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Investigating Causal Relationships on the Oil and International Capital Markets

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Abstract

The aim of the present paper is to study the relationship between international oil prices and international capital markets in the context of the current economic crisis. The research methodology consists in co-integration and Granger causality tests performed on daily data frequency for two of the most important spot oil prices used as a benchmark in oil pricing, mainly the West Texas Intermediate (WTI) and the Europe Brent and for several indices that track the performance of the international capital markets.

Key words: *spot oil price, international capital markets, Granger causality*

JEL Classification: G01, G15

Introduction

Nowadays, more than ever, the issues regarding the commodity and capital markets are of high concern both from the point of view of the natural resources global framework and from the perspective of the current economic and financial crisis. Therefore, the complex connections that characterize the relation between these markets stand for a focal point within the economic research field at international level. Taking into account all these considerations, the purpose of our paper is to capture the relationship between international oil and capital markets and focuses on the present economic crisis period by employing the co-integration technique and the Granger causality tests.

With regard to the scientific literature concerning the subject of our analysis, Sauter and Awerbuch (2002) provide a comprehensive review of the studies approaching oil price movements and their effect on economic and financial performance in IEA (International Energy Agency) countries, and tackle the effects of the oil price changes on the stock markets. The authors mention that the first study to analyze whether the reaction of international stock markets to oil shocks can be justified by current and future changes in real cash flows and/or changes in expected returns is that of Jones and Kaul (1996) that examine four markets: US, Canada, UK and Japan [11].

Jones and Kaul (1996) conclude that in the post-war period, the response of US and Canadian stock prices to oil shocks can be fully justified by the effect of these shocks on real cash flows alone. On the contrary, in both the UK and Japan, oil prices changes seem to cause larger changes in stock prices than can be justified by subsequent changes in real cash flows or by changing expected returns [5]. A study of Sadorsky (1999) that employed monthly data from 1947 to 1996 for the US market conclude that impulse response functions show that oil price movements are important in explaining movements in stock returns: individual shocks to oil prices depress real stock returns while shocks to stock market returns have a positive effect on industrial production. In addition, the author brings evidence that the oil price dynamics have changed in that after 1986, oil price movements explain a larger fraction of the forecast error variance in real stock returns than do interest rates [10].

Huang, Masulis, and Stoll (1996) investigate the relation of daily oil futures returns and daily US stock returns during the 1980s by employing a vector autoregressive approach. They conclude that oil futures returns are not correlated with stock market returns, even contemporaneously, except in the case of oil company returns [3]. Starting from prior works like that of Huang, Masulis, and Stoll (1996), indicating that daily oil futures price changes and the S&P 500 stock index movements are not related, Ciner (2001) studies the dynamic linkages between oil prices and the stock market and notices that this conclusion could be the result of the fact that the tests were not powerful enough to detect nonlinear linkages. Therefore, by employing nonlinear causality tests his work provides evidence that there is a nonlinear feedback relation between oil and the stock market. Furthermore, an important conclusion consists in the fact that stock index returns affect oil futures markets, suggesting a feedback relation, especially in the 1990s [1].

Papapetrou (2001), by focusing on the Greek market, uses a vector-autoregressive method in investigating the dynamic relationship between oil prices, real stock prices, interest rates, real economic activity and employment. The author concludes that impulse response functions show that oil prices are important in explaining stock price movements, the results suggesting that a positive oil price shock depresses real stock returns and that lasts for approximately four months [7].

