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Oil prices, stock markets and firm performance: Evidence from Europe

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ABSTRACT

This paper extends understanding of the relationship between oil prices, stock markets and financial performance of oil and gas firms over the past decade. Firstly, it studies the impact of oil price fluctuations on stock markets in Europe. Secondly, it examines volatility spill-overs between oil and European stock markets. As oil price changes do not equally affect all industries, the study conducts both market-level and sector-level analyses. Thirdly, it examines the impact of crude oil price changes on the financial performance measure of oil and gas firms, both listed and unlisted, from the Western European region.

The findings show the existence of the relationship between oil and European stock markets. The responses of stock returns to oil price movements vary across sectors. Furthermore, the results indicate volatility spill-overs between returns in oil price and stock markets. It was found that crude oil prices impact the performance of listed oil and gas firms significantly and positively in Western Europe. In the case of unlisted firms, the results suggest the existence of other factors that have an impact on their performance. The recent geopolitical crisis (2014) negatively affected the financial performance of both listed and unlisted firms. On the other hand, the financial performance of only listed oil and gas firms was negatively influenced by the global financial crisis (2008–2009).

1. Introduction

The debate regarding the impact of oil prices on economic variables began in the 1970s, in the time of oil price shocks. Hamilton (1983) was one of the first to investigate such impacts and whose work induced debate on this topic. In fact, sharp increases or declines in oil prices are not rare episodes. Over the past decade, global oil prices have demonstrated a significant lack of stability. One can divide the literature on the impact of oil price changes into three major categories: (i) impacts on economic indicators; (ii) impacts on returns of stock markets, including transmission of volatility between oil and stock markets; and (iii) impacts on financial performance of oil and gas companies. A large volume of studies have investigated the effects of movements in petroleum prices on a variety of macroeconomic variables (Hamilton, 1983, 2003; Gisser & Goodwin, 1986; Mork, 1989; Bohi, 1989; Rotemberg & Woodford, 1996; Hooker, 1996; Bachmeier, 2008; Lee, Lee, & Ning, 2017; among others). In general, these studies indicate that the economic activities of various countries are affected by petroleum price fluctuations.

The empirical studies conducted on the interaction between petroleum and stock markets have identified various channels through

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which petroleum prices can affect stock market returns. Jones and Kaul (1996) have argued that the response of equity prices to petroleum can be explained by the influence of petroleum shocks on corporate cash flows. Thus, one can refer to equity valuation approaches to understand the link between petroleum and equity prices, where all expected future cash flows are discounted at a required rate of return in order to obtain equity prices. Since economic conditions, such as interest rates, inflation, economic growth, cost of production, market confidence and so on, are reflected in cash flows and discount rates then they may be under the influence of petroleum shocks (Cunado & Perez de Garcia, 2005; Park & Ratti, 2008; Apergis & Miller, 2009; Chen, Cheng, & Demirer, 2017; among others) and equity prices may react considerably to fluctuation in the price of petroleum. Kilian and Park (2009) demonstrate that depending on the causes of petroleum price changes, the reaction of equity returns to petroleum price shocks can be positive or negative. Demand shocks, which are caused by uncertainty regarding future petroleum supply shortfalls, produce negative interrelationship between petroleum prices and equity returns. In contrast, equity returns are positively affected by higher petroleum prices that are caused by unanticipated global economic expansion (Kilian & Park, 2009). The authors argue that a positive correlation between prices of petroleum and returns on equity will exist at the initial stage of the business cycle, reflecting the fact that petroleum prices and returns on equity are both driven up by strong demand for industrial commodities. However, it is expected that the relationship between petroleum and stock prices can be negative in the long term.

On the impact of oil price changes on equity prices, Jones and Kaul (1996) have examined the response of stock markets in Japan, Canada, the USA and United Kingdom, to oil shocks. Jones and Kaul (1996) concluded that petroleum shocks on cash flows could fully explain the reaction of Canadian and US equity prices to petroleum. Using methods such as international multifactor asset prices models, co-integration, vector autoregressive (VAR) model and vector error-correction model (VECM), Huang, Masulis, and Stoll (1996), Sadorsky (1999), Apergis and Miller (2009), and Fayyad and Daly (2011) have also demonstrated the significant reactions of stock returns to petroleum shocks. Meanwhile, Park and Ratti (2008) have estimated the impact of shocks and volatilities emerged from the oil price on the stock returns of thirteen European countries and the US. They show that oil price shocks impact stock returns in the US and thirteen European counties. In addition, an increase in oil price volatilities has significantly depressed stock returns in many European countries, but not in the US.

One major disadvantage of studies covered above is that analyses concentrate on a whole market index, whereas petroleum price changes affect various industries in different ways. Thus, the classification of industries is crucial for differentiating between the industries, where the price of petroleum might have contrary impacts (Nandha & Brooks, 2009). Some studies have analysed the petroleum price effects on stock market returns at the industry level. For example, Lee and Ni (2002) have studied the impact of petroleum shocks on supply and demand sides of different industries. They found that, for industries mostly using petroleum in production, such as industrial chemicals and petroleum refinery, the predominant effect of petroleum price shocks is on the supply side. In contrast, they indicate that, for other industries, it is particularly important to consider the automobile industry as the major impact of petroleum price shocks is on the demand side. In addition, Gogineni (2010) gives empirical evidence that movements in the petroleum price have an impact on industries' stock returns, on both demand and cost sides. Arouri and Nguyen (2010) have studied the short-term linkages between petroleum and stock markets in Europe at aggregate and sector levels. Their findings are that links between changes in petroleum price and stock markets are strong and significant for most of the European sectors. However, the reaction of stock returns to volatilities in the petroleum price differs considerably among sectors.

