The Impact of the Global Crisis of 2008-09 on the Relationship Between Stock Markets and Oil Prices in the BRIC Countries

** Giray Gozgor*
*** Valéri Natanelov*
**** Guido Van Huylenbroeck*

Abstract

This paper examined the relationship between the equity indices in the BRIC economies and oil prices for the period from September 22, 1997 to November 29, 2013. We focused on various sub-periods to obtain statistically robust and economically solid relationships and to address cross-sectional dependence among stock market indices and oil prices in panel data techniques. For this purpose, we developed a test framework that made use, in a sequential order, of the second generation panel unit root test, the panel cointegration technique accounting for multiple structural breaks, the panel-Granger causality test, and the panel dynamic ordinary least square estimations to analyze the possible interactions. The results showed that there is a long-run positive relationship between the stock market indices and the oil prices only after fall 2008 in the panel framework. We analyzed the related period for each country in detail, and found that oil prices have positive effects on the equity indices in Russia, China, and India. Our findings also indicated that there is a causality relationship that runs from the oil prices to the stock markets' indices in China and India, and there is a pair-wise causality between the equity indices and the oil prices in the Russian economy.

Keywords: **stock markets, BRIC countries, crude oil price, panel data estimation, time series estimation techniques**

JEL Classification: C22, C23, G15, Q49

Paper Submission Date : June 23, 2014 ; Paper sent back for Revision : December 10, 2014 ; Paper Acceptance Date : January 28, 2015

This study aims to examine the relationship between stock market indices and oil price shocks in Brazil, China, India, and Russia (the BRIC) economies. We systematically investigate whether there is an interrelationship among stock market indices and oil prices in these emerging markets in the long-run. The surge in oil prices for the period from 2000 to 2008, the sharp decline in the prices during the period of the great global crisis of 2008-09, and then the hike over the post-crisis period has produced a lot of interest in the interrelationships among stock prices, macroeconomic activity, and price & price volatility shocks from oil markets (Basher, Haug, & Sadorsky, 2012). As compared to the developed economies, these emerging-market economies were solid in the global crisis period, but their growth rates also decreased. On the other hand, emerging market economies have a growing influence on the world economy. According to the nominal gross domestic product data from the world development indicators of the World Bank, China, Brazil, India, and Russia's economies are the second, sixth, ninth, and tenth biggest economies worldwide, respectively. Furthermore, these developing economies have a different oil demand dynamics: Brazil has achieved self-sufficiency in oil consumption by combining investments in oil reconnaissance and substantial ethanol production. China and India's economies have grown rapidly at almost double digits during recent years, and they

* *Associate Professor,* Department of Economics and Finance, Dogus University, Zeamet Street 21, 34722, Istanbul, Turkey. E-mail: ggozgor@dogus.edu.tr
** *Post-Doctoral Researcher,* Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Ghent, Belgium.
*** *Professor,* Department of Agricultural Economics, Ghent University, Coupure Links 653, 9000 Ghent, Belgium.

are net oil-importers, and together, they almost have a 15% share in global oil demand. Russia is a net oil-exporter economy since 1990s, and its role in oil production has been gaining greater importance in global energy markets (Filis, Degiannakis, & Floros, 2011).

As we will discuss in the next section, there is a growing number of papers in literature that investigate the direct relation between stock markets and oil prices both in developed and developing economies. Using different methodological frameworks, our study attempts to systematically examine the relationships between oil prices in the BRIC economies for various interesting sub-periods. For this purpose, we used both panel data estimation and time series techniques over the period from September 22, 1997- November 29, 2013 at daily frequency.

Our contributions to the existing literature can be summarized as follows. First, by using the panel unit root test of Pesaran (2007) and the panel cointegration technique of Westerlund (2006), our panel data methodology was able to address cross-sectional dependency among equity indices and oil prices, or in other words, the panel data estimation techniques applied tell us something about possible interactions in BRIC countries in general. Cross-sectional dependence among panel units is now an important phenomenon in panel data estimation framework, and previous findings show that only when the cross-sectional dependence is taken into account in panel cointegration techniques, a significant relationship between oil prices and stock markets is statistically robust (Li, Zhu, & Yu, 2012). Along with the cross-sectional dependence, the panel cointegration test used in this paper also allows for multiple structural breaks, and therefore, we obtained statistically robust results with respect to possible structural breaks. For this purpose, we used the recent panel-causality test of Dumitrescu and Hurlin (2012) that is based on bootstrapped critical values. Furthermore, using the cointegration technique of Johansen (1991), we separately examined the linear cointegrating relationship for each country in particular. Therefore, our empirical results are robust with respect to the implementation of different econometric methodologies.

We did not find any other study in literature that used panel cointegration techniques in order to examine the issue at stake, so this paper seeks to fill this gap. Our second contribution lies in the fact that we focused on various sub-periods, and therefore, we attempted to obtain not only statistically robust, but also economically solid relationships between stock markets and oil prices in the BRIC countries. For this purpose, our study takes a special interest in the period of the great global crisis of 2008-09 and the post-crisis period. These issues yield interesting findings as we observed boom-and-bust cycles in both emerging stock and global oil markets. Third, this paper used a proxy variable that is referred to as the "local" oil prices. Following Nandha and Faff (2008), Park and Ratti (2008), and Wang, Wu, and Yang (2013), we indeed used the exchange rate from the local currency to the USD for oil prices as applied on each trading day. In this way, we controlled the effects of the USD exchange rate on the transmission mechanism of global oil prices.

