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An Empirical Analysis of the Relationship between Oil Prices and Stock Markets

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Abstract

This paper investigates the relationship between oil prices and stock market returns for the G7 and the BRIC countries for the period 1991-2016 using cointegration and a vector error correction model. Results reveal that there is no long-run relationship between oil prices and the stock market indices of the G7 countries. However, they also reveal that there is a long-run relationship between oil prices and the stock market indices of three out of the four BRIC countries (Brazil, China and Russia). This result appears to be broadly aligned with the idea that over the past quarter of a century emerging countries have been more exposed to oil prices (either as producers or consumers) than developed ones. Furthermore, from an investments' and international portfolio management perspective, it seems that there might be benefits from diversification when holding the stock market index of a G7 country or India and oil assets since these appear to be segmented. On the other hand, such benefits might not be applicable in the case of the stock markets of Brazil, China or Russia and oil assets as these seem to be integrated.

Keywords: BRIC countries, cointegration, G7 countries, oil prices, stock markets

1. Introduction

There is little doubt that oil prices affect the world economy in many ways, for instance, when oil prices rise there is potential transfer of wealth from oil consuming to oil producing nations (Bjornland, 2009), increased cost of production of goods and services, inflationary pressures, loss of consumer confidence and turmoil in the capital markets. In a seminal paper, Hamilton (1983) argued that higher oil prices were to be blamed for almost all recessions that occurred in the US after the Second World War. Other researchers extended Hamilton's work in terms of new data sets and alternative empirical methodologies (e.g. Burbridge & Harrison, 1984; Gisser & Goodwin, 1986) and mostly focused on the relationship between oil prices and various macroeconomic variables. A smaller portion of this research has also focused on the specific relationship between oil prices and financial markets (e.g. Huang, Masulis, & Stoll, 1996; Sadorksy, 1999; Park & Ratti, 2008). This paper falls within the latter strand of the literature and aims to analyse the relationship between oil prices and stock market returns for the G7 (USA, Great Britain, France, Germany, Italy, Canada and Japan) and the BRIC (Brazil, Russia, India and China) countries.

In order to better demonstrate the potential relationship between oil prices and stock markets, we can think of the value of a stock in terms of the discounted stream of its future dividends.

$$P_0 = \sum_{t=1}^{\infty} \frac{DPS_t}{(1+r)^t} \tag{1}$$

Where:

P_0 = the current stock price

$DPSt$ = expected dividend per share at time t

r = the required rate of return

Consider what happens when oil prices rise; assuming oil is an important input in the production process of many companies, this will lead to higher costs if there are no substitution possibilities, hence lower cash flows available to be distributed as dividends to shareholders, which in turn lead to a decline in the share price. Moreover, rising oil prices might exert inflationary pressures, which may lead to an increase in interest rates. Higher interest rates usually imply that investors would require a higher rate of return to invest in stocks instead of government bonds, which again might lead to a drop in share prices. Moreover, according to Bernanke (1983), uncertainty regarding oil prices may also cause firms to postpone investments in anticipation of lower future profits, thus again hampering the future potential cash flows and hence the dividend payments of the firm.

This study examines the effect of oil price changes on the stock market returns of the G7 and BRIC countries, using monthly data over the period 1991-2016. The paper is motivated by the prominence of large, newly industrialized economies during the aforementioned period and aims to assess whether the relationship between oil price changes and stock market changes in these countries is the same as in developed countries. Abosedra and Gosh (2007) argued that over the past three decades, demand for oil in developed countries has decreased due to the decrease in the "oil intensity" of these economies, while exactly the opposite has occurred in the case of developing countries. Moreover, we are also intrigued by the fact that evidence so far regarding the relationship between oil prices and stock prices appears to be mixed, hence by using an updated data set aim to contribute in the literature towards that direction too. Finally, our work could also be useful in the context of international investments and portfolio management; if certain stock markets are found to be integrated with oil markets, then there might be no diversification benefits from including both in an investment portfolio. On the other hand, if evidence of segregation is found then there might be diversification benefits.

