Oil price shocks and OECD equity markets: distinguishing between supply and demand effects

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Abstract: With the recent changes in international financial markets, investors and policy-makers are paying special attention to the relationship between oil price shocks and equity markets. This paper investigates how oil supply and oil demand shocks interact with OECD countries and macroeconomic variables within a cointegration vector error correction framework, which provides extreme flexibility with a parsimonious specification. By defining oil supply and oil demand shocks as endogenous variables, our proposed model allows us to gauge the shock transmission among the system variables through time and investigate the direct and indirect connections between oil price shocks and stock returns. We are also able to observe the long-run relationship between real stock prices and real oil prices measured by world and local prices. Our empirical findings show that the impact of oil price shocks substantially differs among the countries and that the significance of the results differs among the oil price specifications (real national oil price, world oil price, supply shocks and demand shocks).

Keywords: oil price; stock market return; oil supply shocks; oil demand shocks.

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1 Introduction

Most of the empirical literature offers substantial evidence on the impact of oil price fluctuations on equity markets, proposing a negative relationship between oil prices and
equity market returns. Using a standard cash flow dividend valuation model, Jones and Kaul (1996) find a significant negative impact of oil price shocks on US and Canadian stock prices. Shifting from the study of co-movements to volatility analysis, the most recent literature focuses on volatility spillovers between oil and stock markets. Hammoudeh et al. (2004) investigate the spillover effects, day effects, and dynamic relationships among five daily S&P oil sector stock indices and five daily oil prices for the US oil markets using cointegration techniques as well as ARCH-type models. They evidence volatility spillovers from the oil futures market on the stocks of some oil sectors.

For Basher and Sadorsky (2006), a rise in oil prices acts as inflation tax and increases risk and uncertainty, which lead to reduced wealth and affect stock prices seriously. Using a multifactorial model of arbitration that allows for both conditional and unconditional risk factors, the authors find robust evidence that confirms the significant sensitivity of stock markets to the oil price risk in emerging countries.

The negative impact of oil price changes and stock returns is also confirmed by O’Neil et al. (2008) for the USA, the UK, and France, Park and Ratti (2008) for the USA and 12 European oil-importing countries, and Nandha and Faff (2008) for global industry indices (except for extractive industries).

The increase in uncertainty of the energy sector is expected to impact directly and indirectly the financial markets. Therefore, the re-examination of what exactly can be the explication of the negative connection between oil prices shocks and the stock returns remains a main question requiring more concerns to find some responses. The negative reaction of real stock prices to the increase in oil price is attributed according to several authors to the direct effects of this increase in terms on cash flows and inflation. This argument is shared by several authors who document that oil price shocks lead to raising inflation and unemployment and therefore lower macroeconomic growth and financial assets (Shimon and Raphael, 2006). In fact, oil price can corporate cash flow since oil price constitutes a substantial input in production. In addition, oil price changes can influence significantly the supply and demand for output at industrial sector as well as at the whole economy level and therefore decrease the firm performance through its effect on the discount rate for cash flow because of the direct effect that may exert on the expected rate of inflation and the expected real interest rate. These direct and indirect effects of the high volatility in oil prices seem likely to increase uncertainty at firms and in the economy. In this line, Bernanke (1983) and Pindyck (1991) argue that higher change in energy prices creates uncertainty about future energy price and incites, consequently, firms to postpone irreversible investment decisions in reaction to the profits prospects.

Chiou and Lee (2009) examine the asymmetric effects of WTI daily oil prices on S&P 500 stock returns. Using the autoregressive conditional jump intensity model with expected, unexpected, and negative unexpected oil price fluctuations, they find that high fluctuations in oil prices have asymmetric unexpected effects on stock returns. Malik and Ewing (2009) rely on bivariate GARCH models to estimate the volatility transmission between weekly WTI oil prices and equity sector returns and find evidence of spillover mechanisms. Choi and Hammoudeh (2010) extend the time-varying correlation analysis by considering the commodity prices of Brent oil, WTI oil, copper, gold and silver, and the S&P 500 index. They show that commodity correlations have increased since 2003, limiting hedging substitutability in portfolios. In a more recent study, Arouiri et al. (2010) examine the relation between oil prices and 12 stock sectors in European countries. Their results show that the reaction of sector returns to changes in oil prices is considerably
different across sectors and that the inclusion of the oil assets in a portfolio of sector stocks permits the improvement of the portfolio’s risk-return characteristics.

Awartani and Maghryereh (2013) investigate return and volatility spillover effects between the oil market and the GCC stock markets using indices proposed by Diebold and Yilmaz (2009, 2012) that reveal transmission in both directions between 2004 and 2012. They find that the information flow from oil returns and volatilities to the GCC stock exchanges is important, while the flow in the opposite direction is marginal. Besides, the oil market gives other markets more than it receives in terms of both returns and volatilities. These trends were more pronounced in the aftermath of the global financial crisis in 2008 as the net contribution of oil intensified after a burst during the crisis. The empirical evidence from the sample is consistent with a system in which oil plays the dominant role in the information transmission mechanism between oil and equities in the GCC countries.