Indeed, there are two main channels to explain why oil prices should affect stock markets. Theoretically, the stock prices of a company are equal to the expected present value of discounted future cash flows (Huang, Masulis, & Stoll, 1996). Oil price shocks would directly affect equity indices by changing future cash flows. In addition, there could be an indirect effect via the interest rate which is used to discount future cash flows. A second possible channel is that oil prices are a determinant of profits, because they are a main cost of production. This can be related to rise in inflation, therefore, oil prices can cause a slowdown in economic activity that can also be related to stock market returns (Hammoudeh, Dibooglu, & Aleisa, 2004 ; Jones & Kaul, 1996). In this study, we emphasize a third effect, an uncertainty channel. Oil price shocks hit emerging stock markets by creating more uncertain market conditions, but the influence depends on the exchange rate because policy-makers may use exchange rates to (a) mitigate possible negative effects of oil price shocks, and (b) to decrease the size of uncertainty influence that occurs from the oil markets.

The U.S. dollar exchange rates are important drivers of crude oil prices, for example, to the extent that oil prices are de-nominated in the U.S. dollar and that several channels of shock transmission between oil prices and exchange rates exist (Amano & van Norden, 1998; Aloui, Ben Aïssa, & Nguyen, 2013). Indeed, monetary authorities in an open developing economy rather use policy interest rates and money supply to adjust the exchange rate movements through purchasing power parity. Therefore, the value of the exchange rate has significant direct or indirect effects on the consequences of policy implications (Gozgor, 2013). On the other hand,

exchange rate fluctuations can create an additional uncertainty, and this can be influential on the relationship between stock market indices and oil prices, particularly in emerging markets. In addition, returns in stock markets are related with profit of firms, and oil price shocks will not only change production costs, but also affect firms' competitiveness positions in domestic and foreign markets. One of the important determinants of domestic and foreign prices and competitiveness is the value of the exchange rate as stated by the law of one price and the theoretical framework of Krugman (1983).

In short, most of the previous studies neglected the role of exchange rate on the direct relationship between oil prices and stock prices in emerging markets, while this paper does not do so. Hence, from this aspect (also), it seeks to contribute to the literature of emerging markets. Based on the reasons indicated before, we indeed expect a significant relationship between stock markets and oil prices, and actually, this is our main hypothesis.

Literature Review

A seminal paper of Hamilton (1983) was the first to introduce a theoretical framework on the relationship between oil prices and macroeconomic variables, such as GDP, inflation, and unemployment. Hamilton (2009) confirmed the relationship between oil price shocks and macroeconomic indicators, but Kilian (2009) indicated that oil price shocks are not similar, and that they have asymmetric effects on the macroeconomic variables related to their source and structure. However, the relationship has got more complex and dynamic since we have known the theoretical framework of Kilian (2009). For instance, using the framework of Kilian (2009), Kilian and Park (2009) examined the relationship between the U.S. stock prices and oil price shocks. They considered a percentage change in the global crude oil production, the global real economic activity, the real oil price, and the return of the U.S. stocks. They indicated that oil demand shocks suppressed the stock prices, while oil supply shocks have much less effects on the U.S. stock prices. Furthermore, using a structural vector autoregressive (SVAR) model, Apergis and Miller (2009) investigated the impact of soil market shocks on the equity prices in developed countries and concluded that oil price shocks do not have a statistically significant effect on the stock market returns.

Following these theoretical frameworks, several papers have focused on the effects of crude oil prices on the equity returns and fluctuations in stock markets, but their empirical results are mixed. Several papers found significant evidence of a negative effect of crude oil prices on stock returns (Basher & Sadorsky, 2006; Ghouri, 2006; Kilian & Park, 2009; Miller & Ratti, 2009; Nandha & Faff, 2008; Park & Ratti, 2008; Papapetrou, 2001; Sadorsky, 1999). Some other papers, however, indicate that there is a significant positive relationship between oil and stock prices (Chortareas & Noikokyris, 2014; El-Sharif, Brown, Burton, Nixon, & Russell, 2005; Li et al., 2012; Zhu, Li, & Yu, 2011). On the other hand, some empirical papers also showed statistically insignificant or little linkage between oil and equity prices (Apergis & Miller, 2009; Henriques & Sadorsky, 2008; Huang et al., 1996).

On the other hand, some studies focused on the relationship between oil prices and stock market returns in emerging market economies. Although the results in these studies are mixed, there are some common points in emerging market cases (Natanelov, Dora, Gellynck, & Van Huylenbroeck, 2013a). For instance, Basher and Sadorsky (2006) indicated that there is a negative relationship between oil shocks and stock market prices in 21 emerging market economies, but their findings are not robust for different data frequency. Bhar and Nikolova (2009) pointed out that the BRIC countries are dependent on the case of whether they are an oil-importer or oil-exporter economy. Russia and Brazil are crude oil exporters, but the Brazilian economy is more vulnerable to global oil price shocks because it tries to provide higher export revenues. On the other hand, India and China are crude oil importer countries and changes in global oil price can affect "the conditional volatility of equity returns" in India and China.

Similarly, Aloui, Nguyen, and Njeh (2012) analyzed 25 emerging market economies, and indicated that risks of oil price shocks are significant in most of the emerging markets, but the impact of oil price shocks are asymmetric

with respect to market structure. Similar mixed empirical results were obtained for different developing countries by Wang et al. (2013). Using vector autoregressive (VAR) models, Ono (2011) examined the effects of oil prices on real equity returns for the BRIC economies. He found that stock returns respond positively to the oil price shocks in China, India, and Russia, but that there was no significant relationship in the Brazilian economy. He concluded that the effects of oil price shocks on volatility in real stock returns are significant, and they are larger in China and Russia, respectively.

Li et al. (2012) analyzed the relationship between oil prices and the Chinese stock market for the period from July 2001 to December 2010 at the disaggregated data level. Using the Granger causality framework and the panel cointegration technique that takes cross-sectional dependence and multiple structural breaks into account, they found that real oil prices had a positive effect on the Chinese stock markets in the long run. Natanelov et al. (2013a) also focused on the BRIC countries for the period from January 2006 to January 2011 at daily data. They found that there was a linear cointegration in the Chinese and the Brazilian stock markets with crude oil prices, but in cases of India and Russia, threshold cointegration was present.