To address the above mentioned research questions, we employ the co-integration and error-correction methodology, which consists of the following steps: (1) testing for a unit root in each of the time-series; (2) testing for the existence of cointegrating vectors between oil prices and each of the 11 stock market indices; (3) estimating and testing for the cointegrating relationship (if any) in the framework of a vector error correction model (VEC model) and (4) using the VEC model to establish whether short – and/or long-run relationships exist between oil prices and the specific stock market index.

Our results indicate that there is no long-run relationship between oil prices and the stock market indices of the G7 countries but that there is evidence of such a relationship in three out of the four BRIC countries (Brazil, China and Russia). These results tend to support the idea that over the past quarter of a century emerging economies have been more sensitive to oil prices in comparison to developed ones. They also have implications for the international investor and fund manager since there are not likely to be any diversification benefits in the case where stock market indices and oil prices are integrated (Brazil, China and Russia). On the other hand, where they are segmented (G7 countries and India) such benefits might be achieved.

The remainder of the paper is organized as follows. In section 2 we present a review of related literature. Section 3 presents the data and discusses the methodology used. Empirical results follow in section 4 and section 5 concludes.

2. Literature Review

A great deal of academic research has focused on the relationship between oil prices and macroeconomic variables. For example, in a sequence of papers Hamilton (1983, 1996, and 2003) argued that oil price increases have a significant effect on economic output and have been responsible for recessions that have occurred in the US economy. Other researchers such as Papapetrou (2001), Akram (2004), Rautava (2004), Cunado and De Gracia (2005), S. Chen and H. Chen (2007), Huang and Guo (2007) and Lardic and Mignon (2008), among others, have also studied the relationship between oil prices and different countries' GDP growth rates, inflation and employment.

However, and despite the fact that changes in the price of oil are often believed to be a crucial factor for understanding changes in stock prices, research on the relationship between the two has been comparatively less. Chen, Roll, and Ross (1986) included oil prices in their multi-factor asset pricing model and found that they did not affect stock prices. Al-Mudhaf and Goodwin (1993) investigated the stock returns of 29 oil companies listed on the NYSE and found a positive impact of oil price shocks on the returns of firms that had significant assets in domestic oil production. Jones and Kaul (1996) tested whether stock returns in Canada, Japan, the UK and the US over the period 1947-1991 were affected by oil shocks. They employed the standard dividend valuation model and found evidence that, in the case of the US and Canada, stock prices do tend to react to oil price shocks.

Huang et al. (1996) employed a VAR model and found that the return on oil futures does not affect the S&P 500 index. A similar result was found by Apergis and Miller (2009), who focused on the stock markets of 8 developed countries (Australia, Canada, France, Germany, Italy, Japan, UK and US). On the other hand, Sadorsky (1999) also employed a VAR model and found that oil prices do have a significant role in explaining stock returns in the US over the period 1947-1996. Similarly, Cheung and Ng (1998) used co-integration to study the long-run relationship between 5 national stock market indices (Canada, Germany, Italy, Japan and the US) and measures of real activity, including oil prices, and found that oil prices are negatively related to stock prices. Faff and Brailsford (1999) investigated the relationship between oil prices and stock returns at the industry level in Australia and found positive oil price sensitivity of the oil, gas and diversified resources industries.

Hong, Torous, and Valkanov (2002) documented that there is a significant negative relationship between lagged oil industry returns and the US stock market. Such findings are also in line with those of Papapetrou (2001), who presented evidence that oil prices are negatively related to the Greek stock market for the period 1989-1999. Maghyereh (2004) studied the relationship between oil prices and stock market returns in 22 emerging markets using VAR analysis and found that oil shocks do not have a significant impact on the stock markets of emerging economies. El Sharif, Brown, Burton, Nixon, and Russel (2005) investigated the relationship between oil prices and stock prices of UK energy companies and found evidence of a positive relationship. Lanza, Manera, Grasso and Giovannini (2005) used co-integration techniques to focus on the long-run determinants of the stock prices of six oil majors over the period 1998-2003. They found that spot and future oil prices along with the relevant stock market indices and exchange rates are significant in explaining the long-run dynamics of the companies' stock prices (Note 1).