Naifar and Al Dohaiman (2013) investigate firstly the impact of both change and volatility of oil price variables on stock market returns under regime shifts in the case of Gulf Cooperation Council countries. They employ a Markov regime-switching model to generate regime probabilities for oil market variables. Two-state Markov switching models are used, referring to the crisis regime and non-crisis regime. Secondly, they investigate the non-linear interdependence between oil prices, interest rates, and inflation rates before and during the subprime crisis. They consider various Archimedean copula models with different tail dependence structures. Their results show evidence supporting a regime-dependent relationship between GCC stock market returns and OPEC oil market volatility except for the case of Oman. The findings also show an asymmetric dependence structure between inflation rates and crude oil prices and indicate that this structure was oriented towards the upper side during the recent financial crisis. Moreover, the authors find significant symmetric dependence between crude oil prices and short-term interest rates during the financial crisis.

Reboredo and Rivera-Castro (2014) use daily data for the aggregate S&P 500 and Dow Jones STOXX Europe 600 indexes and the US and European industrial sectors (automobile and parts, banks, chemical, oil and gas, industrial goods, utilities, telecommunications, and technologies) over the period from 1 June 2000 to 29 July 2011 to examine the connection between oil prices and stock market returns. The results of the wavelet multi-resolution analysis show that oil price changes have little effect on stock market returns in the pre-crisis period at either the aggregate or the sectorial level. With the onset of the financial crisis, the results support the positive interdependence between oil price shocks and stock returns at both the aggregate and the sectorial level.

Using the multivariate frequency approach, Creti et al. (2014) analyse the co-movement between oil prices and equity markets in oil-exporting and oil-importing countries. Their empirical results show that the relation between the oil price and the stock market is more important in oil-exporting countries. Guesmi and Fattoum (2014) confirm this result by applying the multivariate asymmetric GARCH models. They find that oil price shocks in crisis periods have an important impact on the connection between oil prices and oil-importing countries and oil-exporting countries.

Sadorsky (2014) uses a different multivariate GARCH process (VARMA and DCCA) to study the conditional correlation dynamics between emerging stock markets and commodities. Their results show that the correlations between stocks and commodities increase significantly after financial crisis periods. Narayan and Gupta (2015) re-examine the impact of oil prices on stock market returns between September 1859 and December 2013. They test the null hypothesis of no predictability using a
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They find that the oil price is a persistent and endogenous predictor variable and that our proposed stock return predictability model is heteroscedastic. They conclude that the non-linear process characterises the predictability and that negative oil prices predict US stock returns more than positive oil prices do.

Ghosh and Kanjilal (2014) examine the co-movement between oil prices and stock market prices using daily data for the period of 2003–2011. Based on non-linear cointegration analysis, they note the presence of cointegration between the two variables and show that oil price shocks cause stock market returns, confirmed by Toda–Yamamoto’s (Toda and Yamamoto, 1995) Granger causality test.

Nguyen et al. (2015) apply asymmetric causality to examine the relationship of the US equity market with energy returns, metal, and agriculture commodities future prices. In the presence of asymmetry, they document the feedback effect between equity and commodity futures markets. Applying the time-varying approach, Schalck and Chenavaz (2015) examine the determining factors of oil commodity prices and report that the global demand and stock market prices affect oil commodity returns positively. They also note that exchange and interest rates exert a negative impact on oil commodity prices. Kang et al. (2015) apply the variance decomposition and impulse response function, that is, the structural VAR model, to examine the relationship between oil prices, stock prices, and stock price volatility using the US economy daily data for the period of 1973–2013. They find that a positive aggregate global demand negatively affects the correlation between stock returns and stock volatility. Their empirical analysis also reports that global oil production has a positive effect on the covariance between stock returns and stock volatility. In a more recent work, Hammoudeh et al. (2015) apply the SVAR model to study the effects of shocks in the monetary policy of the USA on groups of commodity prices. The authors consider both the commodity prices and the price indices of different subsets or sectors of commodities. The empirical framework permits them to consider the structural shocks to monetary policy, captured by unexpected variations in the federal funds rate, and then to quantity the effects of these shocks on the various commodity sector prices and the economic activity.

The present paper makes three major contributions to the existing energy finance literature: (i) it examines the effects of oil price shocks on stock markets, including oil supply shocks, oil demand shocks driven by the global economic activity, and oil-specific demand shocks separately, using a vector error correction model (VECM); (ii) it identifies different channels of oil shocks from different variables: production indexes and short-term interest rates considering structural breaks; and (iii) it reports that the assumption of exogeneity of the variables is not supported and that there is no need to impose restrictions on the estimated coefficients to determine the short-term relationships.

We illustrate the convenience of this empirical framework by considering the dynamic interactions between oil supply shocks, oil demand shocks, and oil-specific demand shocks and OECD stock markets between January 1990 and December 2013, which are characterised by a continuum increasing trend of crude oil prices as well as their long-swings behaviour.