Lake and Katrakilidis (2009) investigated the impact of oil price returns and oil price volatility on the Greek, the US, the UK and the German stock markets, using monthly data that covered the September 1999 – March 2007 period. The study concludes that both the Greek and the US stock market index returns are sensitive to the oil price returns changes. However, the German and the UK stock market returns are not influenced by the oil price returns movements [6]. Rault and Arouri (2009) study the relationship between oil prices and stock markets in Gulf Corporation Council (GCC) countries which are major net oil-exporters and important OPEC with excessively dependent on oil economies. They use data sets with weekly and monthly frequency for two periods: June 7, 2005 – October 21, 2008 and January 1996 – December 2007, respectively. Interestingly, they provide strong statistical evidence that the causal relationship is consistently bi-directional for Saudi Arabia, suggesting that, investors in world oil markets should consider changes in the Saudi stock market as these changes significantly affect oil prices. For the other GCC countries, stock market price movements do not Granger cause oil price changes, while stock price changes are Granger caused by oil price shocks [9].

Data Description

Within the analysis there were considered daily time series for the period between January 3, 2008 and March 30, 2010. In order to represent the oil market, two of the most important benchmark spot prices were considered, specifically the London Brent Crude Oil spot price (nominated BRENT within the analysis, see *Fig. 1*), and Cushing, OK WTI spot price (nominated WTI within the analysis, see *Fig. 2*). Oil market data was obtained from the Energy Information Administration - EIA (Agency for Statistics and analytical analysis of the U.S. Department of Energy) [12].

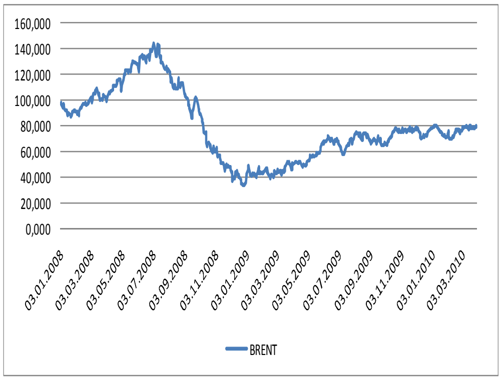

Fig. 1. Evolution of the London Brent Crude Oil spot price

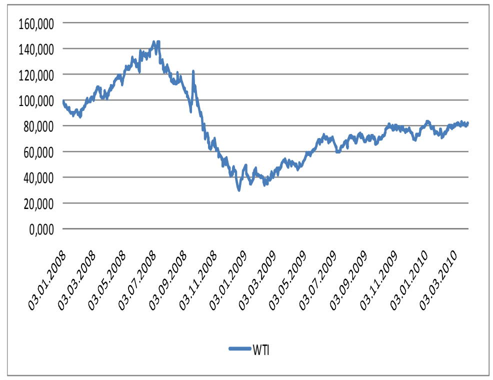

Fig. 2. Evolution of the Cushing, OK WTI spot price

The international capital markets are represented within this study by several MSCI Barra indices and the respective data were collected from Thomson Reuters. The selected indices are as follows: All Country World Index - ACWI (tracks the equity market performance of developed and emerging markets; as of June 2009 it consisted of 45 country indices; see *Fig. 3*), the MSCI Frontier Markets Index - FMIND (measures equity market performance of frontier markets; as of June 2009 it consisted of 25 frontier market country indices; see *Fig. 4*) [13].

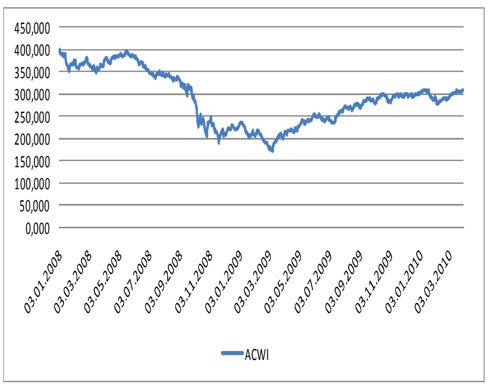

Fig. 3. Evolution of the All Country World Index

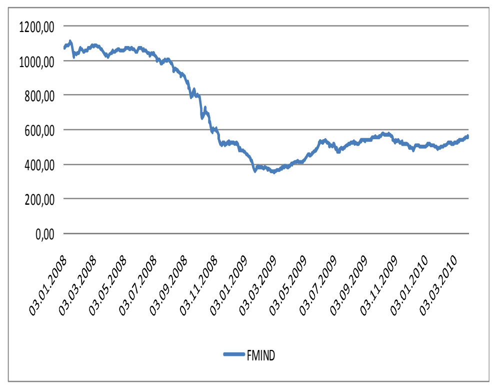

Fig. 4. Evolution of the MSCI Frontier Markets Index

In order to track the performance of the financial sector we included in the analysis the All Country World Financials Index – ACWIFI that provides a universal benchmark for the financial sector (see *Fig. 5*) [14].