Basher and Sadorsky (2006) argued that an increase in oil prices is similar to an “inflation tax”, which results in reduction of wealth and has a negative effect on stock markets in emerging markets. Anoruo and Mustafa (2007) looked into the relationship between oil and stock market returns in the US during the period 1993-2006 using co-integration and found evidence of a long-term relationship. They moreover documented that causality runs from the stock market to the oil market but not vice versa.

Park and Ratti (2008) examined the relationship between oil prices and their volatility and the stock returns of 13 European countries and the US over the period 1986-2005. They documented that, with the exception of Norway, which is an oil-exporting country, oil price shocks have a significant negative impact on stock prices in the same month or within one month of occurring. Along the same lines, O’Neil, Penm, and Terrell (2008), focused on the stock markets of the US, UK and France and also documented a negative relationship. Driesprong, Jacobsen, and Maat (2008) focused on a number of developed and developing countries and argued that oil price changes have significant predictability on stock market returns for the majority of the countries examined.

Issac and Ratti (2009) tested the long-run relationship between oil prices and various stock markets during the period 1971-2008 using a VEC model. Their analysis showed evidence of a long-run negative relationship for six OECD countries. Oberndorfer (2009) focused on the relationship between energy market developments and the pricing of European energy stocks. His results indicated that increases in oil prices tend to negatively affect the stock returns of European utilities but they lead to an appreciation of oil and gas stocks. Eryigit (2009) looked at the effects of oil price changes on sectoral indices of the Turkish stock exchange using the co-integration method and found a negative relationship between oil prices and a number of industries. Basher, Haug, and Sadorsky (2010) utilized a VAR approach to document that oil price rises tend to depress emerging stock markets. P. Narayan and S. Narayan (2010) focused on the relationship between oil prices and the Vietnam stock exchange over the period 2000-2008. Using cointegration they provided evidence that oil prices and stock prices share a positive long-run relationship.

Lin, Fang, and Chen (2011) found that oil price shocks on the stock markets of Greater China have been mixed (e.g. the effect in Taiwan is negative while the effect in Hong-Kong is positive). Moya-Martinez, Ferrer-Lapena, and Escribiano-Sotos (2014) examined the sensitivity of the Spanish stock market to movements in oil prices over the period 1993-2010 and found that the degree of oil price exposure is rather limited; however, significant differences were found across industries. Saif and Neha (2015) used the method of co-integration over the period 2010-2014 to document that there is no long-term relationship between oil prices and the Indian stock market.

3. Data and Methodology

3.1 Data

The data-set used in this paper focuses on the period 1991-2016 and observations are taken on a monthly basis. Table 1 below depicts the various stock market indices that have been utilized. As far as oil prices are concerned, we use Brent oil prices, which according to the IMF form the basis for around 65% of transactions in the international oil markets (Arouri, Boubaker, & Nguyen, 2014). All aforementioned data has been collected from DataStream.

Table 1. Stock market indices

Country	Stock Market Index
G7 Countries:	
USA	Dow Jones Industrial
Great Britain	FTSE 100
Japan	NIKKEI 225
France	CAC 40
Germany	DAX 30
Italy	FTSE MIB
Canada	S&P/TSX Composite
BRIC Countries:	
Brazil	BOVESPA
Russia	MICEX
India	CNX NIFTY(50)
China	Shanghai SE Composite

The following table presents summary statistics of the stock market indices used and oil prices. The stock market of Russia appears to be the most volatile (highest standard deviation) of all stock markets followed by those of India and Brazil. It is also the one exhibiting the greater range between its maximum and minimum values over the period examined. More developed markets appear to be less volatile with the FTSE100 exhibiting the lowest volatility of the lot. Oil prices appear to be quite volatile but less volatile than the stock markets of Brazil, Russia and India. They are, nonetheless, more volatile than the stock markets of the G7 countries and India (Note 2).