Our analysis reveals two main findings regarding the interaction between oil and major OECD stock markets. The impact of oil shocks on stock markets is more pronounced during the period of world turmoil. Our analysis contributes to the previous literature by including supply and demand shocks to take into consideration the asymmetric response of stock returns to these two types of shocks. The main results that we find are that oil prices affect stock market returns differently depending on the
various oil price shock specifications and the different countries. Oil supply shocks have a negative effect on stock market returns in the net oil-importing OECD countries. The stock markets receive a negative impact from oil demand shocks in the oil-importing OECD countries and a positive impact in the oil-exporting OECD countries.

Our study is founded on a multivariate framework to encompass several channels through which news and consequently shocks are transmitted between oil and OECD stock markets. In other words, an attractive research task is to determine whether the vector error correction model is appropriate for providing more insights into the shocks' transmission between oil and stock markets. In fact, it is well known that oil prices and stock market returns change over time. Therefore, if we consider these co-movements over time within emerging stock markets, it would be interesting to analyse the impulse response functions and the impact of three types of real oil price shocks on real stock returns: all oil price shocks, oil demand price shocks, and oil supply price shocks. Our investigation focuses on ten OECD countries: Canada, the Czech Republic, Denmark, Hungry, Korea, Mexico, Norway, Poland, Sweden, and the USA. Our choice is motivated by the fact that they are considered as the most mature markets.

The remainder of this paper proceeds as follows. Section 2 focuses on the empirical analysis. In this section, we present the variable definitions and the modelling approach. The discussion of empirical findings is the subject of Section 3. Finally, Section 4 concludes.

2 Data and methodology

2.1 Data description

To examine the empirical linkages between oil price shocks and stock market returns in ten OECD countries, we collect data on real stock prices, real industrial production, nominal interest rates, and oil prices over the period from January 1990 to December 2013. The countries included in our analysis are Canada, the Czech Republic, Denmark, Hungry, Korea, Mexico, Norway, Poland, Sweden, and the USA. All the data used in this paper are monthly. Thus, the starting date of the sample period is determined by the availability of the monthly data serving to compute our variables for each country.

The Real Stock Price (RSP) is computed as the difference between the stock price index and the inflation rate given by the log difference in the consumer price index. The ‘OECD’ and ‘EUROSTAT’ databases compile the data for stock market indices. Real stock returns in each market, denoted $R_t$, are computed using the first difference in the natural logarithms of the aggregate real stock market prices following the equation $R_t = (ln(P_t) - ln(P_{t-1})) \times 100$, where $P_t$ represents the real stock market index at time $t$.

To avoid the impact of the inflation rate, we use approximately the real stock returns instead of the returns calculated for each market. This proxy for the real stock returns is already used by Park and Ratti (2008) and Cunado and Perez de Gracia (2014).

We use the real national (and respectively world) oil prices (ROP) for each country as a proxy for the oil price. The real national price is computed as the product of the nominal oil price and the exchange rate deflated by the consumer price index of each country. The UK Brent nominal price is used as a proxy for the nominal oil price. This proxy is commonly used by authors such as Cunado and Perez de Gracia (2003, 2005, 2014) and Engemann et al. (2011) to investigate the type of interconnections between oil
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shocks and macroeconomic variables. In addition, we define the world real oil price as the nominal oil price deflated by the US producer price index.

Based on the works of Sadorsky (1999), Park and Ratti (2008), and Cunado and Perez de Gracia (2014), the real industrial production (RIP) is computed as the nominal industrial production deflated by the consumer price index of each country.

The real oil production (yOIL) and short-term interest rates (STI) are included in the analysis to supervise the behaviour of the stock markets’ return to the oil price shocks. Further, the use of the oil production variable together with the oil price is motivated by the wish to benefit from the dispersion between oil supply and oil demand shocks. This variable is used in earlier studies by Kilian (2009), Kilian and Park (2009), and Güntner (2013).

The data for the oil price and the oil production are obtained from the Energy Information Administration (EIA) database and the International Financial Statistics (International Monetary Fund). Finally, the data for the macroeconomic data (industrial production, producer price index, consumer price index, short-term interest rates, and exchange rate) are compiled from the ‘OECD’ database and the Global Financial Data (GFD).

The indirect effects of oil price shocks on real stock returns are supervised based on two variables that are commonly used in previous studies. According to Bernanke et al. (1997), Sadorsky (1999), Park and Ratti (2008), Lee et al. (2012), and Cunado and Perez de Gracia (2014), the short-term interest rate constitutes a good proxy that allows the monitoring of the connections between oil price shocks and stock returns. The use of this variable is motivated by the fact that central banks react sensitively to higher oil prices through the short-term nominal interest rate. This reaction induces an indirect effect of oil price shocks on real economic activity and therefore on real stock market returns. The second indirect effect of the oil price shocks on the real economic activity and therefore the real stock returns can be supervised using the industrial production variable.