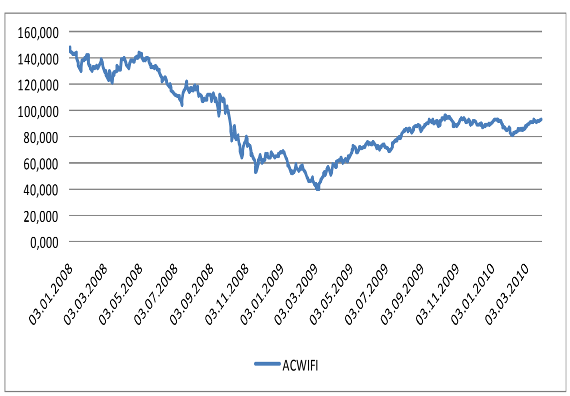

Fig. 5. Evolution of the Country World Financials Index

The indices were selected so as to represent the most part of the international capital market and to reflect the potential connections with the financial sector during the present economic turmoil.

Research Methodology and Results

We initially tested all the data to identify if they are stationary by employing the unit root test, as intuitively, from a graphical examination, one can notice that none of the time series is stationary. All the tests were performed with the Eviews package. Therefore, we employed the Augmented Dickey-Fuller stationarity test. Given the probability value *(pValue)*, one can not reject the null hypothesis of the test for any of the time series. Therefore, it can be concluded that the studied time series are non-stationary. (see *Table 1*).

Table 1. Augmented Dickey-Fuller stationarity test for each price and index series

Null Hypothesis	t-Statistic	Prob.
BRENT has a unit root	-0.852665	0.9590
WTI has a unit root	-1.045257	0.9355
ACWI has a unit root	-0.845745	0.9596
FMIND has a unit root	-0.050129	0.9956
ACWIFI has a unit root	-1.191927	0.9104

Consequently, all the time series were transformed by determining the logarithmic returns. Afterward, the Augmented Dickey-Fuller test was applied to each of the return series (see *Table 2*).

Table 2. Augmented Dickey-Fuller stationarity test for the returns series

Null Hypothesis	t-Statistic	Prob.
BRENT_R has a unit root	-23.43299	0.0000
WTI_R has a unit root	-23.57548	0.0000
ACWI_R has a unit root	-17.95432	0.0000
FMIND_R has a unit root	-20.41873	0.0000
ACWIFI_R has a unit root	-20.45216	0.0000

The following step consisted in testing for co-integration relationships between the chosen variables by employing the Johansen test for each pair formed by the oil spot prices and the MSCI indices, all the data considered being the logarithmic series from the raw data [4]. The ADF test proved that all the logarithmic series were not stationary (see *Table 3*).

Table 3. Augmented Dickey-Fuller stationarity test for the logarithmic series

Null Hypothesis	t-Statistic	Prob.
BRENT_LOG has a unit root	-0.949399	0.9483
WTI_LOG has a unit root	-1.076681	0.9307
ACWI_LOG has a unit root	-0.902460	0.9537
FMIND_LOG has a unit root	-0.144546	0.9940
ACWIFI_LOG has a unit root	-1.189086	0.9110

In order to choose optimal lag length there were applied different criteria: Likelihood–Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan–Quinn Information Criterion (HQ). The results of the Johansen co-integration test are provided within the following tables (see *Table 3*, *Table 4, Table 5,* and *Table 6* for the BRENT_LOG and see *Table 7*, *Table 8, Table 9,* and *Table 10*).