Regarding the issue of whether the data is normally distributed, we can see that for the majority of the data series, the median value is close to the mean, which shows that although the series may not be exactly normally distributed, they can be considered to be distributed approximately normal. In addition, we also need to look at the skewness and kurtosis statistics. A data series is assumed to be normally distributed if its kurtosis is equal to 3 and its skewness is equal to zero. However, when skewness and kurtosis lie within a range of ±2 of the aforementioned values they can be considered to be "acceptable" for further analysis; see for example Trochim and Donnelly (2006) and, Gravetter and Wallnau (2014). As can be seen from the table both skewness and kurtosis figures do lie within the ±2 range.

Table 2. Summary statistics

	OIL	*BOVESPA*	*MICEX*	*NIFTY 50*	*SHANGHAI*	*CAC 40*
Mean	3.6334	10.2243	6.4325	7.8703	7.6121	8.1445
Median	3.4452	10.5077	7.0241	7.9455	7.6215	8.2223
Standard Deviation	0.7294	0.7529	1.1165	0.7708	0.3868	0.3713
Kurtosis	1.6135	1.6359	2.9813	1.4086	2.5436	2.0888
Skewness	0.2109	-0.3708	-1.0100	-0.0177	0.3767	-0.4227
Minimum	2.3627	8.6843	3.0596	6.7001	6.9584	7.4310
Maximum	4.9373	11.1816	7.5540	9.0997	8.6566	8.8000
Range	2.5745	2.4973	4.4943	2.3996	1.6982	1.3689
No. of observations	301	237	223	240	223	301
	CANADA	*DAX 30*	*DOW JONES*	*FTSE MIB*	*FTSE 100*	*NIKKEI 225*
Mean	9.0059	8.4181	9.0760	10.1866	8.4760	9.5668
Median	9.0635	8.5387	9.2372	10.2094	8.5652	9.6399
Standard Deviation	0.4621	0.5539	0.4996	0.3306	0.2964	0.3006
Kurtosis	2.0014	2.1749	2.6428	1.9280	2.5277	1.9159
Skewness	-0.4759	-0.4715	-0.8240	-0.0919	-0.8202	-0.2582
Minimum	8.0945	7.2973	7.9645	9.4809	7.7461	8.9317
Maximum	9.6567	9.3816	9.8055	10.7889	8.8514	10.1770
Range	1.5621	2.0844	1.8410	1.3080	1.1053	1.2453
No. of observations	301	301	301	219	301	301

3.2 Methodology

The first step in our analysis is to carry out stationarity analysis for the time-series data of oil prices and stock market indices. The most widely used test for this purpose is the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979). Following that, we try to assess whether a long-term relationship between oil prices and each of the stock market indices exists. This is done by applying the cointegration test developed by Johansen (1991, 1995). Finally, in the cases where there is evidence of a cointegration relationship, a VEC model is estimated and then the direction of this relationship is examined using the Granger causality test (Granger, 1969, 1980, 2001).

3.2.1 Unit Root Tests

Testing for a unit root is an important part of time-series analysis. When a time series has a unit root, it is termed non-stationary, which means that (1) its variance is time-variant and goes to infinity as time approaches infinity and (2) it shows no long-run mean reversion. As already mentioned, in this paper we employ the ADF test to assess the stationarity of the time-series employed in our analysis.

The equation used to carry out the ADF test is the following:

$$\Delta Y_t = \beta_0 + \beta_1 t + \delta Y_{t-1} + \sum_{i=1}^{m} \beta_i Y_{t-i} + u_t \tag{2}$$

Where:

Y is the variable subject to the stationarity test,

Δ is the first difference operator,

t is the trend variable, and

u_t is the error term.

The null and alternative hypotheses are:

H_0: δ=0 (there is a unit root).

H_1: δ<0 (there is no unit root).

If H_0 is rejected, then Y has no unit root and can be considered to be stationary.