Following the idea that ‘not all oil price shocks are alike’ (Kilian, 2009), in this paper the analyses will be based on the specification proposed by Cunado and Perez de Gracia (2014). This specification can be written as follows: \( \Delta OIL_t = (OIL_t - OIL_{t-1}) \). This relation specifies the oil price variations defined as the first log difference of world real oil prices. In addition, let \( \Delta yOIL_t = (yOIL_t - yOIL_{t-1}) \). The specification of world real oil production changes is defined as the first log difference of world oil production. The oil supply shocks (OSS\(_t\)) and oil demand shocks (ODS\(_t\)) will be computed respectively as follows:

\[
OSS_t = \begin{cases} 
\Delta OIL_t, & \text{if } \text{sign}(\Delta OIL_t) \neq \text{sign}(\Delta yOIL_t), \\
0, & \text{otherwise.}
\end{cases}
\]

\[
ODS_t = \begin{cases} 
\Delta OIL_t, & \text{if } \text{sign}(\Delta OIL_t) \neq \text{sign}(\Delta yOIL_t), \\
0, & \text{otherwise.}
\end{cases}
\]

In equations (1) and (2), \( \Delta OIL_t \) is the growth rate of world real oil price in time \( t \) and \( \Delta yOIL_t \) is the growth rate of world oil production in time \( t \). From these equations, a change in oil price is corresponds to an oil supply shock if the sign of the oil price variation and the sign of the oil production variation are different. If the oil price
variation and the sign of the oil production variation exhibit equal signs, the change in oil price is identified as an oil demand shock. In other words, an oil price increase (decrease) together with a world oil production increase (decrease) will be identified as a demand shock. In the opposite case, an oil price increase (decrease) followed by a world oil production decrease (increase) will be identified as a supply shock.

2.2 Methodology

The primary interest of this study is to investigate the effects of oil shocks – expressed in both world and national real prices – on stock returns in OECD stock markets using the following models: the vector error correction (VECM) model introduced by Johansen (1988) and alternatively the vector autoregressive (VAR) methodology proposed by Sims (1980). The advantage of the cointegration procedure of Johansen and Juselius (1990) is that it allows firstly the testing for the existence of one or more cointegration relationships between the different series. Second, the Johansen method is a multivariable test that enables the determination of the number of cointegration relationships between the selected series. The VECM contains the cointegration relation built into the specification, so it restricts the long-run behaviour of the endogenous variable to converge to its cointegrating relationship while allowing for short-run adjustment dynamics.

Thus, this approach avoids the two-stage tests applied in the Engel–Granger procedure that permit a single cointegration relationship. This approach also has the advantage of considering the problem of simultaneity. Finally, the assumption of exogeneity of the variables is not supported and there is no need to impose restrictions on the estimated coefficients to determine the short-term relationships.

Consider a VECM model based on monthly data for $y_t = (RSP_t, RIP_t, STI_t, ROP_t)$ given by:

$$
\Delta y_t = \alpha \beta' y_{t-1} + B_0 + \sum_{i=1}^{p} B_i \Delta y_{t-i} + \epsilon_t
$$

(3)

where $\Delta$ is the first difference of the operator, $B_0$ is a four-dimensional column vector of deterministic constant terms, and $(B_i)_{i=1, \ldots, p}$ denotes four-order matrices of short-run information parameters. $\alpha \beta'$ is a four-order matrix of long-run information parameters, where $\alpha$ represents the adjustment speed to equilibrium and $\beta$ contains the long-run or equilibrium coefficients. $\epsilon_t$ denotes a four-dimensional vector of residuals, where $\epsilon_t \sim iid(0, \Omega)$. The $\text{rank}(\alpha \beta') = r$ is the number of cointegration vectors, which may differ depending on the country and the nature of the oil price specification (national, world, all oil price shock, supply shock, or demand shock). If $r = 0$, the time series variables are not cointegrated in this case, and the variables have first to be differenced and one has a VAR in difference.

In the first step, we use the conventional unit root tests of Dickey–Fuller (ADF) and Phillips–Perron (PP) and the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests to verify the stationarity of all the variables. In the second step, we apply the endogenous breaks LM unit root test of Lee and Strazicich (2003, 2004) to avoid ‘spurious rejections’ from the conventional unit root tests.

Since each of the variables real stock prices, real industrial production, nominal interest rates, and real national (respectively world) oil prices contains a unit root, we proceed in the second step to determine the lag length of the VAR version of the VEC model using the Akaike Information Criterion (AIC). Then, we apply Johansen’s
cointegration test to determine the number of cointegrating vectors (rank(αβ′) = r) using two different likelihood ratio statistics (LR): the trace statistic and the maximum eigenvalue statistic. In the third step, the VEC model is estimated following the maximum likelihood method. Finally, we analyse the impact of oil price changes on stock markets by examining the impulse response functions (IRFs) obtained by estimating the previous VECM.

3 Empirical results

3.1 Unit root test

For the ten OECD countries, the outcomes of the ADF, Phillips–Perron, and KPSS unit root tests in level and in the first difference of the real stock prices, short-term interest rate, real industrial production, and real oil (national and world) prices are presented in Table 1A.

The results in Table 1A (see Appendix) show that almost all the variables are integrated of order one except for the real oil price, which seems, at first glance, to be trend stationary in level for Canada, Korea, Mexico, Poland, and Sweden. However, this result can be considered carefully. In fact, the plot of the real national oil price time series shows for each country that the series are not really trend stationary in level. The history of the real national oil prices shown in Figure 1 indicates the presence of breaks in all the oil price series.