Table 4. Co-integration Johansen test BRENT_LOG – ACWI_LOG
Optimal number of lags=3

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.020657	14.29727	0.0751
At most 1	0.004692	2.629162	0.1049
Trace test indicates no cointegration at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.020657	11.66810	0.1237
At most 1	0.004692	2.629162	0.1049
Max-eigenvalue test indicates no cointegration at the 0.05 level			

Table 5. Co-integration Johansen test BRENT_LOG – FMIND_LOG
Optimal number of lags=16

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.016987	11.36410	0.1901
At most 1	0.003674	2.009655	0.1563
Trace test indicates no cointegration at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.016987	9.354445	0.2578
At most 1	0.003674	2.009655	0.1563
Max-eigenvalue test indicates no cointegration at the 0.05 level			

Table 6. Co-integration Johansen test BRENT_LOG – ACWIFI_LOG
Optimal number of lags=2

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.019465	12.80873	0.1220
At most 1	0.003210	1.800707	0.1796
Trace test indicates no cointegration at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.019465	11.00802	0.1538
At most 1	0.003210	1.800707	0.1796
Max-eigenvalue test indicates no cointegration at the 0.05 level			

Table 7. Co-integration Johansen test WTI_LOG – ACWI_LOG
Optimal number of lags=20

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.027467	18.08321	0.0199
At most 1	0.005498	2.988075	0.0839
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.027467	15.09513	0.0369
At most 1	0.005498	2.988075	0.0839
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level			

Table 8. Co-integration Johansen test WTI_LOG – FMIND_LOG
Optimal number of lags=16

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.015282	10.50233	0.2441
At most 1	0.003828	2.093825	0.1479
Trace test indicates no cointegration at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.015282	8.408502	0.3387
At most 1	0.003828	2.093825	0.1479
Max-eigenvalue test indicates no cointegration at the 0.05 level			

Table 9. Co-integration Johansen test WTI_LOG – ACWIFI_LOG
Optimal number of lags=6

Hypothesized No. of CE(s)	Eigenvalue	*Trace Statistic*	Prob
None	0.019428	12.92391	0.1176
At most 1	0.003619	2.015564	0.1557
Trace test indicates no cointegration at the 0.05 level			

Hypothesized No. of CE(s)	Eigenvalue	*Max-Eigen Statistic*	Prob
None	0.019428	10.90835	0.1588
At most 1	0.003619	2.015564	0.1557
Max-eigenvalue test indicates no cointegration at the 0.05 level			

The next stage of analysis consisted in testing the bivariate Granger causality on the pairs formed by the oil price returns and capital-market indices returns for all the pairs of data series that were not co-integrated.

The Granger test, developed by Granger (1969) [2] investigates initially, if the current values of a variable can be explained by the past values of the same variable and whether the subsequent introduction of lagged values of other variables improves the explanation of the first variable. Therefore, *y* is said to be Granger caused by *x* if *x* helps in the prediction of *y*, or equivalently if the coefficients on the lagged values of *x* are statistically significant. However, it should be noted that Granger causality measures the precedence and information content of the variable x and does not represent causality in the common sense of the word and does not imply that y is the effect or the result of x [8].

Within this study were run bivariate regressions of the form:

$$\begin{aligned} y_t &= \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + ... + \alpha_k y_{t-k} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + ... + \beta_k x_{t-k} + \varepsilon_t \\ x_t &= a_0 + a_1 x_{t-1} + a_2 x_{t-2} + ... + a_k x_{t-k} + b_1 y_{t-1} + b_2 y_{t-2} + ... + b_k y_{t-k} + u_t \end{aligned} \quad (1)$$

where *y* is the return of the oil spot price (WTI_R or BRENT_R), and x is the return determined for each MSCI index (ACWI_R, FMIND_R, ACWIFI_R). y_{t-k} and x_{t-k} stand for the lagged values of the time series, while ε and u are the residuals of regression equations.