3.2.2 Johansen Cointegration Tests

The cointegration theory is based on the finding that many economic and financial time series may be non-stationary, i.e. contain a unit root. Engle and Granger (1987) were the first to point out that a linear combination of two (or more) series that contain a unit root may be stationary. If such a stationary linear combination exists, the initial time series are said to be cointegrated. This stationary linear combination is defined as the cointegrating equation and may be interpreted as the long-run equilibrium relationship between the variables.

In this paper we employ the Johansen cointegration test (Johansen, 1991, 1995) to test the following hypotheses:

H_0: There is no cointegration relationship between oil prices and the stock market index of each country.

H_1: There is a cointegration relationship between oil prices and the stock market index of each country.

The cointegration tests are based on the VAR model (of order p) represented by the following equation:

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + BX_t + \varepsilon_t \tag{3}$$

Where:

Yt is a vector of non-stationary variables,

Xt is a vector of deterministic variables, and

εt represents error terms.

The above VAR model can be re-written in matrix form as follows:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta\ Y_{t-i} + BX_t + \varepsilon_t \tag{4}$$

Where:

$$\Pi = \sum_{i=1}^{p} A_i - I$$

$$\Gamma_i = -\sum_{j=i+1}^{p} A_j$$

Granger's representation theorem asserts that if the coefficient matrix *Π* has reduced rank, that is to say $r < k$, then there exist $k \times r$ matrices, *α* and *β*, each with rank *r* such that $\Pi=\alpha\beta'$ and $\beta' y$ is *I(0)*. *r* is the number of cointegrating relations (the cointegrating rank) and each column of *β* is the cointegrating vector. In order to identify the cointegrating relations two statistics are used; the trace and the maximum eigenvalue (λ-max) statistic.

The trace statistic regarding the null hypothesis of *r* cointegrating relations is computed as follows:

$$LR_{tr}(r/k) = -T\sum_{i=r+1}^{k}\log(1-\lambda_i) \tag{5}$$

Where, λi is the *ith* largest eigenvalue of the **Π** matrix in equation 4.

The maximum eigenvalue statistic tests the null hypothesis of *r* cointegrating relations against the alternative of *r+1* cointegrating relations:

$$LR_{\max}(r/r+1) = -T\log(1-\lambda_{r+1}) = LR_{tr}(r/k) - LR_{tr}(r+1/k) \tag{6}$$

For $r = 0, 1, \ldots, k-1$

3.2.3 Vector Error Correction Model (VEC Model) and Granger Causality Tests

If a cointegration relationship is established, then we can assume that there is a long-term relationship between oil prices and the relevant stock market index. Thereafter, causality relationships between the two variables may be analysed by using a VEC model. A VEC model between two variables X and Y can be represented by the following equations:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{a}\alpha_i \Delta Y_{t-i} + \sum_{i=1}^{b}\beta_i \Delta X_{t-i} + \lambda EC_{t-1} + u_{Xt} \tag{7}$$

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{a}\alpha_i \Delta Y_{t-i} + \sum_{i=1}^{b}\beta_i \Delta X_{t-i} + \lambda EC_{t-1} + u_{Yt} \tag{8}$$

In the above equations *α* and *β* are parameters that need to be estimated, *a* and *b* indicate lag lengths, the *ECt-1* coefficient is the error correction term and *X* and *Y* are independent and dependent variables.

Once the VEC model is estimated, Granger causality tests can be carried out in order to assess whether oil prices "Granger cause" movements in the relevant stock market index or vice-versa. Effectively, what is tested here is whether the coefficients of the lagged variables in equations 7 and 8 and the error correction terms are zero. If the coefficient of *ECt-1 (λ)* is statistically significant, then we can assume that there is a long-term relationship between the independent and dependent variables. Moreover, if the coefficients of the lagged variables are jointly significant (e.g. $\Sigma\alpha i\Delta Yt\text{-}i$ in equation 7), then we may assume that there is also a short-term relationship between the independent and dependent variables.

