role. If oil price is high, OPEC will need to re-invest the amounts of cash that they generate, and lot of this ended up invested in US 10-years bond. Other studies show that investors with considerable exposure to long-term bonds may be able to protect their investment through allocation to commodities, especially oil. Findings detected a surprisingly clear negative correlation between long-term bonds and certain oil-related instruments (Sury and Sury M, 2011). Further examination of the literature for bonds shows - online with other literature - A negative relationship between bonds and oil prices with "oil forming at best a very partial hedge against bond prices" (Lucey et al., 2010).

Economic activity and oil prices are another point under investigation from a lot of studies. Thus, there are studies showing that there is clear evidence that oil prices affect the US economy (Brown and Yucel, 2002; Sadorsky, 1999). Hamilton (1983) illustrated that oil price increases were responsible for every eight post-World War II US recession-except one- and concluded that declines in real gross national product derived from oil prices from 1948 to 1980. An increase in oil price volatility increases perceived price uncertainty for all economies. When prices are stable, economic agents underlying this when making economic decisions.

Baltic exchange price index, which is used in our study, is a leading indicator that provides a clear view into the global demand for commodities and raw materials and it is therefore an indicator of industrial output. The Baltic exchange dry index, used as a wealth proxy in our study, typically increases in value as demand for commodities and raw goods increases and decreases in value as demand for commodities and raw goods decreases. Increasing volatility of the index creates instability and a strong negative impact of economic growth. Rise in oil prices causes rise in price of goods and negative effects in aggregate demand for commodities. Relevant research (Filis et al., 2013) indicate that income can influence the economic growth as this is approximated by the industrial production. Similarly, industrial production is used as a proxy for economic growth by relevant literature (Filis, 2010; Espinoza et al., 2012).

Finally, another strand of the literature shows that the unexpected changes of exchange rates affect oil prices. The volatility of exchange rates influence prices of world traded goods and commodities and hence the price of crude oil (Piesse and Thirtle, 2009). According to Kwek and Koay (2006) and Bloningen (2005), the volatility of exchange rates influences traders and investors sentiment as they prefer to operate and invest their money in stable economies with a stable currency. The movements of the US Dollar and specifically the dollar depreciation and the related risk of further devaluation probably strengthen investor demand for oil futures affecting its price as well. Kilian (2009) argues that crude oil is traded in dollars. In addition, Japanese Yen is one of the most powerful currencies worldwide and a currency of carrying trade.

3. METHODOLOGICAL CONSIDERATIONS

Time series data have some special features characterizing them. Thus, they have been developed econometric techniques for the analysis of these characteristics. The first important feature of the distribution of the returns is that it tends to be leptokurtic with fat tails compared with the normal distribution. Secondly, another feature of data series returns is the leverage effect. This is a phenomenon which asymmetries are attributed. Third, another feature is "volatility clustering," which appears when there is a tendency of larger changes in data return prices following large changes, and smaller changes following small changes. Finally, another important feature of daily and squared daily return data series is the autocorrelation structure of the series, a phenomenon that volatility is persistent over time. ARCH models, introduced by Engle and Ng (1993), were designed to model and forecast conditional variance. The variance of the dependent variable is modeled as a function of the past value of the dependent variable and independent - or exogenous - variables. ARCH models, extended to the GARCH models by Bollerslev in 1986, allow the fat tails which are often observed in financial distributions and impose an autoregressive structure on the conditional variance. These techniques are widely used in econometric analysis and they are capable of capturing not only the volatility persistence of return series over time, but the volatility clustering as well.

An important drawback of ARCH and GARCH models is the fact that they are symmetric. In other words they account for the volatility reactions in positive and negative shocks in a symmetric way. The development of asymmetric models - which are capable of capturing the asymmetric features of the data - solve that problem.

Exponential GARCH (EGARCH) models can capture most of the asymmetry and express the variability of the conditional variance in a higher than normal level (Nelson, 1991). They were cover the need of models which take into account the asymmetry of time series. Despite their advantages EGARCH models are technically difficult as they involve highly non-linear algorithms.

The Glosten–Jagannathan–Runkle (GJR) - GARCH model, adopted in this paper and introduced by Glosten et al. (1993), has fewer parameters to be estimated and is a simple extension of the GARCH model accounting for any asymmetries involved. Asymmetry occurs when an unexpected drop in price due to bad news increases volatility more than an unexpected increase in price due to good news of similar magnitude. The GJR (p,q) model has p GARCH coefficients associated with lagged variances, q ARCH coefficients associated with lagged squared innovations, and q leverage coefficients associated with the square of negative lagged innovations.