Using the unconditional and the conditional copula models, Zhu, Li, and Li (2014) examined the dynamic dependence between crude oil prices and stock markets in 10 Asia-Pacific countries for the period from January 4, 2000 to March 30, 2012. They showed that there was an increasing interaction between oil prices and stock markets in China and India in the post-crisis period. Fang and You (2014) investigated the relationship between oil prices and stock market returns in China, India, and Russia for the period from January 2001 to May 2012. They indicated a significant negative relationship in the Indian economy, a significant positive linkage in the Russian economy, and found no statistically significant relationship in case of China.

Methodology

This paper investigates the relationship between equity indices and oil prices in the BRIC economies in the long-run. For this purpose, we initially used panel unit root tests and panel cointegration techniques. Our panel data methodology addresses cross-sectional dependence among stock market indices and oil prices; so that the panel techniques would tell us possible interactions in related emerging countries in general. When we found a significant relationship, we employed the panel dynamic ordinary least square (PDOLS) and the panel-Granger causality test. Furthermore, using the cointegration technique of Johansen, we separately examined the linear cointegrating relationship for each country in particular. When we found a significant linear cointegration, we used the dynamic ordinary least square (DOLS) estimation techniques to obtain long-run coefficients. We also implemented the Granger causality test to test the direction of influence. We briefly explain our framework for the econometric methodology as follows :

↳ **Cross-Sectional Dependence and Second Generation Panel Unit Root Tests :** The classical unit root tests are subject to criticism that is based on the low statistical power. Therefore, panel unit root (henceforth, PUR) tests have begun to be widely used in literature. However, the evidence provided by homogenous PUR tests may not be relied upon (Gozgor, 2014). Furthermore, the impact of cross-sectional dependence is most likely to be significant in our equity indices and oil prices series due to the increasing role of financial globalization (Sharma, Mahendru, & Singh, 2013). Therefore, we first considered performing a formal test of cross-sectional dependence, such as that proposed by Pesaran (2004). If the results support the presence of cross-sectional dependence, "second-generation" PUR tests will be used. There are now a number of second generation PUR tests available in literature, but given the relatively small number of individuals in the panel of our study, the recent test proposed by Pesaran (2007) was probably a better choice (Gozgor, 2014).

↳ **Panel Cointegration Technique of Westerlund (2006) and Estimation Techniques :** In this study, we used panel cointegration tests to determine whether long-run relationships exist among equity indices and oil prices in

the BRIC. The Fisher-Johansen-type test of Maddala and Wu (1999), the linear panel cointegration tests of Kao (1999) and Pedroni (1999, 2004) did not consider possible structural breaks in the series. On the other hand, Westerlund (2006) proposed the panel cointegration test procedure that allows for multiple structural shifts in the series. Therefore, this study employs the panel cointegration test of Westerlund. Westerlund (2006) used the global minimization of the sum of squared residuals approaches of Bai and Perron (1998) in the estimation of the location of breaks.

Furthermore, following the results of the panel data estimations, we checked the robustness of our findings using the panel-Granger causality test of Dumitrescu and Hurlin (2012). This test statistics is calculated by simply running standard Granger causality regressions for each cross-section. Dumitrescu and Hurlin's (2012) method only considers the short-run relationship, since it requires that the variables in the system are stationary. It takes the average of the test statistics, and it is defined as the Wbar statistic. The standardized version of the test statistic follows a standard normal distribution, and it is defined as the Zbar statistic. Following their findings of the panel cointegration and the panel-Granger causality techniques, we proceeded to investigate the validity of our findings from the panel data estimations in the long-run. For this purpose, we employed the PDOLS estimation technique of Kao and Chiang (2000) and Mark and Sul (2003) to obtain the long-run coefficient for the panel framework of the BRIC countries.

In addition, using Johansen's (1991) cointegration techniques, we separately examined the linear cointegrating relationship for each country. In the case of significant linear cointegration, we used the DOLS estimation techniques of Saikkonen (1992) and Stock and Watson (1993) to obtain long-run coefficients for each country. We also employed the Granger causality test to check the robustness of our empirical findings.

↳ **Data and Empirical Model :** In this paper, we used the daily frequency data for the period running from September 22, 1997 to November 29, 2013. We focused on the data for the trading days, which are based on days that all markets are open and this is the main limitation of this study. On the other hand, the observation number is limited in the panel data analysis, and the starting observation is based on the starting date from when the daily data are available for all stock markets (Aloui et al., 2012). We have in total 3218 observations.

We also focus on several sub-periods: (a) September 22, 1997- October 21, 2005, (b) October 24, 2005-November 29, 2013, (c) October 24, 2005-September 16, 2008, (d) September 17, 2008 - November 29, 2013. Our sub-periods are designed to investigate the pre-crisis and the post-crisis periods. We considered the period of 2005 as it includes the mid-point of our sample. Our stock market prices are based on the closing prices of the Ibovespa Brazil Sao Paulo stock exchange index, the MICEX index, the S&P BSE SENSEX index, and the Shanghai stock exchange composite index of Brazil, Russia, India, and China, respectively. Following Ghouri (2006), we used the WTI cushing spot price FOB (dollars per barrel) for the global oil prices. We created a local proxy oil price by multiplying world oil prices with the related exchange rates, namely the BRL/USD, the RUB/USD, the INR/USD,

Table 1. Descriptive Summary Statistics

Variables	Definition	Mean	Std. Dev.	Kurtosis	Skewness	Observations
Stock Markets (Brazil)	Real Price	1.19	0.73	-1.54	0.23	3218
Stock Markets (China)	Real Price	1.83	0.79	3.20	1.62	3218
Stock Markets (Russia)	Real Price	1.07	0.76	-1.59	0.10	3218
Stock Markets (India)	Real Price	1.24	0.78	-1.58	0.28	3218
Oil Price (Brazil)	Real Price	0.83	0.41	-0.76	-0.08	3218
Oil Price (China)	Real Price	0.82	0.39	-0.83	0.23	3218
Oil Price (Russia)	Real Price	0.91	0.53	-1.11	0.19	3218
Oil Price (India)	Real Price	0.96	0.57	-0.68	0.56	3218

Table 2. Results of the CD Test of Pesaran (2004) for Stock Market Indices and Oil Prices

Cross-sectional Dependence	9:1997-12:2013	9:1997-10:2005	10:2005-12:2013	10:2005-9:2008	9:2008-12:2013
The CD statistics and (probability)	2.78 (0.00)	13.5 (0.00)	31.8 (0.00)	56.1 (0.00)	46.9 (0.00)

Notes: The CD test of Pesaran (2004) is defined under the null hypothesis of no cross-sectional dependence in the equation of stock market indices and oil prices in the BRIC countries. The *p* - values are in parentheses.