The results obtained from running the Granger test are presented in the following tables.

Table 10. Bivariate Granger causality test BRENT_R – ACWI_R (Lags=3)

Null Hypothesis	Obs	F-Statistic	Prob.
ACWI_R does not Granger Cause BRENT_R	559	9.56471	0.0000036
BRENT_R does not Granger Cause ACWI_R		0.42226	0.7371100

Table 11. Bivariate Granger causality test BRENT_R – FMIND_R (Lags=16)

Null Hypothesis	Obs	F-Statistic	Prob.
FMIND_R does not Granger Cause BRENT_R	546	2.13591	0.00628
BRENT_R does not Granger Cause FMIND_R		2.33185	0.00246

Table 12. Bivariate Granger causality test BRENT_R – ACWIFI_R (Lags=2)

Null Hypothesis	Obs	F-Statistic	Prob.
ACWIFI_R does not Granger Cause BRENT_R	560	6.41045	0.00177
BRENT_R does not Granger Cause ACWIFI_R		0.36980	0.69105

Table 13. Bivariate Granger causality test WTI_R – FMIND_R (Lags=16)

Null Hypothesis	Obs	F-Statistic	Prob.
FMIND_R does not Granger Cause WTI_R	546	1.67551	0.04757
WTI_R does not Granger Cause FMIND_R		2.85888	0.00017

Table 14. Bivariate Granger causality test WTI_R – ACWIFI_R (Lags=6)

Null Hypothesis	Obs	F-Statistic	Prob.
ACWIFI_R does not Granger Cause WTI_R	556	1.18285	0.31378
WTI_R does not Granger Cause ACWIFI_R		1.99050	0.06524

Results for Brent Oil Spot Price

As it can be seen from *Table 10*, the Brent spot price is Granger caused by the index that tracks the daily equity market performance of developed and emerging markets. Moreover, with regard to the pair Brent oil spot price – the MSCI index that measures the equity market performance of frontier markets, one can observe the presence of the Granger causality in both directions with a lag of sixteen days, (see *Table 11*). As far as the relationship with the financial sector is concerned, the Brent oil spot price is Granger caused with a lag of two days by the MSCI financial sector index (see *Table 12*).

Results for WTI Oil Spot Price

For the pair WTI oil spot price – frontier markets index, the results displayed in *Table 13* show that there is a Granger causal relationship in both directions, the index determined by MSCI to track the performance of frontier markets Granger causing the WTI oil spot price, while the latter causing Granger the index with a sixteen day lag. For the WTI spot oil price and the financial sector index one cannot reject the hypothesis stating the absence of Granger causality (both probabilities are over 5%) (*see Table 14*).

Conclusions

By considering two of the most important international oil spot prices and a set of indices measured by MSCI Barra, the present case study aimed at investigating Granger causality for the oil market and the international capital market from January 3, 2008 until March 30, 2010. After conducting co-integration tests and Granger causality tests, the results indicate that both oil price and indices react to the information content included by the other time series. Taking into account the period considered into analysis, these results might be justified as a common reaction to information coming from the international environment. As further research there would be of interest to extend the considered period and break it into sub-periods having as edge the month of July 2008, when the oil price reached record values. In addition, there would be useful to focus on other benchmark oil prices.

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Analiza relațiilor de cauzalitate pe piețele petrolului şi piețele internaționale de capital

Rezumat

Scopul articolului de față constă în studiul relației dintre prețurile internaționale ale petrolului şi piețele internaționale de capital în contextul crizei economice actuale. Metodologia de cercetare constă în utilizarea testelor de co-integrare şi a celor de cauzalitate Granger efectuate pe serii de timp cu frecvență zilnică pentru două dintre cele mai importante prețuri ale petrolului considerate a fi de referință în formarea prețurilor petrolului la nivel internațional, mai exact, West Texas Intermediate (WTI) şi Brent Europe şi pentru o serie de indici ce comensurează performanța piețelor internaționale de capital.