Several studies emphasise the importance of distinction between petroleum supply and petroleum demand shocks. Kilian (2009) separates petroleum price shocks into several components: petroleum supply shocks that are triggered by changes in petroleum production; aggregate demand shocks that are caused by shifts in demand for petroleum related to the global business cycle; and petroleum specific demand shocks originating from fluctuations in precautionary demand because of concerns about future petroleum supply shortfalls. The author shows that implications of these supply and demand shocks for the US macroeconomic indicators, and, hence, equity markets are different. Kilian and Park (2009) examine the impact of petroleum price shocks on the US stock market for the period 1973–2006. Their findings indicate that, in the long run, approximately one-fifth of the variation in US stock returns were connected to both the demand and supply shocks that drove the global crude petroleum market. Kang, Ratti, and Vespignani (2016) extend the work of Kilian and Park (2009) by analysing the influence of shocks from US and non-US petroleum production on US stock market returns. Their results show that the association between US petroleum supply shocks and US equity returns is positive. The authors highlight the importance of both petroleum demand and supply shocks in explaining US equity returns when US and non-US petroleum supply shocks are distinguished. In addition, Kang et al. (2016) suggest that the disaggregation is essential to understand the impact of petroleum supply shocks on the stock returns of industries. Following the framework provided by Kilian and Park (2009), Lambertides, Savva, and Tsouknidis (2017) supply evidence that order flow imbalances in the US stock market are significantly affected by petroleum supply and petroleum demand shocks. Specifically speaking, the effect of petroleum supply shocks is negative, whereas petroleum demand shocks have a positive impact. Furthermore, the authors indicate that the association between positive shocks on stock order flow imbalances and stock returns is negative.

A number of studies have analysed the effects of volatility transmission between petroleum and stock markets. The research conducted by Agren (2006) applies an asymmetric type of the BEKK-GARCH (1,1) model to investigate volatility spill-overs from petroleum prices to stock markets in five developed economies, such as the US, UK, Norway, Sweden and Japan, for the period 1989–2005. The author found strong evidence of volatility spill-over for the US, UK, Norway and Japan, while weak proof of volatility transmission from petroleum to stock markets was found for Sweden. Malik and Hammoudeh (2007) investigated volatility transmission amongst the global petroleum market, the US stock markets and stock markets of petroleum-rich Gulf countries, such as Bahrain, Kuwait and Saudi Arabia for the period 1994–2001. They demonstrated that volatility spills over from petroleum market to all three Gulf stock markets. However, volatility from the Saudi Arabian stock market spills over into the global petroleum market showing the big role played by the Saudi Arabian market in the global petroleum market. Chang, McAleer, and Tansuchat (2009) studied volatility transmissions between returns on West Texas Intermediate (WTI) crude oil futures and returns on stocks of ten global oil and gas companies. They employed different specifications of GARCH models, such as the CCC, VARMA-GARCH, and VARMA-AGARCH. By using the CCC model, Chang et al. (2009) found that conditional correlations between returns on crude oil futures and stock returns of petroleum companies are quite low. Surprisingly, in any pairs of return series, the empirical results show the absence of volatility transmission effects. Arouri, Jouini, and Nguyen (2011) have applied various multivariate GARCH models to investigate the transmission of volatility between petroleum and stock market sectors in Europe and the US. Their findings indicate that the volatility spill-over from petroleum market to European stock markets is unidirectional, but in the case of the US is bidirectional. The authors demonstrate that the VAR-GARCH model performs better in analysing diversification and hedging effectiveness than other multivariate models; namely, CCC-GARCH, BEKK-GARCH and DCC-GARCH. Arouri, Jouini, and Nguyen (2012) have examined the volatility transmission between petroleum and European stock markets for the period 1998–2009. They have conducted the study at both aggregate and sector levels applying the recently developed VAR-GARCH model to investigate volatility spillovers. On the whole, Arouri et al. (2012) findings indicate existence of significant volatility transmissions between prices of petroleum and European stock sector returns, where the effects of transmission are more evident from petroleum prices to stock markets.

A number of studies has analysed the impact of petroleum price fluctuations on oil and gas corporations' accounting performance. Dayanandan and Donker (2011) have examined the effects of petroleum price changes on the financial performance of North American oil and gas corporations for the period 1990–2008. Their findings indicate that the prices of petroleum affected these North American oil and gas corporation performances significantly and positively. In addition, Dayanandan and Donker (2011) found that petroleum prices and financial performance of the North American oil and gas corporations were negatively influenced by the financial crisis of 2007–2008. The authors conclude that in resource-based industries, as oil and gas, the predominant explanatory factors of accounting measures of performance are the commodity prices. Gupta (2016) employs firm-level monthly data covering 70 countries to investigate the relationship between petroleum price shocks, country-level determinants, competition and oil and gas equity returns. The author found that firm-level returns are negatively affected by macroeconomic stress and positively impacted by petroleum price shocks. The sensitivity of oil and gas companies located in petroleum-rich countries to market stress and petroleum price shocks is higher compared to companies in countries with lower petroleum production. Furthermore, oil and gas companies that face less competition are less responsive to petroleum price shocks.

Taking into account the previous empirical studies, the major objective of this paper is to shed new light on the relationship between oil prices, stock markets and the financial performance of oil and gas companies. Following recent work on the volatility transmission between oil prices and stock markets (Arouri et al., 2011, 2012), the current study extends the understanding of volatility spill-over effects by investigating the impact of oil price fluctuations on European stock sector indices for the updated period that incorporates important events such as global financial and geopolitical crises. Furthermore, in contrast to the work of Gupta (2016), which focuses on the impacts of oil price shocks, country-level determinants and competition on firm-level equity returns, this study examines the effects of oil price changes on financial performance, measured by return on equity, of 137 listed and 531 unlisted oil and gas firms from the Western European region. The study hence aims to answer the following questions:

(1) Do fluctuations in oil price have an impact on stock markets in Europe?
(2) Do volatility spill-over effects exist between oil prices and stock markets in Europe?
(3) Is the price of oil a dominant factor in explaining the financial performance of listed and unlisted oil and gas firms in Western Europe?

To our knowledge, this study is unique in the sense that it first covers the period from 2005 to 2015, which has witnessed few major events: the global financial crisis, Arab Spring and geopolitical crisis, followed by a significant oil market imbalance. The study emphasises the significance of the global financial and geopolitical crises, given the fact that oil prices were heavily affected during these events, compared to the Arab Spring. Second, it addresses the issue of volatility spill-overs between oil prices and nine European sector indices analysing both the spill over direction and the magnitude for different sectors using up to date econometric approaches. Mateus, Chinthalapati, and Mateus (2017) suggest that it is not desirable to use market indices in the analysis of volatility spill-over effects, as each sector's weight is different in the composition of indices. Hence, general indices could be biased to some specific industries. In addition, the advantage of using sector indices is that market-level analysis may conceal characteristics of various sectors (Arouri et al., 2012). Third, it examines the impact of crude oil prices on the Western European oil and gas firms' financial performance, for both listed and unlisted firms.