Table 3. Results of the CIPS Tests of Pesaran (2007) for Stock Indices and Oil Prices

Heterogeneous Unit Root Test: The CIPS	9:1997-12:2013	9:1997-10:2005	10:2005-12:2013	10:2005-9:2008	9:2008-12:2013
Zt-bar statistics (Stocks)	0.711 (0.52)	0.326 (0.44)	0.461 (0.75)	-0.287 (0.29)	-0.027 (0.36)
Heterogeneous Unit Root Test: The CIPS	9:1997-12:2013	9:1997-10:2005	10:2005-12:2013	10:2005-9:2008	9:2008-12:2013
Zt- bar statistics (Oil Prices)	0.583 (0.44)	0.737 (0.68)	0.259 (0.64)	0.155 (0.38)	0.335 (0.59)

Notes: The CIPS test of Pesaran (2007) assumes cross-sectional dependence in the form of a single unobserved common factor. The test is defined under the null hypothesis that there is a unit root in stock market indices and oil prices in the BRIC countries. The test statistics include both constant and trend terms. The optimal lag length is selected by the Akaike Information Criterion (AIC). The *p* - values are in parentheses.

the CNY/USD for Brazil, Russia, India, and China, respectively. We obtained the stock prices and the exchange rates from Bloomberg statistics. Our world oil prices data came from the database of the U.S. Energy Information Administration. We used data for the real price where the mid-point observations are equal to one. We have included a brief summary of the descriptive statistics in the Table 1. Furthermore, we define our empirical model as follows:

$$STOCKS_{i,t} = \alpha \pm \beta\, LOCOIL_{i,t} + v_i + v_t + \varepsilon_{i,t}$$

where,

$STOCKS_{i,t}$ is the real stock market index (equity index) in country *i* at times *t*, $LOCOIL_{i,t}$ *is* the real proxy oil price in country *i* at times *t*, and country effects, period effects, and the error term are denoted by v_i, v_t and $\varepsilon_{i,t}$, respectively.

Empirical Results and Discussion

As a preliminary, we tested for cross-sectional dependence among the equity indices and the local oil prices in the BRIC countries by applying the cross-section independence (CD) test of Pesaran (2004). We report the results in the Table 2.

According to the results of the CD test of Pesaran (2004) in Table 2, the null hypothesis of no cross-sectional dependence of stock market indices and local oil prices among the BRIC economies is rejected. Thus, stock markets and oil prices are cross-sectionally dependent for all related periods. We then applied the second-generation panel unit root test that is accounted for cross-sectional dependence, and performed the cross-sectional augmented panel unit root (CIPS) test of Pesaran (2007). We report the results of the CIPS test, using both constant and trend terms, in Table 3.

The results of the CIPS test of Pesaran (2007) in Table 3 show that stock market indices and oil prices in BRIC countries can be described as non-stationary processes for all related periods. We then used the panel cointegration test of Westerlund (2006), and report the findings in Table 4.

The results of the four test statistics of the panel cointegration test of Westerlund (2006) in Table 4 indicate that there is only a long-run relationship between stock market indices and oil prices for the period from September 17, 2008 to November 29, 2013 in the panel data framework. Firstly, we checked the stationarity of the related variables and then used the recent and the robust panel-Granger causality test of Dumitrescu and Hurlin (2012) to determine the direction of the relationship, and report the results for the crisis and the post crisis period, that is, September 17, 2008 to November 29, 2013 in Table 5.

Table 4. Results of the Panel Cointegration Test of Westerlund (2006)

9:1997-12:2013	Value	*Z*- value	*P* - value	Robust *P*-value
G_t	-1.72	1.58	0.94	0.91
G_a	-7.95	1.18	0.88	0.89
P_t	-2.71	1.77	0.96	0.94
P_a	-5.54	1.14	0.87	0.92
9:1997-10:2005	**Value**	***Z*-value**	***P* -value**	**Robust *P* - value**
G_t	-1.57	1.94	0.97	0.97
G_a	-6.71	1.56	0.94	0.95
P_t	-3.18	1.21	0.88	0.88
P_a	-5.60	1.12	0.87	0.88
10:2005-12:2013	**Value**	***Z*-value**	***P* -value**	**Robust *P* - value**
G_t	-2.24	0.28	0.61	0.63
G_a	-9.77	0.63	0.74	0.67
P_t	-3.46	0.88	0.81	0.83
P_a	-5.92	1.01	0.84	0.88
10:2005-9:2008	**Value**	***Z*-value**	***P* -value**	**Robust *P* - value**
G_t	-2.71	0.65	0.47	0.45
G_a	-11.2	1.21	0.31	0.28
P_t	-5.47	-1.46	0.36	0.32
P_a	-9.45	-3.82	0.41	0.39
9:2008-12:2013	**Value**	***Z-value***	***P-value***	***Robust P-value***
G_t	-7.84	-18.3	0.00	0.00
G_a	-38.1	-21.7	0.00	0.00
P_t	-23.6	-4.45	0.00	0.00
P_a	-42.5	-23.8	0.00	0.00

Notes: Panel cointegration test of Westerlund (2006) has the null hypothesis that there is no cointegration. The constant and the linear deterministic trend terms are also included. Lag intervals are selected by the AIC.