The general form of the GJR (p,q) model is given as follows:

$Y_t = X_t'\theta + u_t$

Where, X_t is a vector of exogenous variables and u_t is the error term

$$\sigma_t^2 = k + \sum_{i=1}^{p} \gamma_i \sigma_{t-1}^2 + \sum_{i=1}^{q} a_i u_{t-1}^2 + \sum_{i=1}^{q} \xi_i I(u_{t-j} < 0) u_{t-1}^2$$

The indicator function $I(u_{t-j} < 0)$ equals 1 if $u_{t-j} < 0$, and 0 otherwise. Thus, the leverage coefficients are applied to negative innovations, giving negative changes additional weight.

For stationarity and positivity, the GJR model has the following constraints:

- $k > 0$
- $\gamma_i \geq 0,\ \alpha_j \geq 0$
- $\alpha_j + \xi_j \geq 0$
- $\sum_{i=1}^{p} \gamma_i + \sum_{j=1}^{q} a_i + \frac{1}{2}\sum_{j=1}^{q} \xi_j < 1$

The GARCH model is nested in the GJR model. If all leverage coefficients are zero, then the GJR model reduces to the GARCH model. This means you can test a GARCH model against a GJR model using the likelihood ratio test.

In our analysis we employ a GJR-GARCH (1,1) model which is defined by the following system of equations as follows:

The mean equation is:

$Y_t = X_t'\theta + u_t$

The conditional variance equation is:

$$\sigma_t^2 = k + \gamma\sigma_{t-1}^2 + a u_{t-1}^2 + \xi I(u_{t-j} < 0) u_{t-1}^2$$

Where, u_t GED (0, σ_t^2) it is assumed to follow the generalized error distribution. GED was adopted because of its ability to accommodate leptokurtosis.

The leverage effect occurs when $\xi > 0$. The condition for a non-negative variance requires that,

$k \geq 0,\ \gamma \geq 0,\ \alpha \geq 0,\ \alpha + \xi > 0$

When $R_t - \hat{R}_t < 0$ $R_t \Rightarrow u_t < 0$. The observed return R_t is less than the estimated return (mean return). When $I(u_{t-j} < 0)$ equals to 1 the negative change u_{t-1}^2 at time t−1 correlates with the volatility at time t.

In this type of modeling good news ($u_{t-1} > 0$) related to the bad news ($u_{t-1} < 0$) and has a different effect on the conditional variance. If $u_{t-1} > 0$, then at time t−1 we had good news, with a positive effect on the return because the residual is positive. Good news reflects on the coefficient α (ξ absorbs the effect of the bad news). However, bad news has an effect on α + ξ. If $I(u_{t-j} < 0)$ equals to 1 equation becomes:

$$\sigma_t^2 = k + \gamma\sigma_{t-1}^2 + a u_{t-1}^2 + \xi u_{t-1}^2 * 1 = k + \gamma\sigma_{t-1}^2 + (\alpha + \xi) u_{t-1}^2$$

When $\xi > 0$, we have the "leverage effect." In this case bad news have a greater effect on conditional volatility.

4. DATA

Concerning the empirical analysis, daily observations over a time period from June 1st, 2004 to May 30th, 2014 were extracted from Thomson Reuters DataStream. The sample consists of crude oil prices for the Benchmark West Texas Intermediate (WTI) expressed in US $ per barrel (Oil), Gold Bullion LBM U$/Troy Ounce (Gold), US Benchmark 10 Year DS Govt. Index - Clean Price Index (Bond), the US $/Yen exchange rate (d/y), Wheat, No.2 Hard -Kansas - Cts/Bu (Wheat), Dow Jones Industrial Average Index (DJ) and Baltic exchange dry index (Baltic). Our analysis focuses on returns as all price series were non-stationary in levels (we were unable to reject the hypothesis that the level of each series were non-stationary in levels).

We specifically examine WTI as a widely used data series in the empirical research. WTI is a primary crude oil stream traded on the US spot market at Cushing, Oklahoma center. In the oil market, WTI crude oil is considered to be a high quality crude, the most important benchmark oil and presumably the most important oil future market. Wheat and Gold are two of the main representatives of the large commodity markets. Wheat - Additionally to corn crops - Plays in agricultural market a strategic role affecting the global economy. Global wheat production is raised in 2014 to a record of 716 million tones. Gold is mainly a financial asset and it is considered that works as a "safe haven" from risky financial markets, and as a "store of value" and a "good hedge" in investment portfolios as we saw in the second section. Additionally, 10 years DS Government Bond Treasure (Bond) data series is the most recent auctioned 10 years treasure which is called "on the run issue." DJ Index is highly important variable affecting oil because of the increased participation of financial investors and formation of their portfolios with a variety of intergraded commodities. Dollar/Yen exchange rate has been used due to the significance of the dollar as the most traded invoice currency and Yen as one among the most important currencies of carrying trade. Finally, the Baltic Exchange price index is a leading indicator that provides a clear view into the global demand for commodities and raw materials and it is therefore an indicator of industrial output.