Our results indicate the existence of the relationship between oil prices and stock returns for most of the European stock sector indices. Furthermore, we found that crude oil prices have a positive impact on the performance of listed oil and gas firms in Western Europe. The geopolitical crisis (2014) has negatively influenced the performance of both listed and unlisted firms, whereas the financial crisis (2008–2009) had a negative impact only on listed oil and gas firms.

The remainder of this paper is structured as follows: the next section presents the data sources, variables and summary statistics, while section three presents the models and section four the empirical results. Lastly, section five concludes.

2. Data sources, variables and summary statistics

2.1. Stock markets' data and summary statistics

In order to examine the impact of oil price fluctuations on stock markets and volatility transmission between the price of oil and sector stock prices in Europe, data was collected for the Dow Jones Stoxx Europe 600 index and nine sector indices; namely, *Automobile and Parts, Basic Materials, Financials, Health Care, Industrials, Oil and Gas, Technology, Telecommunications,* and *Utilities*. The Stoxx Europe 600 index consists of a fixed number of 600 firms (large, mid and small capitalisation) from eighteen European countries that are presented in the table below. It hence reflects the overall performance of European stock markets.

According to the market standard Industry Classification Benchmark (ICB), the Dow Jones Stoxx Europe 600 sector indices were introduced in 1998. These sector indices represent the performance of biggest European firms in each of the industries, across eighteen countries in Europe, same as the Dow Jones Stoxx Europe 600 index. Thus, they provide an alternative vision for exposure of European equity by activity sector.

Data on the stock market and sector indices were collected from Datastream International and are expressed in euros. The Brent crude oil spot prices were obtained from the Energy Information Administration, which represents the oil market. Brent crude is extracted in the North Sea and around two-thirds of the globally traded cure oil supplies are priced on this basis. In addition, Brent crude is considered as a benchmark for the production of oil from the EMEA (Europe, the Middle East and Africa) region. As the Energy Information Administration provides Brent crude oil spot prices in US dollars, the data on euro/dollar exchange rates was collected from Datastream International in order to express the prices in euro.

For the purposes of this paper, the weekly data was used for the period of 3rd January 2006 to 29th December 2015 because the dynamic interaction of oil and stock prices is better captured by weekly data, rather than by daily and/or monthly data. According to Arouri et al. (2012), daily data frequently causes potential biases emerging, for instance, from bid-ask leaps and when trading days are non-synchronous, while the monthly data due to the aggregation of time and compensation effects may conceal some mechanisms of volatility transmission. The studies of Arouri and Nguyen (2010) and Arouri et al. (2012) have empirically demonstrated that the usage of weekly data in analysing the oil and stock market relationships leads to better estimation outputs. Hence, the study period selected allows us to examine the effects of the recent events, namely the global financial and geopolitical crises.

Fig. 1 below shows the interrelationship between the price of Brent crude oil and DJ Stoxx Europe 600 index over the period 2006–2015. It is evident that, most of the time, the European stock market index and Brent crude oil prices co-move closely. However, from 2012 to 2014 and at the end of 2015, they experienced opposite trends. The common trend between them started in 2007 and lasted until almost the end of estimation period, but the highest peak in the price of Brent crude oil was not followed by the DJ Stoxx Europe 600 index during the recent financial crisis. Such patterns imply the possibility of volatility transmission and a return to dependency between the oil and the European stock market.

Fig. 2 presents the weekly returns of Brent crude oil and stock markets over the period from January 2006 to December 2015. It may be noted that Brent crude oil and all the stock sectors experienced significant volatility during the recent financial crisis, particularly in the second half of 2008. The higher ranges of this volatility were experienced by DJ Stoxx Europe 600, *Telecommunications, Automobile and Parts* and *Health Care* sector indices.

Table 2 reports main descriptive statistics of Brent crude oil and stock market returns (see Table 1 for list of countries in the Dow Jones Stoxx Europe 600 index). On average, *Industrials* and *Basic Materials* stock sectors showed higher positive returns, whereas Brent crude oil, *Financials* and *Oil and Gas* stock sectors showed higher negative returns over the sample period. Brent crude oil returns and *Automobile and Parts, Basic Materials, Financials* stock sector returns then appeared to be more volatile compared to returns of other stock sectors. The *Automobile and Parts* stock sector thus released the highest maximum and lowest minimum returns compared to other stock sectors over the estimation period. In most cases, skewness was negative and kurtosis was higher than 4. According to the Jarque-Bera test for normality based on excess kurtosis and skewness, the normality condition is rejected at 1% significance level for all return series. Here, the statistical tests for conditional heteroscedasticity of order six are represented by ARCH, which strongly indicates ARCH effects in all cases. The Ljung-Box tests performed for autocorrelations of order six that was applied to raw series show significant autocorrelations in six out of eleven cases. Unconditional correlations between Brent crude oil and stock market weekly returns were also computed. On average, correlations are weak, but surprisingly they are positive, which suggests that growth in the price of oil over investigation period was viewed as indicator of increases in stock market returns. The highest correlations with Brent crude oil have *Basic Materials* and *Oil and Gas* sectors, 0.37 and 0.46 respectively, while *Health Care* and *Telecommunications* sectors have the lowest correlation with oil, 0.11 and 0.17, respectively. As was expected, correlations between returns of DJ Stoxx Europe 600 index and stock sector indices are quite high on average and presumably reflect the weight of each sector in the index.[1] The highest correlations were observed between the DJ Stoxx Europe 600 index and the *Financials* (0.92) and *Industrials* (0.95) sectors, which are more weighted in the index. On the other hand, the *Automobile and Parts* sector, which is one of the least weighted, has the lowest correlation with DJ Stoxx Europe 600 index, which is 0.45.