Table 5. Results of the Panel-Granger Causality Test of Dumitrescu- Hurlin (9:2008-12:2013)

Panel-Granger Causality Test	9:2008-12:2013	*W* -Stat	*Z* bar-Stat	Probability
Null hypothesis	Stocks do not homogeneously cause Oil Prices	1.432	0.606	(0.5443)
Null hypothesis	Oil Prices do not homogeneously cause Stocks	2.180	1.660	(0.0968)*

Note: * denotes the rejection of the null hypothesis at the 10% significance level. The *p*- values are in parentheses.

The results of the panel-Granger causality test of Dumitrescu and Hurlin (2012) in Table 5 show that there is a unidirectional causality that runs from oil prices to the equity indices in the BRIC countries in general. We, therefore, implemented the PDOLS estimation technique of Kao and Chiang (2000) and Mark and Sul (2003) for the related period to examine how oil prices commonly affect stock market indices in our panel data framework, and to obtain long-run coefficient of the oil prices on the stock market indices in the BRIC countries. We report the related results in the Table 6.

The long-run coefficient of the PDOLS estimations in Table 6 reveals that a 1% percent increase in the oil prices pioneers to 0.52% rise in the stock market indices in the BRIC countries. Up to now, our results are robust for different periods, different panel methodology frameworks, small number of panel units, possible multiple breaks in the series, and size distortions. However, when we look at the economics perspective, previous literature has stated that dynamics of the oil prices and their effects on the equity markets in emerging market economies can be country specific, that is, it can depend on whether the country is oil-importing or oil exporting (Bhar & Nikolova, 2009; Filis et al., 2011; Wang et al., 2013). To test this hypothesis and to check the robustness of the general findings of our panel data estimation procedure, we also examined the impacts of the oil prices on the equity indices for each country in particular. For this purpose, we used the linear cointegration test of Johansen (1991) for each country in order to analyze whether there is a long-run relationship between stock market indices and oil prices over the crisis and the post-crisis period [1]. We report the results of the Johansen's cointegration test in the Table 7.

The results of the two test statistics of the cointegration test of Johansen (1991) in the Table 7 illustrate that there is a cointegration relationship between stock market indices and the oil prices in all four countries for the period from September 17, 2008 to November 29, 2013. At this point, we implemented the Granger Wald-causality test and report the results for the period from September 17, 2008 to November 29, 2013 in Table 8. All variables must be stationary in the Granger Wald-causality test. Therefore, we used stationary forms of the variables in the Granger Wald-causality tests.

The results of the Granger Wald-causality test in Table 8 point out that there is a causality relationship that runs from oil prices to stock market indices in China and India, and there is a pair-wise causality between stock market indices and oil prices in the Russian economy. We, therefore, applied the DOLS estimation techniques of Saikkonen (1992) and Stock and Watson (1993) for the crisis and the post-crisis periods to examine how oil prices affect stock market indices in Brazil, Russia, India, and China. We report the results of the long-run coefficient of the oil prices on the stock markets in the Table 9. According to the results of the DOLS estimation in Table 9, oil prices have a positive impact on the equity indices, and the long-run coefficients are found as 0.91, 1.11, and 0.62 in Russia, China, and India, respectively.

In this paper, we observe that there is a long-run positive relationship between stock market and oil prices only after fall 2008 in the panel framework. Therefore, we investigated the period from September 2008 to December 2013 in detail and we found that stock market indices are positively related with the oil price shocks in China, India, and Russia, but there is no significant relationship in the Brazilian economy. We do not reject the validity of our main hypothesis and show that the price transmission from oil prices to stock markets of the BRIC countries is significant during the period of the oil price surge after fall 2008, and the BRIC equity indices are positively related with the oil price movements, and these empirical findings are in line with findings of Zhu et al. (2011) and

Table 6. Results of the Panel DOLS Estimations for Stocks and Oil Prices (9:2008-12:2013)

Panel for the BRIC Countries	Stock Market Indices in the BRIC Countries
Lagged Oil Price	0.525 (0.041) [12.5]***
Lags & Leads	(1,1)
Adjusted R-squared	0.40

Notes: Dependent variable is the stock market indices in the BRIC countries. The constant term is estimated but not reported. We use the Barlett Kernel and the Andrews's bandwidth for the coefficient covariance. The optimal number of lag length is selected by the AIC. Figures in brackets and parentheses are *t*-statistics and standard errors, respectively. *** indicates statistical significance at the 1% levels.

[1] We apply the unit root tests of Phillips and Perron (1988) using constant and trend terms and unit root tests of Perron (1997) considering structural-breaks. The results indicate that oil prices and stock market indices are non-stationary time series. We did not report the results keeping in mind the word limit of the paper, and these results are available upon request.

Aloui et al. (2012). The empirical results of this paper are also in line with the results obtained by previous studies of Ono (2011), Li et al. (2012), and Zhu et al. (2014) in which they showed an increasing positive interaction between oil prices and stock market indices in China and India during the crisis and the post-crisis period, namely after fall 2008. The results are in favor of significant positive interaction between the oil prices and the Russian stock indices and are in line with the previous findings of Ono (2011), Natanelov et al. (2013a), and Fang and You (2014). The pair-wise Granger causality relationship between oil prices and stock market indices in the Russian economy was also obtained by Natanelov et al. (2013a). On the other hand, the neutrality of oil shocks in the Brazilian stock markets is in line with the previous results of Ono (2011), and this can be explained via the greater

Table 7. Results of the Bivariate Cointegration Rank Test of Johansen (9:2008 -12:2013)