Figure 1  Real national oil price and real world oil price (see online version for colours)

The conventional unit root tests (ADF, PP, and KPSS) fail to reject the null hypothesis when structural breaks are present. These tests drive their critical values assuming no breaks under the null hypothesis. Consequently, in the presence of a unit root with a
break, they tend to reject the null hypothesis, suggesting that the time series is stationary around the trend when it is non-stationary with a break. For this reason, we conduct tests for endogenous breaks in the unit root. Christiano (1992), Perron and Vogelsang (1992), and Zivot and Andrews (1992) develop methods to search endogenously for a break point and test for the presence of a unit root when the process has a broken constant or trend and demonstrate that their tests are robust and more powerful than the conventional unit root tests. To avoid this problem and to examine the potential presence of breaks, in this paper we use the endogenous two-break LM unit root tests proposed by Lee and Strazicich (2003, 2004). These seem to be unaffected by breaks under the null hypothesis. We find, as anticipated, significant structural breaks in the real national oil prices of Canada, Korea, Poland, and Sweden but not Mexico (see Table 2A reported in Appendix). The presence of structural breaks in oil price series of Canada, Korea, Poland, and Sweden signifies that the four series are $I(1)$ and not $I(0)$ in the sense of Dickey–Fuller unit root test. For this case of Mexico, the time series of real national oil prices seems to be linear trend stationary, potentially because of the shortness of the data. Regarding the ADF, PP, KPSS, and LM unit root tests, the results conclude in favour of a unit root for all the level series used in all the countries’ VECM data. Finally, we conclude that the variables real stock prices, real industrial production, nominal interest rates, and real national (respectively world) oil prices have the same order of integration, so our selected variables successfully satisfy the non-stationarity condition of Johansen cointegration method.

3.2 Cointegration analysis

Empirical model estimation approaches already used in previous well-known studies such as Hamilton (1983, 1996, 2011), Lee et al. (1995), Bernanke et al. (1997), among others, are based on the VAR methodology proposed by Sims (1980). Cointegration models are also more popular in estimating the dynamics in context of oil prices and economic activity. Among other, Cunado and Perez de Gracia (2014) applied a cointegrating model and a VAR model to examine the dynamics between stock market returns and oil supply and demand shocks. Cointegration approach (asymmetric cointegration approach) is also earlier used also by Sandrine and Mignon (2008) to examine the oil prices-economic activity nexus.

If all the variables contain a unit root, we test for cointegration in each VECM using both the trace and the maximum eigenvalue tests. The results of applying the Johansen and Juselius (1990) approach are shown in Table 1. The table includes the ranks in the first line, the number of cointegration vectors in the second line, and the eigenvalues and trace statistics for each selected country. The critical value is indicated using asterisks. The null hypothesis is that the number of cointegrating relationships is equal to $r$, which is given in the ‘maximum rank’ observed in the first line of Table 1. The alternative is that there are more than $r$ cointegrating relationships. We reject the null if the trace statistic is greater than the critical value. We start by testing $H_0: r = 0$. If this null hypothesis is rejected, we repeat for $H_0: r = 1$. The process continues for $r = 2$, $r = 3$, and so on and stops when a test is not rejected. The existence of one or more cointegration vectors explains that the variables have a long-run relationship and we should continue to use the VECM (vector error correction model).
### Table 1: Johansen and Juselius Cointegration Test Results (Variables: Oil Prices, Industrial Production, Interest Rates, and Stock Prices)

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** World oil prices

*production, interest rates, and stock prices

Note: Table values indicate the test results for various countries and variables, with significance levels denoted as ** for 1% significance, *** for 1% and 5% significance, and * for 10% significance.
Table 1: Johansen and Juselius cointegration test results (variables: oil prices, industrial production, interest rates, and stock prices) (continued)

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<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>National oil prices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>Trace statistic</td>
<td>53.797**</td>
<td>83.459***</td>
<td>23.798</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Trace statistic</td>
<td>46.456*</td>
<td>62.588*</td>
<td>25.536</td>
</tr>
<tr>
<td>Denmark</td>
<td>Trace statistic</td>
<td>35.288</td>
<td>68.175**</td>
<td>19.982</td>
</tr>
<tr>
<td></td>
<td>Max. eigen. stat.</td>
<td>15.306</td>
<td>32.962**</td>
<td>12.294</td>
</tr>
<tr>
<td>Hungary</td>
<td>Trace statistic</td>
<td>60.786***</td>
<td>70.783**</td>
<td>25.746</td>
</tr>
<tr>
<td></td>
<td>Max. eigen. stat.</td>
<td>35.039***</td>
<td>36.345**</td>
<td>16.759</td>
</tr>
<tr>
<td>Korea</td>
<td>Trace statistic</td>
<td>62.243***</td>
<td>75.461***</td>
<td>23.093</td>
</tr>
<tr>
<td>Mexico</td>
<td>Trace statistic</td>
<td>50.686**</td>
<td>57.911</td>
<td>25.328</td>
</tr>
<tr>
<td></td>
<td>Max. eigen. stat.</td>
<td>25.360*</td>
<td>25.740</td>
<td>17.129</td>
</tr>
<tr>
<td>Norway</td>
<td>Trace statistic</td>
<td>54.306***</td>
<td>77.325***</td>
<td>23.448</td>
</tr>
<tr>
<td></td>
<td>Max. eigen. stat.</td>
<td>30.949**</td>
<td>57.866***</td>
<td>14.896</td>
</tr>
<tr>
<td>Poland</td>
<td>Trace statistic</td>
<td>52.029**</td>
<td>72.239***</td>
<td>23.54915</td>
</tr>
<tr>
<td>Sweden</td>
<td>Trace statistic</td>
<td>44.153</td>
<td>69.033**</td>
<td>18.860</td>
</tr>
<tr>
<td>USA</td>
<td>Trace statistic</td>
<td>98.789***</td>
<td>119.500**</td>
<td>14.654</td>
</tr>
<tr>
<td></td>
<td>Max. eigen. stat.</td>
<td>84.135***</td>
<td>85.835**</td>
<td>10.137</td>
</tr>
</tbody>
</table>