2.2. Firms' data, variables and summary statistics

The annual financial and accounting data, expressed in euros, of both listed and unlisted firms that operate in the extraction of crude petroleum and natural gas sector were collected from the ORBIS database (NACE Rev.2 0610 and 0620) for the period 2005–2014. The beginning and ending of the sample period are dictated by the availability of financial data provided on the online version of the ORBIS database. The initial sample consisted of firms from 17 Western European countries: Austria, Cyprus, Denmark, France, Germany, Greece, Ireland, Italy, Luxemburg, Malta, the Netherlands, Norway, Spain, Sweden, Switzerland, Turkey and the United Kingdom. According to Tables 3 and 4, there were initially 161 and 579 listed and unlisted firms respectively (and 1583 and 5761 firm-year

[1] For sector weightings see: https://www.stoxx.com/document/Bookmarks/CurrentFactsheets/SXXGR.pdf.

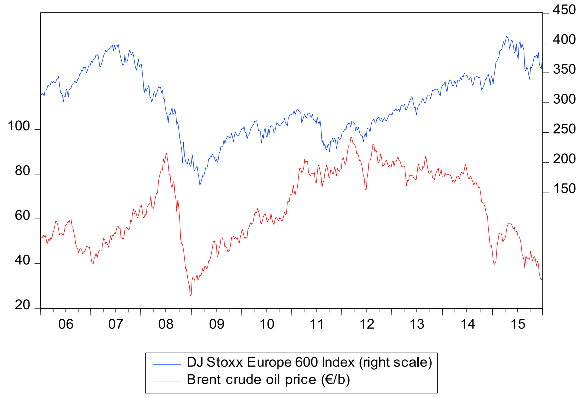

Fig. 1. Trends of the DJ Stoxx Europe 600 index and Brent crude oil price.

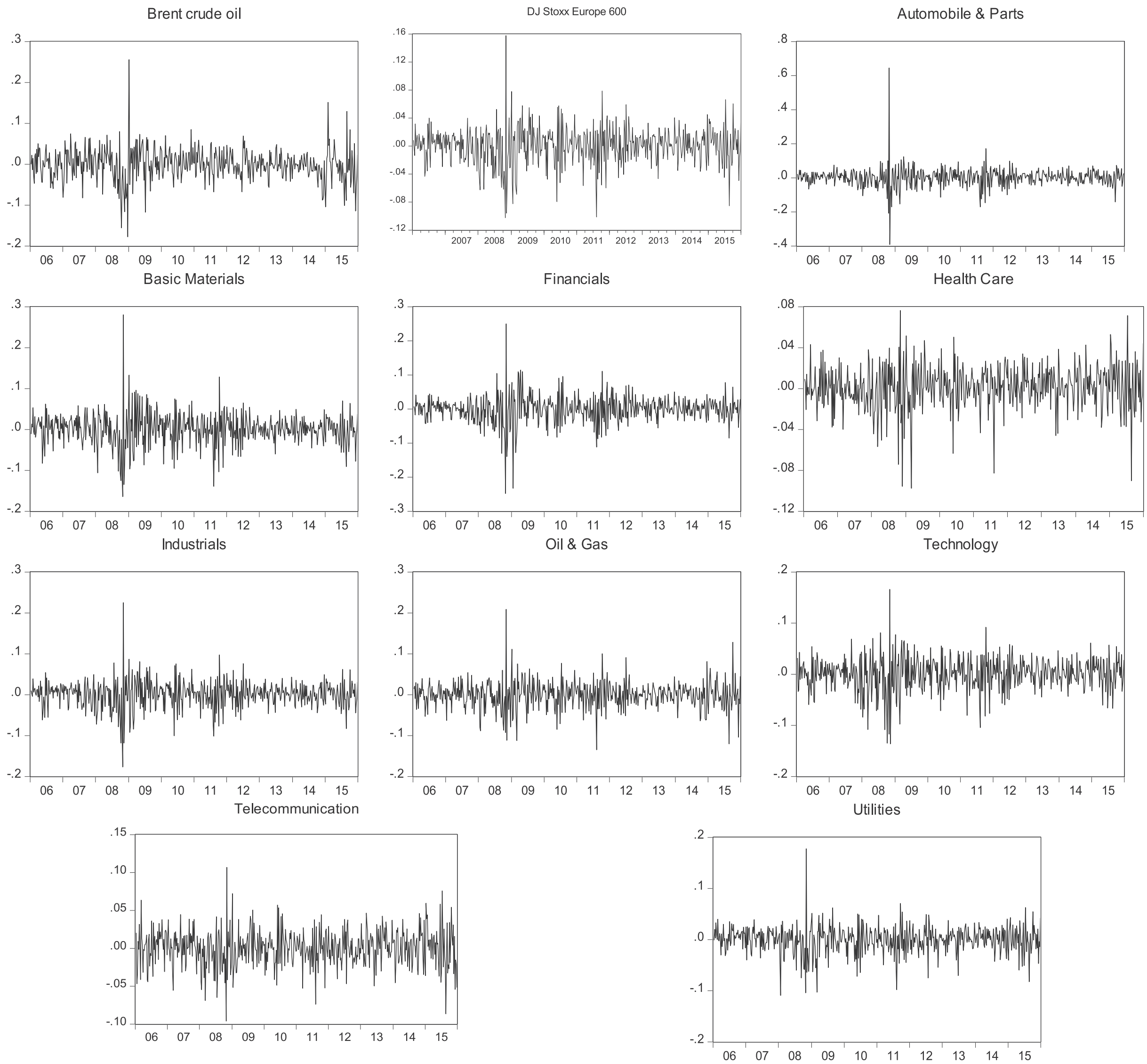

Fig. 2. Weekly returns of Brent crude oil and stock market Sector Indices (January 2006 to December 2015).

Table 1
List of countries in the Dow Jones Stoxx Europe 600 index.

Countries	
Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

observations, respectively).

France and the United Kingdom had the largest number of listed firms and observations with 45 firms and 448 observations, 38 firms and 377 observations, respectively. However, the Netherlands with 62 firms and 610 observations, Norway with 92 firms and 911 observations, the United Kingdom with 358 firms and 3571 observations stand out in the sample in terms of unlisted firms.

In order to ensure a consistent and homogenous sample, a few selection procedures were undertaken. First, firms with missing information in key financial figures were excluded from the initial sample. Second, firms with a small value of total assets were dropped. Finally, firms with detected outliers in the key variables were removed. This was done by computing z score of each variable's observation and removing those whose value of z score was greater than the common range value for outliers.