Stock Market Index - Oil Price (Brazil)			
(lag=1; Criteria: AIC)		**Model**	
λ_{trace}			
H_0: $r = 0$ *vs* H_1:$r \geq 1$	25.87	35.66***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r \geq 2$	12.51	6.78	Not rejected
λ_{max}			
H_0: $r = 0$ *vs* H_1:$r = 1$	19.38	28.87***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r = 2$	12.51	6.78	Not rejected
Stock Market Index - Oil Price (China)			
(lag=1; Criteria: AIC)		**Model**	
$\lambda_{trace\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r \geq 1$	25.87	47.21***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r \geq 2$	12.51	8.37	Not rejected
$\lambda_{max\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r = 1$	19.38	38.84***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r = 2$	12.51	8.37	Not rejected
Stock Market Index - Oil Price (India)			
(lag=1; Criteria: AIC)		**Model**	
$\lambda_{trace\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r \geq 1$	25.87	32.74***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r \geq 2$	12.51	4.76	Not rejected
$\lambda_{max\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r = 1$	19.38	27.94***	Rejected
H_0: $r \leq 1$ *vs* H_1:$r = 2$	12.51	4.76	Not rejected
Stock Market Index - Oil Price (Russia)			
(lag = 1; Criteria: AIC)		**Model**	
$\lambda_{trace\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r \geq 1$	25.87	27.10**	Rejected
H_0: $r \leq 1$ *vs* H_1:$r \geq 2$	12.51	4.42	Not rejected
$\lambda_{max\ statistics}$			
H_0: $r = 0$ *vs* H_1:$r = 1$	19.38	22.67**	Rejected
H_0: $r \leq 1$ *vs* H_1:$r = 2$	12.51	4.42	Not rejected

Notes: The model includes linear deterministic trend. *** and ** indicate significance levels at the 1% and 5% levels.

Table 8. Results of the Granger-Wald Causality Test (9:2008-12:2013)

BRIC Countries	Granger-Wald Causality Test	Chi-square-Stat	Probability
Null hypothesis	Stocks does not cause Oil Price in Brazil	0.592	(0.4416)
Null hypothesis	Oil Prices does not cause Stocks in Brazil	0.353	(0.5519)
Null hypothesis	Stocks does not cause Oil Price in China	0.686	(0.4074)
Null hypothesis	Oil Prices does not cause Stocks in China	15.80***	(0.0001)
Null hypothesis	Stocks does not cause Oil Price in India	0.077	(0.7811)
Null hypothesis	Oil Prices does not cause Stocks in India	3.109*	(0.0778)
Null hypothesis	Stocks does not cause Oil Price in Russia	7.602***	(0.0058)
Null hypothesis	Oil Prices does not cause Stocks in Russia	4.143**	(0.0418)

Notes: The *p*- values are in parentheses. *** , **, and * are significance levels at the 1% , 5%, and 10%

Table 9. Results of the Dynamic Ordinary Least Square Estimations (9:2008-12:2013)

Regressors	Brazil	China	India	Russia
Constant	1.93 (0.11)***	2.12 (0.63)***	1.13 (0.08)***	0.35 (0.09)***
Lagged Oil Price	0.037 (0.09)	1.109 (0.13)***	0.623 (0.05)***	0.905 (0.06)***
Lags & Leads	(1,1)	(1,1)	(1,1)	(1,1)
Adjusted *R*- squared	0.014	0.453	0.475	0.574
Hansen Instability	0.036 [$p > 0.2$]	0.085 [$p > 0.2$]	0.092 [$p > 0.2$]	0.077 [$p > 0.2$]

Notes: The coefficient covariance matrix is calculated by the Barlett Kernel and the bandwidth selection method of Andrews (1991). The Hansen instability refers to the LM statistic in parameter instability test of Hansen (1992) that has the null hypothesis that the series are cointegrated. Standard errors are in parentheses and probability values arei n brackets. *** and ** indicate significance levels at the 1% and 5% , respectively.

importance of ethanol production in Brazil after the period of 2006 (Natanelov, McKenzie, & Van Huylenbroeck, 2013b ; Wang et al., 2013).

In recent years, the relationship between the equity prices in emerging markets and crude oil prices has been examined by several different methodological frameworks; however, examination of the role of investors' motivation due to the global financial crisis of 2008-09 on this relationship has remained limited. In this context, this paper finds a significant link between equity markets in the BRIC countries and crude oil markets by considering the role of the U.S. Dollar. Our empirical findings refer to the importance of fundamental portfolio diversification and hedging strategies in this relationship.

In addition, in line with previous paper of Natanelov et al. (2013a), we found that speculation or, more generally, investor motivation in oil markets after the global financial crisis of 2008-09 is one of the main determinants of equity prices in the BRIC countries. Investors would generally decide to remain in “secure financial positions,” namely, they would invest in “palpable goods," such as gold, silver, or commodities, instead of stocks, or currencies during periods of financial or economic depression. The empirical results in favor of the monumental importance of the crude oil market for emerging financial markets highlights the need for financial regulation at an international level, particularly during rgw periods of global recession or during post-recession recovery periods, which can also introduce equity price bubbles.

Conclusion, Implications, and Directions for Further Research

This study investigates the long-run relationship between the equity indices and the oil prices in the BRIC economies over the period from September 22, 1997- November 29, 2013 at the daily data set. We added the effects of exchange rates and created a proxy measure as “local” oil prices and investigated various sub-periods in

the whole sample. Applying the cross-sectional dependence test, we preliminarily show the cross-sectional dependence among stock and oil markets in the BRIC countries, and therefore, used the second generation panel unit root test. We then proceeded to apply the panel cointegration technique, the panel-Granger causality test, and the PDOLS estimations. Our results show that there is a long-run relationship between the stock market indices and the oil prices only for the period from September 16, 2008 to November 29, 2013 prices in the panel framework. Using the linear cointegration technique, we separately examined the linear cointegrating relationship for each country, and used the DOLS estimation technique to obtain long-run coefficients. We found that the oil prices have a significant positive effect on the stock market indices in Russia, China, and India. Our analyses on the related period also points out that there is a Granger causality relationship that runs from the oil prices to the stock market indices in China and India, and there is a pair-wise causality between the stock market indices and the oil prices in the Russian economy.