Notes: (1) Model with an intercept. (2) Model with an intercept and a linear trend. $r$: number of cointegrating vectors. *, **, and *** denote rejection of the null hypothesis at the 10%, 5%, and 1% levels of significance, respectively. In Column 3 ($r = 0$) we test the null hypothesis of no cointegration against the alternative of cointegration. In Column 4 we test the null hypothesis of 0 or 1 cointegrating vectors against the alternative of $r = 2$. The lag length in all the tests was selected according to the Akaike Information Criterion (AIC), although a robustness analysis suggests that the results of these tests are robust to the chosen lag length.
The results displayed in the first part (world oil prices) of Table 1 show that there is at least one cointegration vector with an intercept and/or trend in all the countries. Consequently, we can conclude that there is at least one cointegration vector for all the selected countries. In the second part (national oil prices) of Table 1, the null hypothesis of no cointegration is also rejected in all sampled countries (at the 5% level of significance). Looking at the Johansen cointegration test results, we conclude that the VECM can be applied to all the countries under the ‘all shock’ specification of world oil prices.

3.3 Impact of oil price shocks on stock markets

To assess the effect of oil price shocks on stock returns for the USA, Canada, the Czech Republic, Denmark, Hungary, Korea, Mexico, Norway, Poland, and Sweden, we estimate four different VECM processes (see Section 3.1) for each of the selected OECD countries. As explained above and following Sadorsky (1999), Park and Ratti (2008), and Cunado and Perez de Gracia (2003, 2005, 2014), among others, each process contains the variables stock prices, real industrial production indexes, short-term interest rates, and different specifications for oil price shocks: (i) the national real oil price; (ii) the national oil price as defined in (1) and (2); (iii) the world real oil price; and (iv) the world oil price as defined in (1) and (2).

Using the above-estimated models, we use impulse response functions to analyse the impact of three types of real oil price shocks on real stock returns: all oil price shocks, oil demand price shocks, and oil supply price shocks. To compute the impulse response functions (IRFs), the disturbances from the moving-average (reduced-form) representation of each VECM model are then orthogonalised using the Cholesky decomposition.

In this section, we analyse the impact of world real oil price shocks on real stock returns by examining the impulse response functions. Figures 2 to 7 show the impulse response of real stock returns resulting respectively from 1 SD shock to oil prices measured by the log of world and national real oil prices from the VECM \((RSP_t, RIP_t, STI_t, ROP_t)\) estimated for ten OECD countries. The three columns of each figure describe respectively the effect of positive real oil all shock, real oil demand shock, and real oil supply shock. Monte Carlo-constructed 95% confidence bounds are provided to judge the statistical significance of the impulse response functions. Like previous empirical works focusing on separate oil price shocks to different demand and supply components (see, for example, Apergis and Miller, 2009; Kilian and Park, 2009; Güntner, 2013; Cunado and Perez de Gracia, 2014), we also find that the impact of real oil changes on the ten OECD countries’ real stock returns may differ depending on the nature of the oil shock. The main results are presented for world and national oil price shocks as follows.

3.4 World real oil price shocks

Figure 2 shows that world oil price shocks have a significant negative effect on stock market returns in the Czech Republic, Denmark, Korea, Mexico, Poland, and Sweden, while they have a positive effect only in the USA and Hungary. The effect on stock returns in Canada is, however, not significant. For the stock market returns in Norway, the impact is mixed, specifically negative in the third and fourth months and positive in the second year.
Figure 2  Impulse-response functions of real stock returns to world real oil shocks (see online version for colours)

a) Canada  b) Czech Republic

c) Denmark  d) Hungary

e) Korea  f) Mexico

g) Norway  h) Poland

i) Sweden  j) USA
To assess the possible different effects of oil demand and supply shocks, we further estimate the VECM using specifications (1) and (2) separating oil price shocks into different demand and supply components. Comparing the results in Figures 3 and 4, we find that oil demand shocks have negative effects in the Czech Republic, Denmark, Korea, Mexico, Norway, Poland, and Sweden, while they have a positive effect on stock returns only in the USA, Canada, and Hungary.