The aforementioned descriptions of the above mentioned data may justify the economic importance of investigating the relationship between these data and their correlation of formatting oil prices.

Market prices index are transformed to daily returns $R_t = \log \frac{p_t}{p_{t-1}}$

Where, R_t is daily return of used indexes for day t, P_t is current day closing price, P_{t-1} is closing price of the previous day, and log is natural logarithm.

5. METHODOLOGY AND EMPIRICAL FINDINGS

Descriptive statistics of daily returns are presented in Table 1 to aid our understanding of the nature and distributional characteristics for the Crude oil (*roil*), DJ (*rdj*), Gold (*rgold*), Bond (*rbond*), Wheat (*rwheat*), Baltic exchange dry index (*rbaltic*), US Dollar/Yen (*rdy*) return time series. The sample mean returns of these series are close to zero and we cannot reject the null hypothesis that the mean returns are not statistically different from zero. Also, by using the Jarque–Bera statistics, we conclude that essential departures from normality occur while the series are slightly asymmetric and leptokurtic. In order to establish the stationarity of our variables the augmented Dickey–Fuller test was first conducted - allowing for both an intercept and a time trend - in levels for all prices series data and the number of the lagged level terms was chosen based on Akaike's information criteria and Schwarz-Bayes criterion information criteria. When the test was conducted in first differences results show that all the individual series were stationary.

Our findings also show that the daily squared returns of the Baltic exchange dry index ($rbaltic^2$) and US Dollar/Yen (rdy^2) affect the conditional mean of the oil and hence in Table 2 are presented the preliminary statistical analysis of these series. At the 5% significance level the hypothesis that the means of the above series are equal to zero, is not rejected, so daily volatilities of these series influence the conditional mean of oil variable.

Table 3 shows the autocorrelation function (ACF) and partial ACF for daily returns and squared daily returns of oil time series. The Ljung–Box statistics show an autocorrelation on daily returns and strong autocorrelations in the squared daily returns, indicating conditional heteroskedasticity.

The final specification for the estimation of the mean and volatility for the oil series. The relevant specifications are:

Mean equation:

$$roil_t = b_0 + b_1 rdj_{t-1} + b_2 rgold_t + b_3 rbond_t + b_4 rwheat_t + b_5 rbaltic_t^2 + b_6 rdy_{t-1}^2 + u_t$$

Variance equation:

$$\sigma_t^2 = k + \gamma\sigma_{t-1}^2 + a u_{t-1}^2 + \xi I(u_{t-j} < 0) u_{t-1}^2$$

$u_t \sim GED\ (0, \sigma_t^2)$

To establish the appropriateness of the model we made some diagnostic tests. We test the residuals for serial correlation of the estimated model. Table 4 presents the LB(n) statistics for standardized residuals (which are not statistically significant) and for standardized squared residuals. The results show that the ARCH effect has disappeared and that the assumption of normal distribution is rejected.

Table 5 presents the results for the mean equations. The magnitude and the statistical significance of the DJ coefficient (0.11) imply the high degree of integration among financial and commodities markets. Moreover, the statistical significance of the b2 (Gold) coefficient (0.032) exerts positive effect on the conditional mean return of oil, evidence that probably the gold and oil prices are interconnected in a cause and effect relationship through their link to inflation. Additionally, b3 coefficient (10y-bonds) exerts negative effect, confirming the relevant literature due to the fact that the rise of interest rates influences the economic development. Wheat coefficient (b4) is also negative indicating that commodity markets and especially that of wheat may affect the oil prices. Lastly, the volatility of Baltic Exchange Price Index (b5), which is used as proxy for economic development, as well as volatility of $/Yen (b6) exchange rate reduce oil prices, probably because of the uncertainty and the anticipated and prescribed risk that they suggest.