Accordingly, as stated in the introduction, along with the rise in oil prices beginning in the mid-2000s, there has been an uptrend in the equity prices of BRIC economies. These price trends in oil prices and the equity markets in emerging markets collapsed. We suggest that financial derivatives might be useful tools to adjust the effects of rising or volatile oil and equity prices. Along with the crude oil prices, the monetary policy stances of developed economies, global liquidity conditions, and the strength of the USD can also be determinants of the equity prices in the BRIC countries. However, these subjects still need to be researched further, particularly concerning the different impacts of local oil prices on the developing economies at the national level.

Overall, the findings in this paper emphasize that the global crisis of 2008-09 interestingly introduced statistically robust and economically solid relationships between the oil prices and the stock market indices in China, India, and Russia. Although we obtain common and similar relationships among the BRIC countries except Brazil, the degree of interaction varies substantially among countries. This can be explained by the country-specific factors, such as strong economic growth but relatively weak-efficient stock markets in China, the more regulated oil sector in India, huge oil reserves and large oil companies in Russia, and the changing energy policies in Brazil. Our results show that the price pattern of the Russian equity index and the oil prices are almost parallel after fall 2008 and there is a significant co-movement in the Chinese and the Indian economies. Therefore, our empirical results are important not only for policy-makers, but also for speculators, risk management issues, international asset allocations, portfolio diversifications, and hedging strategies.

Finally, while Wang et al. (2013) indicated that linear models can successfully capture the relationship between changes of oil prices and equity indices, the lack of linear panel cointegration for the period from 1997 to fall 2008 may be a signal for regime dependent cointegration. Therefore, in the case a linear panel cointegration cannot be found, we suggest that one can implement the panel threshold cointegration, such as that examined by Zhu et al. (2011). The issue of a structural break can also be considered in the panel unit root test. For example, Carrion Silvestre, Barrio-Castro, and Lopez-Bazo (2005) developed a panel unit root test approach that allows for the presence of multiple structural breaks and cross-sectional dependence. Furthermore, one can consider the structural break methods for time series (e.g. Gregory & Hansen, 1996a; Gregory & Hansen, 1996b). We also leave these issues to be taken up by researchers in future studies.

Acknowledgment

We would like to thank the Department of Agricultural Economics, Ghent University for extending their support while we prepared this paper in the fall 2013 semester.

References

Aloui, C., Nguyen, D.K., & Njeh, H. (2012). Assessing the impacts of oil price fluctuations on stock returns in emerging markets. *Economic Modeling, 29* (6), 2686 - 2695.

Aloui, R., Ben Aïssa, M.S., & Nguyen, D.K. (2013). Conditional dependence structure between oil prices and exchange rates: A copula-GARCH approach. *Journal of International Money and Finance, 32* (February), 719- 738.

Amano, R. A., & van Norden, S. (1998). Oil prices and the rise and fall of the U.S. real exchange rate. *Journal of International Money and Finance, 17* (2), 299 - 316.

Andrews, D.W. K. (1991). Heteroskedasticity and autocorrelation consistent covariance matrix estimation. *Econometrica, 59* (3), 817 - 858.

Apergis, N., & Miller, S.M. (2009). Do structural oil-market shocks affect stock prices ? *Energy Economics, 31* (4), 569 - 575.

Bai, J., & Perron, P. (1998). Estimating and testing linear models with multiple structural changes. *Econometrica, 66* (1), 47- 78.

Basher, S.A., & Sadorsky, P. (2006). Oil price risk and emerging stock markets. *Global Finance Journal, 17* (2), 224 - 251.

Basher, S.A., Haug, A.A., & Sadorsky, P. (2012). Oil prices, exchange rates and emerging stock markets. *Energy Economics, 34* (1), 227- 240.

Bhar, R., & Nikolova, B. (2009). Oil prices and equity returns in the BRIC countries. *World Economy, 32* (7), 1036 - 1054. DOI: 10.1111/j.1467-9701.2009.01194.x

Carrion Silvestre, J.L., Barrio-Castro, T.D., & Lopez-Bazo, E. (2005). Breaking the panels: An application to the GDP per capita. *Econometrics Journal, 8* (2), 159-175.

Chortareas, G., & Noikokyris, E. (2014). Oil shocks, stock market prices, and the U.S. dividend yield decomposition. *International Review of Economics and Finance, 29* (January), 639 - 649.

Dumitrescu, E.I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modeling, 29* (4), 1450 - 1460.

El-Sharif, I., Brown, D., Burton, B., Nixon, B., & Russell, A. (2005). Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. *Energy Economics, 27* (6), 819 - 830.

Fang, C. - R., & You, S. - Y. (2014). The impact of oil price shocks on the large emerging countries' stock prices: Evidence from China, India and Russia. *International Review of Economics and Finance, 29* (January), 330 - 338.

Filis, G., Degiannakis, S., & Floros, C. (2011). Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. *International Review of Financial Analysis, 20* (3), 152-164.

Ghouri, S.S. (2006). Assessment of the relationship between oil prices and US oil stocks. *Energy Policy, 34* (17), 3327 - 3333.

Gozgor, G. (2013). The application of stochastic processes in exchange rate forecasting: Benchmark test for the EUR/USD and the USD/TRY. *Economic Computation and Economic Cybernetics Studies and Research, 47* (2), 225 - 246.

Gozgor, G. (2014). The impact of trade openness on the unemployment rate in G7 countries. *Journal of International Trade and Economic Development, 23* (7), 1018 -1037. DOI:10.1080/09638199.2013.827233

Gregory, A.W., & Hansen, B.E. (1996a). Residual-based tests for cointegration in models with regime shifts. *Journal of Econometrics, 70* (1), 99 - 126.

Gregory, A.W., & Hansen, B.E. (1996b). PRACTITIONERS CORNER : Tests for cointegration in models with regime and trend shifts. *Oxford Bulletin of Economics and Statistics, 58* (3), 555 - 560. DOI: 10.1111/j.1468-0084.1996.mp58003008.x

Hamilton, J.D. (1983). Oil and the macroeconomy since World War II. *Journal of Political Economy, 91* (2), 228 - 248.