**Figure 3** Impulse-response functions of real stock returns to world oil demand shocks (see online version for colours)
Nevertheless, oil supply shocks have a significant negative effect only in Canada, Korea, and Sweden, while they have a positive effect on stock returns only in Hungary and Mexico. The effects on stock returns in Denmark, Norway, Mexico, and Poland are, however, not significant. For the stock market returns in the USA, the impact is mixed, that is, negative in the first month, positive in the second month, and null afterwards. This result is in line with the findings by Cunado and Perez de Gracia (2014) for the UK and Kilian and Park (2009) for the USA and by Apergis and Miller (2009) regarding the differentiated effects due to the oil demand and oil supply shocks.

Figure 4  Impulse-response functions of real stock returns to world oil supply shocks (see online version for colours)
To conclude the discussion in this subsection, it should be noted that the net oil-importing countries (the USA, the Czech Republic, Korea, and Sweden) are affected negatively by oil supply shocks except for Hungary, while the net oil-exporting countries (Denmark, Norway, and Mexico) are not affected by oil supply shocks except for Canada (positive effect). On the other hand, both net oil-exporting and net oil-importing countries (the Czech Republic, Denmark, Korea, Mexico, Norway, Poland, and Sweden) receive a negative impact from oil demand shocks except for the USA, Canada, and Hungary (positive effect).

3.5 National real oil price shock

In this subsection, we examine the impact of national real oil price shocks on real stock returns. Figure 5 shows that national oil price shocks exert significant negative effects on stock returns in Canada, the Czech Republic, Denmark, Korea, Mexico, Norway, Poland, and Sweden, while they have a positive effect on stock returns in the USA and Hungary.

Next, when decomposing the oil prices into demand and supply shocks (Figures 6 and 7), we also find that national oil demand and oil supply shocks have different impacts on real stock returns. Comparing Columns 2 and 3 in Figure 3, we find that oil demand shocks have negative effects in the USA, the Czech Republic, Korea, Poland, and Sweden, while they have a positive effect on stock returns only in Denmark, Hungary, and Norway. The effects on stock returns in Canada and Mexico are, however, not significant.

Nonetheless, oil supply shocks have a significant negative impact on stock returns in the USA, Canada, the Czech Republic, Denmark, and Mexico, while they have a positive effect on stock returns in Hungary, Korea, and Sweden. The effects on stock returns in Norway and Poland are, however, not significant. A similar result for the UK stock market can be found in the studies by Apergis and Miller (2009), Kilian and Park (2009), Güntner (2013), and Cunado and Perez de Gracia (2014).

The chief results in this subsection can be summarised as follows. First, oil demand shocks have a negative effect in the net oil-importing countries (the USA, the Czech Republic, Korea, Poland, and Sweden) except for Hungary, while the net oil-exporting countries (Denmark and Norway) are positively affected by oil demand shocks except for Canada and Mexico (no effect). Second, oil supply shocks have a negative effect in both net oil-exporting and net oil-importing countries (the USA, Canada, the Czech Republic, Denmark, and Mexico) except for Hungary, Korea, and Sweden (positive effect). Thus, we note here that the oil supply shocks have no effect in Norway and Poland.

Overall, the empirical evidences we found suggest that the impact of the variation in oil prices on stock prices depend strongly on the underlying cause of this variation. For instance, if the increases in oil prices are due to a supply shock, such is in the case over periods of the Iranian revolution in 1979 as well as the first Golf war in the year 1990, the oil price change negatively impacts the economic activity in oil importing countries since energy inputs becomes more expensive. Oppositely, if the increases in oil prices are due to a demand shock, such is the case in the last decade characterised be an increase in the oil demand by emerging countries, the oil price change negatively impacts the economic activity in oil importing economies because of a higher energy costs. The increase in oil prices due to a demand shock may also have a positive impact on economic activity in oil importing countries if it is due to expected greater exports to
those economies in a context of higher world income and consumption. Taken together, these analyses show that an oil price increase is expected to exert a more negative impact on stock returns when it is due to a supply shock than when it is due to a demand shock.

**Figure 5** Impulse-response functions of real stock returns to national real oil shocks (see online version for colours)
Figure 6  Impulse-response functions of real stock returns to national oil demand shocks
(see online version for colours)

a) Canada  b) Czech Republic

c) Denmark  d) Hungary

e) Korea  f) Mexico

g) Norway  h) Poland

i) Sweden  j) USA
Figure 7  Impulse-response functions of real stock returns to national oil supply shocks
(see online version for colours)

a) Canada  b) Czech Republic

c) Denmark  d) Hungary

e) Korea    f) Mexico

g) Norway   h) Poland

i) Sweden   j) USA
4 Conclusion

Oil price fluctuations constitute a systematic asset price risk that induces a significant reaction of stock returns. The reaction of stock returns to oil shocks can be accounted for by their impact on current and expected future real cash flows. Oil prices also act as an inflationary factor since oil constitutes a substantial resource for industrial as well as other sectors, inducing an increase in operating costs and therefore an increase in prices. The reaction of real stock prices to the increase (decrease) in oil prices is attributed accordingly to the direct effects of this increase (decrease) in terms of cash flows and inflation. Oil price shocks lead to rising inflation and therefore depressed macroeconomic growth and financial assets. In fact, oil prices can incorporate cash flows since they constitute a substantial input in production. In addition, oil price changes can influence significantly the supply and demand for output and therefore decrease the firm performance through their effect on the discount rate for cash flows because of the direct effect that they may exert on the expected rate of inflation and the expected real interest rate.