The final sample is comprised of 137 and 531 listed and unlisted firms respectively (926 and 3485 firm-year observations, respectively) from 14 Western European countries; namely, Austria, Denmark, France, Germany, Greece, Ireland, Italy, Malta, the Netherlands, Norway, Spain, Sweden, Turkey and the United Kingdom.

Return on equity (thereafter, ROE) is used as the main financial performance indicator and is the dependent variable. Explanatory variables are the following: *Size*, *Gearing*, *Profitability* and *Oil price*. These variables were chosen from the ones that are frequently employed in the related studies. *ROE* is computed by Net Income over Shareholder Funds. The *Size* is measured by natural logarithm of Total Assets. *Gearing* reflects the leverage and is calculated by Non-Current Liabilities over Shareholder Funds. *Profitability* is computed by EBIT (Earnings before Interest and Taxes) over Total Assets. *Oil price* is represented by the annual average Brent crude oil spot prices expressed in euro. In order to take into consideration global events that occurred during the study period and had a direct impact on the price of oil, two binary (dummy) variables were incorporated. Dummy 1 represents the final stage of the recent global financial crisis (2008–2009) and Dummy 2 represents the geopolitical crisis (2014) that was followed by the oil market imbalance. The value of dummy variables during the events is one and zero otherwise. The interactive dummy variables were generated (dummy variable multiplied by oil price) to better capture the effects of global events.

Table 5 reports basic descriptive statistics for the dependent and independent variables used in the empirical investigation of oil price impacts on financial performance of European oil and gas firms (listed and unlisted).

The *ROE*, *Gearing*, *Profitability* and *Size* of the top twenty five percent of listed firms were more than 23.43%, 64.41%, 14.74% and 13.75, respectively. On the other hand, the figures of the top twenty five percent of unlisted firms were more than 38.82%, 95.44%, 20.75% and 13.54, respectively. Comparing explanatory variables of listed and unlisted oil and gas firms, it can be seen from Table 5 that, on average, unlisted firms are smaller and more profitable, but highly leveraged compared to the listed firms. The correlation matrix between dependent and independent variables of both listed and unlisted firms is presented in Table 6.

In general, the correlations between independent variables are small, thus suggesting that multicollinearity should not be an issue during the estimation process. In general, the positive correlation between *Size* and *Profitability* variables suggest that larger firms are inclined to be more profitable, while the negative correlation between *Oil price* and *Profitability* is stronger in the case of unlisted rather than listed firms.

3. Empirical models

3.1. Oil prices and stock returns - vector autoregressive model (VAR)

The vector autoregressive (VAR) model is usually employed for the purpose of forecasting systems of interconnected time series and studying the dynamic effects on the system of variables arising from arbitrary disturbances. The VAR approach considers each variable to be endogenous in the model as a function of all endogenous variables' lagged values, as a result of which the need for structural modelling is bypassed. The autoregressive term happens because of the appearance of the dependent variables' lagged values on the right side of the model and because of the fact that a vector of two and more variables is included in the model, the vector term takes place (Fayyad & Daly, 2011).

One of the main strengths of the VAR model is that it enables us to capture the dynamic relationships between the investigated variables. The efficiency of this model in investigating the effects of oil prices on stock markets has been documented by Park and Ratti (2008), Fayyad and Daly (2011), Kang et al. (2016) and Lambertides et al. (2017). Before application of the vector autoregressive model, each series were tested for unit roots (first-difference of raw data), by employing the Augmented Dickey-Fuller statistic where the

Table 2
Descriptive statistics of weekly returns for Brent crude oil, DJ Stoxx Europe 600 index and nine sector indices (January 2006 to December 2015).

	Brent crude oil	DJ Stoxx	Automobile &Parts	Basic Materials	Financials	Health Care	Industrials	Oil & Gas	Technology	Telecom.	Utilities
Mean	−0.083%	0.032%	0.170%	0.058%	−0.088%	0.119%	0.091%	−0.080%	0.034%	0.026%	−0.023%
Median	0.017%	0.286%	0.456%	0.164%	0.172%	0.139%	0.468%	0.082%	0.156%	0.173%	0.203%
Maximum	25.558%	15.767%	64.490%	28.055%	25.008%	7.636%	22.504%	20.871%	16.614%	10.679%	17.790%
Minimum	−17.77%	−10.223%	−39.100%	−16.430%	−24.795%	−9.764%	−17.654%	−13.488%	−13.606%	−9.615%	−10.931%
Std. Dev.	3.8139%	2.664%	5.518%	3.956%	4.029%	2.117%	3.368%	3.308%	3.274%	2.433%	2.658%
Skewness	0.163	−0.150	2.028	0.182	−0.466	−0.644	−0.1591	0.136	−0.407	−0.099	−0.185
Kurtosis	8.375	6.223	42.655	8.852	10.564	5.776	8.400	7.441	5.520	4.216	8.062
Jarque-Bera	629.41***	227.44***	34493.56***	746.21***	1260.92***	203.30***	635.27***	429.83***	152.25***	32.97***	559.33***
ARCH	49.97***	105.16***	96.74***	115.10***	129.46***	47.35***	182.70***	43.79***	107.78***	41.41***	45.32***
Ljung-Box	29.53***	8.14	40.48***	12.62**	14.12**	14.91**	23.06***	7.41	7.09	10.32	4.04
Corr. with oil	1.000	0.301	0.207	0.368	0.221	0.105	0.265	0.462	0.217	0.167	0.240
Corr. with DJ Stoxx	0.301	1.000	0.453	0.890	0.920	0.662	0.948	0.841	0.852	0.755	0.836
Observations	521	521	521	521	521	521	521	521	521	521	521

Notes: The null hypothesis of statistical tests are rejected at 10% (*), 5% (**) and 1% (***) levels.

International Review of Economics and Finance 61 (2019) 270–288

Table 3
Sample of listed firms and firm-year observations by country.