In Table 6 we present the results for the variance equation. We observe that the value of γ coefficient (0.947), which reflects the influence of σ_{t-1}^2, is higher than the value of the α coefficient (0.023) which correlates the price variation of the present day to the price variation of the previous day. This results in the volatility of oil returns being persistent over time and consequently the volatility shocks (information) are slowly assimilated to the oil market. Furthermore, the ξ coefficient is positive (0.056) which implies that negative shocks provoke a larger response than positive shocks of equal magnitude. The price of oil normally

Table 1: Sample statistics

Statistics	*roil*	*rdj*	*rgold*	*rbond*	*rwheat*	*rbaltic*	*rdy*
Observations	2609	2609	2609	2609	2609	2609	2609
Mean	8.80E-05	0.00019	4.41E-04	1.90E-04	1.69E-04	−4.82E-04	2.78E-05
Standard deviation	0.005574	0.011566	0.012566	0.011566	0.02427	0.02171	0.006669
Skewness	0.044237	−0.07996	−0.55855	−0.07996	0.100287	−0.10253	0.102793
Kurtosis	10.308	14.6274	8.004944	14.6274	12.16309	7.293721	7.534718
JB	5808.841	14699.75	2858.746	14699.75	9131.767	2008.723	2240.036
ADF	−51.8252	−40.4595	−51.5392	−40.4595	−58.1475	−19.7831	−53.8439

ADF: Augmented Dickey–Fuller, JB: Jarque–Bera rises as a result of good economic prospects. Therefore, negative changes in the price of oil are associated with negative financial news which means that the volatility is transmitted from the other markets to the oil market leading to an increased volatility. Finally, the sum of $\gamma + \alpha + \frac{\xi}{2} = 0.947 + 0.023 + \frac{0.056}{2} = 0.9948$ which measures the volatility persistence is close to one and thus the shocks are expected to last a long time.

Table 2: Sample statistics of squared returns

Statistics	$rbaltic^2$	rdy^2
Observations	2609	2609
Mean	4.71E-04	4.45E-05
Standard deviation	0.001183	0.000114
Skewness	7.313299	9.582476
Kurtosis	77.8714	152.218
JB	632645.9	2460428
ADF	−24.2442	−6.61955

ADF: Augmented Dickey–Fuller, JB: Jarque–Bera

6. CONCLUSION

Changes in oil prices, according to the literature, tend to be permanent, difficult to predict and governed by different regimes and different determinant factors. One view is that oil price behavior is due to the fundamentals of supply and demand. Unquestionably speculation and financial markets play a very active role causing deviations from the equilibrium price and attracts many scientific arguments and works. In this study we use daily observations to examine, in the short-run, the role of basic financial indicators and widely traded commodities on the crude oil price were using a GJR-GARCH model.

Specifically we examine the influence of gold, 10-years bonds, wheat, industrial metals price index, US Dollar/Yen exchange rate, DJ-stock market index and Baltic exchange dry index, on the WTI crude oil market.

Table 3: Serial dependence in first and second moments of oil variable

Residuals				Squared residuals			
Lags	Autocorrelation	Partial correlation	LB (n)	Lags	Autocorrelation	Partial correlation	LB (n)
1	−0.015	−0.015	0.5639	1	0.201	0.201	105.65
2	0.003	0.003	0.5863	2	0.237	0.204	252.03
3	0.059	0.059	9.5378	3	0.292	0.232	474.79
6	−0.016	−0.022	26.042	6	0.205	0.045	1084.7
12	0.04	0.033	49.711	12	0.159	−0.027	1883.2
18	0.027	0.022	60.79	18	0.196	−0.029	2926.3
24	−0.038	−0.038	77.29	24	0.207	−0.001	3778.3
30	−0.009	−0.017	82.678	30	0.141	−0.08	4367.2
36	−0.018	−0.001	108.62	36	0.249	0.008	5130.4
48	−0.034	−0.023	166.75	48	0.204	−0.01	6441.1
60	0.005	0.002	190.53	60	0.1	−0.071	7481.5

LB (n) are the n-lag Ljung-Box statistics for oil_t and oil_t^2 respectively. LB (n) follows Chi-square distribution with n degree of freedom; the sample period contains 2609 daily returns

Table 4: Diagnostics on standardized and squared standardized residuals

Residuals				Squared residuals			
Lags	Autocorrelation	Partial correlation	LB (n)	Lags	Autocorrelation	Partial correlation	LB (n)
1	−0.027	−0.027	1.8571	1	0.052	0.052	6.9791
2	−0.002	−0.002	1.8651	2	−0.016	−0.019	7.6877
3	0.014	0.014	2.3824	3	0.021	0.023	8.8779
6	0.008	0.007	2.931	6	−0.004	−0.006	9.7948
12	0.032	0.032	8.1905	12	−0.018	−0.015	13.814
18	0.0001	−0.002	11.508	18	−0.006	−0.008	16.59
24	−0.03	−0.032	24.025	24	−0.025	−0.025	23.868
30	−0.016	−0.018	26.453	30	−0.031	−0.03	28.214
36	0.003	−0.002	31.555	36	−0.008	−0.011	30.361
48	−0.027	−0.027	50.041	48	−0.017	−0.016	38.427
60	−0.004	−0.004	65.541	60	−0.021	−0.02	56.085