4. Empirical Results

Table 3 presents the unit root tests for oil prices and each of the 11 stock market indices. The maximum lags were determined by using the Akaike Information Criterion (AIC) (as in Anoruo & Mustafa, 2007) and the unit root tests included a constant and a time- trend. The results suggest that all series are not stationary at their levels but they become stationary at the 1% level after first differencing, i.e. their order of integration is one (Note 3).

Table 3. Results of ADF unit root tests

Series	Level	Lags	p-value	1st Difference	Lags	p-value
OIL	-1.4170	1	0.5741	-5.0178***	12	0.0002
BOVESPA	-1.8962	0	0.6533	-15.3358***	0	0.0000
MICEX	-1.7933	1	0.7049	-6.9670***	5	0.0000
NIFTY 50	-2.5243	1	0.3162	-14.6642***	0	0.0000
SHANGHAI	-3.3760	7	0.0574	-4.5169***	6	0.0018
CAC 40	-1.7738	1	0.7152	-15.9599***	0	0.0000
CANADA	-2.4034	1	0.3770	-15.5180***	0	0.0000
DAX 30	-2.0937	1	0.5467	-15.7276***	0	0.0000

DOW JONES	-1.8717	0	0.6667	-17.8483***	0	0.0000
FTSE MIB	-2.5445	4	0.3065	-7.6976***	2	0.0000
FTSE 100	-2.0806	0	0.5541	-17.5987***	0	0.0000
NIKKEI 225	-2.0318	0	0.5811	-17.3881***	0	0.0000

Note. *** denotes rejection of the null hypothesis at the 1% level (i.e. there is no unit root).
MacKinnon (1996); one-sided p-values.

Given that all series are integrated of the same order, we may now implement the cointegration procedure (Johansen, 1991, 1995). Two variants of the Johansen cointegration tests have been used, the trace and the maximum eigenvalue (λ-max), to determine the number of cointegrating vectors between oil prices and each stock market index. In the trace test, the null hypothesis that there are at most r cointegrating vectors is tested against the general alternative. In the maximum eigenvalue test, the null hypothesis of r cointegrating vectors is tested against the alternative of at least (r+1) cointegrating vectors. Table 4 summarises our results.

Table 4A. Results of cointegration tests (trace statistic)

Models	H0	H1	Trace Statistic	
Oil Price - Bovespa (3 lags)	r = 0	r = 1	15.8224	**
	r < 1	r = 2	2.8590	
Oil Price - MICEX (12 lags)	r = 0	r = 1	20.4584	***
	r < 1	r = 2	2.9660	
Oil Price - NIFTY (1 lag)	r = 0	r = 1	3.7263	
	r < 1	r = 2	0.4702	
Oil Price - Shanghai (8 lags)	r = 0	r = 1	18.5315	**
	r < 1	r = 2	3.4168	
Oil Price - CAC (1 lag)	r = 0	r = 1	6.2357	
	r < 1	r = 2	2.5192	
Oil Price - Canada (1 lag)	r = 0	r = 1	6.8073	
	r < 1	r = 2	2.1128	
Oil Price - DAX (1 lag)	r = 0	r = 1	4.8313	
	r < 1	r = 2	1.7489	
Oil Price - Dow Jones (1 lag)	r = 0	r = 1	6.0812	
	r < 1	r = 2	2.6947	
Oil Price - FTSE MIB (3 lags)	r = 0	r = 1	11.0803	
	r < 1	r = 2	2.5343	
Oil Price - FTSE100 (1 lag)	r = 0	r = 1	7.1559	
	r < 1	r = 2	2.2771	
Oil Price - NIKKEI (1 lag)	r = 0	r = 1	9.9623	
	r < 1	r = 2	2.4408	

Note. ***: denotes rejection of the null hypothesis at the 1% level; critical values are 19.937 (r = 0 vs. r =1) and 6.634 (r < 1 vs. r = 2) (MacKinnon, Haug, & Michelis, 1999).
**: denotes rejection of the null hypothesis at the 5% level; critical values are 15.494 (r = 0 vs. r =1) and 3.841 (r < 1 vs. r = 2) (MacKinnon, Haug, & Michelis, 1999).
The order of the VAR length was determined by using the Akaike Information Criterion (AIC).