Country	Initial sample	% of initial sample	N$^{\underline{o}}$ of firms	% of initial sample	Final sample	% of final sample	N$^{\underline{o}}$ of firms	% of initial sample
Austria	10	0.63%	1	0.62%	9	0.97%	1	0.73%
Denmark	128	8.09%	13	8.07%	43	4.64%	11	8.03%
France	448	28.30%	45	27.95%	266	28.73%	42	30.66%
Germany	40	2.53%	4	2.48%	16	1.73%	3	2.19%
Greece	30	1.90%	3	1.86%	15	1.62%	3	2.19%
Ireland	30	1.90%	3	1.86%	11	1.19%	2	1.46%
Italy	119	7.52%	12	7.45%	78	8.42%	12	8.76%
Netherlands	49	3.10%	5	3.11%	17	1.84%	3	2.19%
Norway	40	2.53%	4	2.48%	29	3.13%	4	2.92%
Spain	140	8.84%	14	8.70%	114	12.31%	14	10.22%
Sweden	31	1.96%	4	2.48%	23	2.48%	4	2.92%
Turkey	141	8.91%	15	9.32%	11	1.19%	2	1.46%
United Kingdom	377	23.82%	38	23.60%	294	31.75%	36	26.28%
Total	**1583**	**100%**	**161**	**100%**	**926**	**100%**	**137**	**100%**

Table 4
Sample of unlisted firms and firm-year observations by country.

Country	Initial sample	% of initial sample	N$^{\underline{o}}$ of firms	% of initial sample	Final sample	% of final sample	N$^{\underline{o}}$ of firms	% of initial sample
Austria	79	1.37%	8	1.38%	49	1.41%	7	1.32%
Cyprus	10	0.17%	1	0.17%	0	0.00%	0	0.00%
Denmark	20	0.35%	2	0.35%	9	0.26%	2	0.38%
Germany	340	5.90%	34	5.87%	132	3.79%	27	5.08%
Italy	60	1.04%	6	1.04%	29	0.83%	6	1.13%
Luxembourg	10	0.17%	1	0.17%	0	0.00%	0	0.00%
Malta	10	0.17%	1	0.17%	9	0.26%	1	0.19%
Netherlands	610	10.59%	62	10.71%	324	9.30%	55	10.36%
Norway	911	15.81%	92	15.89%	684	19.63%	90	16.95%
Spain	20	0.35%	2	0.35%	4	0.11%	2	0.38%
Switzerland	10	0.17%	1	0.17%	0	0.00%	0	0.00%
Turkey	110	1.91%	11	1.90%	0	0.00%	0	0.00%
United Kingdom	3571	61.99%	358	61.83%	2245	64.42%	341	64.22%
Total	**5761**	**100.00%**	**579**	**100.00%**	**3485**	**100%**	**531**	**100%**

Table 5
Descriptive statistics for dependent and independent variables. The sample consists of 137 and 531 Oil and Gas listed and unlisted firms for the period 2005 to 2014. *ROE* is defined as net income divided by shareholder funds. *SIZE* is the natural logarithm of total assets. *GEARING* is defined as non-current liabilities divided by shareholder funds.*Profitability* is measured by EBIT over total assets.

	Listed Firms				Unlisted Firms			
	ROE (%)	SIZE	GEARING (%)	Profitability (%)	ROE (%)	SIZE	GEARING (%)	Profitability (%)
Mean	0.02	12.19	49.67	4.58	18.22	12.08	90.71	7.80
Median	6.01	12.01	13.79	0.17	11.32	12.10	23.02	3.13
First Quartile	−11.74	10.58	0.001	−6.47	−1.82	10.57	0.00	−1.61
Third Quartile	23.43	13.75	64.41	14.74	38.82	13.54	95.44	20.75
Std. Dev.	70.36	2.78	94.60	52.89	85.26	2.15	151.25	42.85

Table 6
Correlation Matrix for independent variables (Listed and Unlisted Firms).

	Listed Firms				Unlisted Firms			
	SIZE	GEARING	Profitability	OIL	SIZE	GEARING	Profitability	OIL
SIZE	1.000				1.000			
GEAR	0.174	1.000			0.284	1.000		
Profitability	0.280	0.056	1.000		0.224	0.085	1.000	
OIL	0.116	0.022	−0.003	1.000	0.085	−0.005	−0.053	1.000

automatic selection of lags was based on Schwarz information criterion. The results obtained have indicated that all series are stationary. The estimated VAR equations are the following:

$$S_t = C_1 + \sum_{t=1}^{k} a_{1i} S_{t-i} + \sum_{t=i}^{k} b_{1i} O_{t-i} + e_{1t} \tag{1}$$

$$O_t = C_2 + \sum_{t=1}^{k} a_{2i} S_{t-i} + \sum_{t=i}^{k} b_{2i} O_{t-i} + e_{2t} \tag{2}$$

Where weekly logarithmic returns of the Dow Jones Stoxx Europe 600 index and nine sector indices are represented by S and oil prices by O, respectively. The estimated parameters are a, b and C, and i,j components indicating how the i market's return responds to a unit of emerged random shock from the j market's return after certain periods. In addition, these components represent the i market's impulse response in a given period to a unit standard error shock in the j market, and the stochastic error terms are represented by e, and in the language of VAR they are called shocks or innovations. Selection of an appropriate lag structure in the system is required by VAR. Hence, in order to determine the appropriate lag structure in the model, information criteria as Akaike and Schwarz were applied. The number of lags was chosen based on the smallest value of Schwarz information criterion, which suggested using two lags.

3.2. Volatility transmission - VAR-GARCH model

In order to investigate the volatility transmission between prices of oil and European stock markets, we employed the VAR-GARCH (vector autoregressive – generalised autoregressive conditional heteroscedasticity) model. The model was introduced by Ling and McAleer (2003) and successfully applied by Arouri et al. (2011), Arouri et al. (2012) and Lin, Wesseh, and Appiah (2014) to study volatility transmissions between petroleum and stock markets, and by Chan, Lim, and McAleer (2005), Hammoudeh, Yuan, and McAleer (2009) and Chang, Khamkaew, Tansuchat, and McAleer (2011) to different economic issues. As was noted by aforementioned studies, the VAR-GARCH model performs well in empirical modelling of volatility transmissions, as compared to univariate models. In addition, Arouri et al. (2012) remark upon two major advantages of this model. Firstly, it enables to analyse the conditional cross effects and transmissions of volatility as well as dynamics of conditional volatility between series. Secondly, it provides meaningful estimates of the unknown parameters of the model with avoidance of the computational complications in comparison to some other multivariate models, such as the full-parameterised BEKK-GARCH model. This paper estimates the bivariate VAR(1)-GARCH(1,1) model for each European stock market and sector indices, where the conditional mean and variances are the following:

$$Y_t = \mu + \Phi Y_{t-1} + \varepsilon_t \tag{3}$$

$$\varepsilon_t = D_t \eta_t \tag{4}$$

Where, Y_t is r_t^S and r_t^O. r_t^S refers to the logarithmic returns of stock market and sector indices, while r_t^O refers to oil price logarithmic returns; ε_t is ε_t^S and ε_t^O. Residual terms of the mean equations for stock market and sector indices, while oil price returns are represented by ε_t^S and ε_t^O, respectively; η_t equals to η_t^S and η_t^O, which are a sequence of *i.i.d.* random vectors; D_t equals to $diag(\sqrt{h_t^s}, \sqrt{h_t^o})$. Conditional variances of r_t^S and r_t^O are respectively represented by h_t^S and h_t^O:

$$h_t^S = C_S^2 + \beta_{S1}^2 h_{t-1}^S + \alpha_{S1}^2 \left(\varepsilon_{t-1}^S\right)^2 + \beta_{S2}^2 h_{t-1}^O + \alpha_{S2}^2 \left(\varepsilon_{t-1}^O\right)^2 \tag{5}$$

$$h_t^O = C_O^2 + \beta_{O1}^2 h_{t-1}^O + \alpha_{O1}^2 \left(\varepsilon_{t-1}^O\right)^2 + \beta_{O2}^2 h_{t-1}^S + \alpha_{O2}^2 \left(\varepsilon_{t-1}^S\right)^2 \tag{6}$$

A two-step procedure was then adopted to select the optimal lag structure for the considered models. First, to test for ARCH effects, the univariate ARCH tests on each return series were run, and based on the univariate Akaike information criterion, the optimal GARCH (*p,q*) model was determined. In most of the cases, it was found that the best suited model is GARCH (1,1). Second, it is extremely important to mention that the bivariate VAR-GARCH model is considered, where a bivariate GARCH (1,1) specification of stock sector and oil markets is assumed to be followed by the second conditional moments, as was suggested by Arouri et al. (2012). In their empirical research, Ling and McAleer (2003) show that under only the second order moment condition, the model's parameters of the quasi-maximum likelihood estimators (QMLE) are asymptotically normal and consistent. Then, in order to select the optimal lags in the conditional mean equations, the multivariate Akaike and Schwarz information criteria were employed, where it was suggested to use one lag in most cases. Thus, based on all the pre-tests, it was rational to opt for the VAR(1)-GARCH(1,1) specification.

Both equations (5) and (6) demonstrate the way of volatility transmission over time and across stock and petroleum markets. The return innovations in the petroleum market and to the analogous stock market at time *(t-1)* are represented by $(\varepsilon_{t-1}^S)^2$ and $(\varepsilon_{t-1}^O)^2$, the cross values of error terms which also capture the direct impacts of shock transmission. The volatility interdependence between markets is directly considered by the presence of h_{t-1}^s and h_{t-1}^O. In order to guarantee the stationarity, the roots of the $[I_2 - AL - BL] = 0$ equation must lie outside the unit circle under some regularity condition. As was suggested by Jeantheau (1998), some other identifiability conditions are satisfied by the expressions $I_2 - AL$ and BL that are left coprime. The conditional covariance between petroleum and stock market returns is represented as follows:

$$h_t^{SO} = \rho * \sqrt{h_t^s} * \sqrt{h_t^o} \tag{7}$$

Where ρ refers to the conditional constant correlation (CCC). As was mentioned by Arouri et al. (2012), it is important to note that because of the possibility of correlation coefficient to change over time according to different market and economic situations, the CCC assumption can be considered as restrictive. To estimate the VAR(1)-GARCH(1,1) model, the quasi-maximum likelihood estimation (QMLE) method was employed (Arouri et al., 2012; Ling & McAleer, 2003).

3.3. Firms financial performance – GMM models

We apply dynamic-panel estimation framework in order to study the impacts of oil price changes on European oil and gas companies' performance as the dynamics of oil price effects are efficiently captured by this framework. The preferred models are one and two-step difference and system in generalised method of moments (GMM). These models were successfully implemented by Dayanandan and Donker (2011) to test the impacts of oil price changes on accounting performance measures of oil and gas companies in North America. The generalised method of moments (GMM) is a robust model, where assumptions regarding the precise distribution of the process of data generation are not required (Dayanandan & Donker, 2011). The two varieties of the empirical framework of GMM are employed in this research: the difference of GMM introduced by Arellano and Bond (1991) and the system GMM introduced by Blundell and Bond (1998, 2000).

The coefficients from the moment restrictions related to the co-variances between the explanatory variable and the residual are derived by the difference GMM model. Endogeneity is controlled by the difference GMM, but when the number of observations is small, the model is exposed to a downward finite sample bias because, for subsequent first-differences, the lagged values of dependent and independent variables are considered to be weak instruments (Dayanandan & Donker, 2011). However, besides lagged values the system GMM model also employs lagged first-differences as instruments for levels equations. According to Blundell and Bond (1998, 2000), when the original equation is added in levels, for the endogenous variables within the model the system GMM model executes better predicators. In comparison to the difference GMM model, the authors found that the system GMM model performs much more efficiently and significantly reduces the finite sample bias. Furthermore, it is suggested that the application of the two-step version of both models leads to substantial improvements in efficiency (Arellano & Bond, 1991; Blundell & Bond, 1998, 2000). However, the estimates of standard errors reflect a downward finite sample bias. In addition, it should be noted that the system GMM model is subjected to the risk of instruments proliferation. According to Roodman (2009), an increase in the sample size can easily cause the number of instruments to grow. Thus, a large number of instruments can overfit endogenous variables and weaken the Hansen test of joint validity of instruments. Limiting the lag depth and collapsing the set of instruments are the most common techniques to reduce the amount of instruments used. Despite these constrains, preference is given to the two-step system GMM estimation method. Nevertheless, this remains as a main limitation of the research where the following GMM model was constructed:

$$y_{it} = \alpha y_{i,t-1} + X_{it}^{'}\beta + \varepsilon_{it} \tag{8}$$

$$\varepsilon_{it} = \mu_i + \upsilon_{it}$$

$$E[\mu_i] = E[\upsilon_{it}] = E[\mu_i \upsilon_{it}] = 0$$

Where i represents firm and t represents time, y refers to the dependent variable (return on equity) and X is a vector of all independent variables plus their lagged values. The error term consists of two orthogonal elements: μ_i - the fixed effects and υ_{it} - random shocks. The equation below is estimated, which was derived by subtracting $y_{i,t-1}$ from both sides of equation (8):

$$\Delta y_{it} = (\alpha - 1) y_{i,t-1} + X_{it}^{'}\beta + \varepsilon_{it} \tag{9}$$