The paper examines the extent to which supply and demand oil price shocks have different effects on stock returns in ten OECD countries (the USA, Canada, the Czech Republic, Denmark, Hungary, Korea, Mexico, Norway, Poland, and Sweden) over the period from January 1990 to December 2013. We apply a cointegration vector error correction model with additional macroeconomic variables to investigate the direct and indirect connections between oil price shocks and stock returns.

First, we find a clear long-run relationship between real stock prices and real oil prices measured by world and local prices in all countries. Thus, the short-term dynamics between oil prices and stock prices are analysed using impulse response functions.

The results in this paper show that the effect of real oil price changes on real stock returns in the ten OECD countries considered may differ depending on the nature of the oil shock. Our findings show that the impact of oil price shocks substantially differs among the countries and that the significance of the results also differs among the oil prices’ specification (real national oil price, world oil price, supply shocks, and demand shocks).

The findings suggest that oil supply shocks have a negative effect on stock market returns in the net oil-importing OECD countries, since oil represents an essential input and the increase in oil prices induces a rise in industrial costs. However, the stock markets are negatively affected by oil demand shocks in the oil-importing OECD countries due to higher energy costs and positively affected in the oil-exporting OECD countries due to the perspective of increasing world income and consumption. Finally, oil demand shocks have only a negative effect on stock markets in most of the net oil-exporting and oil-importing OECD countries.

As predicted in previous theoretical works and empirical studies, the results that we found support the assertion that oil price shocks contribute significantly to systematic risk at the financial market level. The response of stock returns to oil price shocks can be attributed to their impact on current and expected future real cash flows.
References


Oil price shocks and OECD equity markets


Notes

1 The table in the annexes displays a chronological list of the empirical studies on the connection between oil prices and stock returns. We can observe the author(s), column period, methodology, and empirical results, respectively. These studies show that the results are conflicting and mixed across different countries.
### Table 1A: Conventional unit root tests

<table>
<thead>
<tr>
<th>Stock prices</th>
<th>Real industrial production</th>
<th>Short-term interest rates</th>
<th>Oil real prices</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
</tr>
<tr>
<td>Variables in levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>-1.417</td>
<td>-1.419</td>
<td>1.652***</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>-3.383*</td>
<td>-2.144</td>
<td>0.519**</td>
</tr>
<tr>
<td>Mexico</td>
<td>-0.535</td>
<td>-0.522</td>
<td>1.735***</td>
</tr>
<tr>
<td>Norway</td>
<td>-0.584</td>
<td>-0.679</td>
<td>1.790***</td>
</tr>
<tr>
<td>USA</td>
<td>-2.769</td>
<td>-1.390</td>
<td>1.762***</td>
</tr>
<tr>
<td>World</td>
<td>-3.383*</td>
<td>-3.124</td>
<td>1.663***</td>
</tr>
<tr>
<td></td>
<td>Stock prices</td>
<td>Real industrial production</td>
<td>Short-term interest rates</td>
</tr>
<tr>
<td>----------</td>
<td>--------------</td>
<td>---------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
</tr>
<tr>
<td>Republic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>–11.067***</td>
<td>–11.082***</td>
<td>0.114</td>
</tr>
<tr>
<td>Sweden</td>
<td>–11.331***</td>
<td>–11.309***</td>
<td>0.080</td>
</tr>
<tr>
<td>USA</td>
<td>–12.554***</td>
<td>–12.527***</td>
<td>0.061</td>
</tr>
<tr>
<td>World</td>
<td>–12.985***</td>
<td>–12.566***</td>
<td>0.0915</td>
</tr>
</tbody>
</table>

Note: ADF denotes augmented Dickey–Fuller unit root tests, PP refers to Phillips–Perron unit root tests, and KPSS denotes Kwiatkowski–Phillips–Schmidt–Shin tests. *, **, and *** denote rejection of the null hypothesis at the 10%, 5%, and 1% levels of significance, respectively. The lag length in all the tests was selected according to the Akaike Information Criterion (AIC).
<table>
<thead>
<tr>
<th>Series</th>
<th>Model A</th>
<th>Model C</th>
<th>Model A</th>
<th>Model C</th>
<th>Model A</th>
<th>Model C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t-stat</td>
<td>Break</td>
<td>t-stat</td>
<td>Break</td>
<td>t-stat</td>
<td>Break</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National oil prices (*)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Model A: change in the intercept. Model C: change in the intercept and trend. The critical values for the LS unit root test with one break are tabulated in Lee and Strazicich (2004, Table 1A). The critical values for the LS unit root test with two breaks, tabulated in Lee and Strazicich (2003, Table 2A), depend on the location of the breaks. For $\lambda_1 = 0.4$ and $\lambda_2 = 0.6$, the critical values equal, respectively, -6.45 (1% level), -5.87 (5% level), and -5.31 (10% level).