Table 4B. Results of cointegration tests (max-eigen statistic)

Models	H0	H1	Max-Eigen Statistic	
Oil Price - Bovespa (3 lags)	r = 0	r = 1	12.9624	
	r < 1	r = 2	2.8600	
Oil Price - MICEX (12 lags)	r = 0	r = 1	17.4924	**
	r < 1	r = 2	2.9660	
Oil Price - NIFTY (1 lag)	r = 0	r = 1	3.2560	
	r < 1	r = 2	0.4702	
Oil Price - Shanghai (8 lags)	r = 0	r = 1	15.1147	**
	r < 1	r = 2	3.4168	

Oil Price - CAC (1 lag)	r = 0	r = 1	3.7165
	r < 1	r = 2	2.5192
Oil Price - Canada (1 lag)	r = 0	r = 1	4.6946
	r < 1	r = 2	2.1128
Oil Price - DAX (1 lag)	r = 0	r = 1	3.0823
	r < 1	r = 2	1.7489
Oil Price - Dow Jones (1 lag)	r = 0	r = 1	3.3866
	r < 1	r = 2	2.6947
Oil Price - MIB (3 lags)	r = 0	r = 1	8.5460
	r < 1	r = 2	2.5343
Oil Price - FTSE100 (1 lag)	r = 0	r = 1	4.8787
	r < 1	r = 2	2.2771
Oil Price - NIKKEI (1 lag)	r = 0	r = 1	7.5215
	r < 1	r = 2	2.4408

Note. ***: denotes rejection of the null hypothesis at the 1% level; critical values are 19.937 (r = 0 vs. r =1) and 6.634 (r < 1 vs. r = 2) (MacKinnon, Haug, & Michelis, 1999).

**: denotes rejection of the null hypothesis at the 5% level; critical values are 15.494 (r = 0 vs. r =1) and 3.841 (r < 1 vs. r = 2) (MacKinnon, Haug, & Michelis, 1999).

The order of the VAR length was determined by using the Akaike Information Criterion (AIC).

The first striking conclusion that may be drawn from our results is that, for the period analysed, there appears to be no cointegration (i.e. no long-run relationship) between oil prices and any of the stock markets of the G7 countries. This appears to be in line with part of the existing literature, for example Haung et al. (1996) who focused on the US and Apergis and Miller (2009) who focused on a number of developed countries. However, they are in contrast to the findings of other papers such as Park and Ratti (2008) and Isaac and Ratti (2009), among others.

Our second finding is that there seems to be evidence of cointegration between oil prices and three out of the four BRIC countries (China, Russia and Brazil). This result seems to be broadly in line with the finding of Basher and Sadorsky (2006), who argued that emerging countries are likely to be more exposed to oil prices than developed ones; hence oil price changes are likely to have a greater impact on the stock markets of the latter set of countries. It is also aligned with the findings of Lin et al. (2001) who looked at China and found that there is relationship between the stock markets of China and oil prices. Regarding India, our findings appear to be aligned to those of Saif and Neha (2015), who also found that there is no long-term relationship between oil prices and the stock market.

Having established that there is cointegration between oil prices and the stock market indices of China, Russia and Brazil, we now implement a VEC model for oil prices and the stock market of each of these countries and apply Granger causality tests. Results are depicted in Table 5.

Table 5. Granger causality tests for Brazil, China and Russia

	Independent Variables in VECM					
Brazil	ECt-1		ΣΔ(OIL)		ΣΔ(BOVESPA)	
Equation for Δ(OIL)	-0.091455	***			0.319071	**
Equation for Δ(BOVESPA)	0.022712		-0.058949	*		
China	ECt-1		ΣΔ(OIL)		ΣΔ(SHANGHAI)	
Equation for Δ(OIL)	0.001164				0.160216	
Equation for Δ(SHANGHAI)	0.025169	***	-0.52566	***		
Russia	ECt-1		ΣΔ(OIL)		ΣΔ(MICEX)	
Equation for Δ(OIL)	0.000662				0.802682	**
Equation for Δ(MICEX)	-0.018961	***	-0.192676			

Note. ***. **. * indicate statistical significance at the 1%. 5% and 10% level. respectively.