Hamilton, J.D. (2009). Understanding crude oil prices. *Energy Journal, 30* (2), 179 - 206.

Hammoudeh, S., Dibooglu, S., & Aleisa, E. (2004). Relationships among U.S. oil prices and oil industry equity indices. *International Review of Economics and Finance, 13* (4), 427 - 453.

Hansen, B.E. (1992). Tests for parameter instability in regressions with I(1) processes. *Journal of Business and Economic Statistics, 10* (3), 321 - 335.

Henriques, I., & Sadorsky, P. (2008). Oil prices and the stock prices of alternative energy companies. *Energy Economics, 30* (3), 998 - 1010.

Huang, R.D., Masulis, R.W., & Stoll, H.R. (1996). Energy shocks and financial markets. *Journal of Futures Markets, 16* (1), 1 - 27. DOI: 10.1002/(SICI)1096-9934(199602)16:1<1::AID-FUT1>3.0.CO;2-Q

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica, 59* (6), 1551-1580.

Jones, C. M., & Kaul, G. (1996). Oil and the stock markets. *Journal of Finance, 51* (2), 463 - 491. DOI: 10.1111/j.1540-6261.1996.tb02691.x

Kao, C., & Chiang, M.H. (2000). On the estimation and inference of a cointegrated regression in panel data. In Baltagi, B.H. (Eds.), *Nonstationary panels, panel cointegration and dynamic panels* (Vol. 15, pp. 179 - 222). Amsterdam: Elsevier.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics, 90* (1), 1 - 44.

Kilian, L., & Park, C. (2009). The impact of oil price shocks on the U.S. stock market. *International Economic Review, 50* (4), 1267- 1287. DOI: 10.1111/j.1468-2354.2009.00568.x

Kilian, L. (2009). Not all oil price shocks are alike: Disentangling demand and supply shocks in the crude oil market. *American Economic Review, 99* (3), 1053 - 1069. DOI: 10.1257/aer.99.3.1053

Krugman, P. (1983). Oil shocks and exchange rate dynamics. In J.A. Frankel (Eds.), *Exchange rates and international macroeconomics* (pp. 259 - 284). Chicago: University of Chicago Press.

Li, S. - F., Zhu, H. - M., & Yu, K. (2012). Oil prices and stock market in China: A sector analysis using panel cointegration with multiple breaks. *Energy Economics, 34* (6), 1951-1958.

Maddala, G.S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics, 61* (S1), 631 - 652. DOI: 10.1111/1468-0084.0610s1631

Mark, N.C., & Sul, D. (2003). Cointegration vector estimation by panel DOLS and long-run money demand. *Oxford Bulletin of Economics and Statistics, 65* (5), 655-680.

Miller, J.I., & Ratti, R.A. (2009). Crude oil and stock markets: Stability, instability, and bubbles. *Energy Economics, 31* (4), 559- 568.

Nandha, M., & Faff, R. (2008). Does oil move equity prices? A global view. *Energy Economics, 30* (3), 986 - 997.

Natanelov, V., Dora, M., Gellynck, X., & Van Huylenbroeck, G. (2013a). Crises, crude oil and BRIC stock markets. *International Journal of Business and Emerging Markets (IJBEM), 5* (4), 304 - 321.

Natanelov, V., McKenzie, A.M., & Van Huylenbroeck, G. (2013b). Crude oil- corn - ethanol- nexus: A contextual approach. *Energy Policy, 63* (December), 504 - 513.

Ono, S. (2011). Oil price shocks and stock markets in BRICs. *The European Journal of Comparative Economics, 8* (1), 29 - 45.

Papapetrou, E. (2001). Oil price shocks, stock market, economic activity and employment in Greece. *Energy Economics, 23* (5), 511 - 532.

Park, J., & Ratti, R.A. (2008). Oil price shocks and stock markets in the U.S. and 13 European countries. *Energy Economics, 30* (5), 2587- 2608.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics, 61* (S1), 653 - 670. DOI: 10.1111/1468-0084.0610s1653

Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory, 20* (3), 597- 625. DOI: 10.1017/S0266466604203073

Perron, P. (1997). Further evidence on breaking trend functions in macroeconomic variables. *Journal of Econometrics, 80* (2), 355 - 385.

Pesaran, M.H. (2004). *General diagnostic tests for cross section dependence in panels*. IZA Discussion Paper Series, No. 1240, 1 - 42. University of Cambridge, Germany.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics, 22* (2), 265- 312. DOI: 10.1002/jae.951

Phillips, P.C.B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75* (2), 335- 346.

Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy Economics, 21* (5), 449 - 469.

Saikkonen, P. (1992). Estimation and testing of cointegrated systems by an autoregressive approximation. *Econometric Theory, 8* (1), 1 - 27.

Sharma, G.D., Mahendru, M., & Singh, S. (2013). Are the stock exchanges of emerging economies interlinked? Evidence from BRICS. *Indian Journal of Finance, 7* (1), 26- 37.

Stock, J.H., & Watson, M.W. (1993). A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica, 61* (4), 783 - 820.

Wang, Y., Wu, C., & Yang, L. (2013). Oil price shocks and stock market activities: Evidence from oil-importing and oil-exporting countries. *Journal of Comparative Economics, 41* (4), 1220 - 1239.

Westerlund, J. (2006). Testing for panel cointegration with multiple structural breaks. *Oxford Bulletin of Economics and Statistics, 68* (1), 101- 132. DOI: 10.1111/j.1468-0084.2006.00154.x

Zhu, H. - M., Li, R., & Li, S. (2014). Modelling dynamic dependence between crude oil prices and Asia-Pacific stock market returns. *International Review of Economics and Finance, 29* (January), 208 - 223.

Zhu, H. - M., Li, S. - F., & Yu, K. (2011). Crude oil shocks and stock markets: A panel threshold cointegration approach. *Energy Economics, 33* (5), 987- 994.