LB (n) are the n-lag Ljung-Box statistics for the residual series. LB (n) follows Chi-square variable with n degree of freedom; the series of residual contains 2609 elements

Table 5: Mean equations

$roil_t = b_0 + b_1 rdj_{t-1} + b_2 rgold_t + b_3 rbond_t + b_4 rwheat_t + b_5 rbaltic_t^2 + b_6 rdy_{t-1}^2 + u_t$						
b_0	b_1	b_2	b_3	b_4	b_5	b_6
0.00016**	0.11*	0.032*	−0.096*	−0.01*	−0.175*	−1.24***
(7.76E-05)	(0.0078)	(0.0054)	(0.0156)	(0.0026)	(0.0687)	(0.6584)

Standards errors are shown in parentheses. *Indicates statistical significance at the 1% level. **Indicates statistical significance at the 5% level. ***Indicates statistical significance at the 10% level

Table 6: Variance equations

$$\sigma_t^2 = k + \gamma\sigma_{t-1}^2 + au_{t-1}^2 + \xi I(u_{t-j} < 0)u_{t-1}^2$$

k	γ	α	ξ
7.95E-08***	0.947*	0.023**	0.056*
(4.13E-08)	(0.007)	(0.009)	(0.013)

In parentheses we show the standards errors. *Indicates statistical significance at the 1% level. **Indicates statistical significance at the 5% level. ***Indicates statistical significance at the 10% level

According to our results, the first determinant factor, gold, reflects a positive transmission effect to the leading oil market. Gold constitutes mainly an important financial asset that investors include in their standard portfolios and a financial instrument that protects against declining movements of other assets. The internationalization of the economies and the integration of the markets has provoked investors to use more gold and oil in their portfolios. Investors move money into gold as a hedge against currencies. Also, investors buy large volumes of gold because they are worried about inflation. Oil and gold prices are considered that they are related in a cause and effect relationship through their link to inflation. Inflation follows the same direction of the oil prices and gold considered as a good inflation hedge tool, so, an increase of crude oil price creates inflationary pressures and increases the demand of gold which price is anticipated to increase.

Similarly, results show a positive relationship between the US Stock Market and the oil prices. The lag effect of interest rates and crude oil returns in the DJ model can be attributed to the investors' behavior to macroeconomic variable changes and more specifically that they take into account the trend of these variables. Investors seem to delay their investment decisions in order to realize whether the economic variables are permanent or temporary. Empirical results for all the other determinant factors show that over the period under consideration those factors affect the oil market negatively.

In our paper the empirical results show a negative correlation between wheat market and oil prices. Wheat seems to be related with uncertainty created of the food prices and the security risk[2] influencing that way oil prices. In the long-term wheat acts as a wealth proxy for the global equilibrium and upward pressure of its price inclines uncertainty and leads to the declining oil prices.

Similarly, 10-years Bonds have negative effect on oil price. Although there is scarce literature explaining the role of long dated US Treasuries on oil prices, international liquidity seems to play an important role in shaping this relationship. If oil prices are high, OPEC countries and other main producers will need to re-invest the amounts of cash that they generate, and lot of this ended up invested in US 10-years bond. When interest of 10-years Bonds goes up oil prices tend to go down.

2 According to the Food and Agriculture Organization (FAO), food security is achieved when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.

Volatility of U.S. $/Yen exchange rate returns exerts significant negative influence on the conditional mean returns of the oil prices. Oil market is priced in the "green currency" which has traditionally influence the price of oil. The increased volatility of U.S. $/Yen exchange rate creates instability and economic uncertainty and influence the prospect of development and therefore pushing down oil prices.

The empirical results of our analysis showed as well a negative transmission of the volatility of Baltic exchange index on oil prices. These findings may be attributed to the prior explanation and the fact that these shocks increasing world uncertainty for economic development and drives down oil prices. The increased volatility of Baltic exchange index creates instability and uncertainty on economic growth pushing down oil prices.

In our paper a number of theories were reviewed testing the selected data and confirming so far the relevant literature with our empirical results. Our results could lead us to a further research for volatility spillover effects and dynamic links, using other data or econometric models of empirical analysis and contributing more substantially to the relevant discussion.

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