Statistical significance regarding ECt-1 (the error correction term) was established by using standard t-tests while. for ΣΔ(OIL). ΣΔ(BOVESPA). ΣΔ(SHANGHAI) and ΣΔ(MICEX) it was established by using the F-statistic.

The results reveal that in the case of Brazil, in the first equation, the coefficients of both *ECt-1* and

ΣΔ(BOVESPA) are statistically significant thus indicating that the stock market index (BOVESPA) Granger-causes oil prices both in the long- and the short-run. On the other hand, from the second equation, it appears that oil prices do not Granger-cause the stock market index in the long-run (coefficient of *ECt-1* is not significant) but there is weak causality in the short-run (coefficient of *ΣΔ(OIL)* is significant at the 10% level).

Regarding China, results clearly indicate that there is one-way Granger-causality from oil prices to the stock market index, both in the short – and the long-run, as the coefficients of *ECt-1* and *ΣΔ(OIL)* are statistically significant. There appears to be no causality from the stock market index to oil prices.

Finally, regarding Russia, the coefficient of *ECt-1* is significant in the second equation thus indicating that there is a long-term relationship between oil prices and the MICEX; this means that oil prices Granger-cause the MICEX, despite the fact that *ΣΔ(OIL)* is not statistically significant. On the other hand, the second equation suggests that there is also short-run causality the other way around, i.e. from the stock market index to oil prices.

5. Conclusion

This paper has used cointegration analysis and the VEC model to examine the long-run relationship between oil prices and the stock market indices of the G7 and the BRIC countries. More specifically, the ADF unit root procedure was utilised to determine the time-series properties of oil prices and the stock market indices of the above countries. This was followed by application of the cointegration method of Johansen (1991, 1995), which was used to establish whether there are any long-term relationships between the stock market index of each country and oil prices. Finally, in the case where such a relationship was established, Granger-causality tests were carried out through the use of a VEC model.

The results from the ADF tests showed that all series were non-stationary at their levels but stationary at their first differences. Cointegration tests revealed that over the period examined, there was no long-run relationship between oil prices and the stock market indices of the G7 countries but that there was such a relationship in three out of four BRIC countries (Brazil, China and Russia). These results seem to be lending support to the idea that over the past 25 years emerging countries have been more exposed to oil prices (either as producers or consumers) than developed ones.

Results from Granger-causality tests based on the VEC model revealed that in the cases of China and Russia oil prices Granger-cause the stock market index in the long-run. This means that oil prices adjust in the long-run to maintain equilibrium with the stock market index in each of these countries. In the case of Brazil, it seems that the stock market index Granger-causes oil prices in the long-run, i.e. it adjusts in the long-run to maintain equilibrium. Regarding the short-term, results indicate that there is causality from the stock market index to oil prices in the cases of Brazil and Russia and causality from oil prices to the stock market index in the case of China.

An important implication of the findings of this paper is that in the case where oil prices and stock market indices are not integrated (G7 countries and India), they can be included in an investment portfolio since there are likely to be benefits of diversification. On the other hand, where oil prices and stock market indices are integrated (Brazil, China and Russia), there is not likely to be any diversification benefit if both are included in the same investment portfolio.

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Notes

Note 1. The six oil majors are: BP, Chevron-Texaco, Eni, Exxon-Mobil, Royal Dutch Shell, Total-Fina-Elf.

Note 2. Natural logarithms of all series were taken before proceeding to any analysis.

Note 3. Given that the result regarding the Shanghai stock market appears to be somewhat marginal (p-value = 0,0574), we also carried out an additional stationarity test proposed by Kwiatkowski-Phillips-Schmidt-Shin (KPSS-1992). Results of this test confirmed that the series is indeed not stationary.