The estimation of difference GMM takes place after first-differencing the data with the aim of liquidating the fixed effects. The difference GMM is supplemented by the system GMM through simultaneous estimation in differences and levels, where the both equations are clearly instrumented (Dayanandan & Donker, 2011). The robustness checks are also conducted through the application of panel least squares, random effects and fixed effects models. The following equation was estimated:

$$ROE_{it} = \beta_0 + \beta_1 SIZE_{it} + \beta_2 GEAR_{it} + \beta_3 Profitability_{it} + \beta_4 OIL_{it} + \beta_5 D1*OIL_{it} + \beta_6 D2*OIL_{it} + \varepsilon_{it} \tag{10}$$

4. Empirical results

To study the interrelations between Brent crude oil prices, European stock market returns and the financial performance of Western European oil and gas firms, the analysis is divided into three stages. First, the analysis starts with the examination of impulse responses to assess the reaction of stock markets to one standard deviation innovations generated from oil returns. Second, the analysis moves to the investigation of volatility transmission between oil and stock markets by estimating VAR(1)-GARCH(1,1) model. Lastly, in the third stage, the analysis estimates one and two-step difference and system GMM models, as well as panel least squares, fixed effects and random effects models to examine the impact of oil price changes on the financial performance of oil and gas firms.

4.1. Oil prices and stock returns

4.1.1. Vector autoregressive model estimates

The estimated impulse responses allow to investigate the reaction of each variable in the system to innovations arisen from other variables. Table 7 reports the accumulated response of the European-wide stock market index, *Automobile and Parts, Basic Materials, Financials, Health Care, Industrials, Oil and Gas, Technology, Telecommunications* and *Utilities* stock sector indices to one standard deviation innovations generated from petroleum returns. Accumulated responses are graphically presented in Fig. 3.

In general, the impulse response results are positive and considerably different across sectors. High reactions are found in sectors, where petroleum is used as one of the main inputs/outputs and low responses in all other cases. The *Oil and Gas* sector index is more influenced by innovations originated from weekly petroleum returns, followed by *Basic Materials, Automobile and Parts, Industrials, Financials* sector indices and Dow Jones Stoxx Europe 600 index. All of these indices respond significantly from the first week. As it can be seen from Table 7 and Fig. 3, these indices react quickly and appear to be relatively efficient as their responses to innovations start to decline from week 10. However, the picture is different for the remaining stock sector indices. The *Technology, Utilities, Telecommunications* and *Health Care* sector indices stand out as being less influenced by one standard deviation innovations in petroleum returns. These indices also react from week one. However, the responses are minor and gradually decline, meaning that they are not efficient in reacting to innovations generated from petroleum returns. As expected, the *Oil and Gas* sector index exhibits a high positive and faster response to petroleum innovations than other indices within a 12- week horizon. On the other hand, it is noticeable that of all the indices, the *Health Care* sector index is less affected by one standard deviation innovations in petroleum returns. It requires the sector index one week to start reacting to a shock.

4.2. Volatility transmission between oil and stock markets

4.2.1. VAR(1)-GARCH(1,1) estimation results

Table 8 presents the VAR(1)-GARCH(1,1) model's estimation results for petroleum-global European stock market and petroleum-stock sector pairs. Regarding the autoregressive terms, it was found that in most cases past week petroleum returns significantly impact their current values which suggests that there is an evidence of petroleum prices being predictable in the short-term. One-period lagged stock returns are significant for the European-wide stock market, *Basic Materials, Industrials, Oil and Gas* and *Technology* stock sectors, implying that future stock returns can be better predicted by past stock returns. These results to some extent contradict findings of Arouri et al. (2012), which show that the one-period lagged stock returns are not significant and thus ineffective in predicting future stock returns. Such divergence could be explained by the difference in estimation period that includes geopolitical events.

In most cases, the coefficients of ARCH and GARCH estimates in the conditional variance equations are statistically significant at 1%, 5% and 10% levels. It was found that the sensitivity of the stock markets to their past conditional volatilities (represented as h^S_{t-1}) appears to be statistically significant for *Oil and Gas* and *Technology* sectors at 5% and 1% levels, respectively. For the stock markets with insignificant past own conditional volatilities, it appears that ARCH model is more appropriate. The results obtained indicate that past unexpected innovations $(\varepsilon^S_{t-1})^2$ impact return dynamics of the stock markets, since in most cases the related coefficients are statistically significant. Furthermore, under the impetuosity of return innovations, the conditional volatility does not change very speedily as ARCH coefficients are relatively small. However, for the *Oil and Gas* sector, the large values of the GARCH coefficients suggest that, over time, the conditional volatility tends to swing gradually. The performance of petroleum price volatility is quite similar to the behaviour of stock market volatility.

Moving to the empirical results regarding the transmission of volatility between oil and the Dow Jones Stoxx Europe 600 index (Table 8, Panel A), it was found that innovations in the oil market, represented by $(\varepsilon^O_{t-1})^2$, do not affect the European-wide stock market's conditional volatility as indicated by the insignificance of the coefficient. Hence, the innovations arising from the oil market do not increase the volatility of the stock market. In addition, statistical insignificance of the h^O_{t-1} coefficient suggests that the oil market's past volatility is not transmitted to the stock market. On the other hand, the innovations $(\varepsilon^S_{t-1})^2$, and volatility, (h^S_{t-1}), occurred on the Dow Jones Stoxx Europe 600 index do not affect oil market volatility, as the coefficients are insignificant in the conditional volatility equation for returns in oil.

In terms of sector indices (Table 8, Panels B to J), empirical findings for the *Automobile and Parts* stock sector provide no evidence regarding the existence of cross-innovation effects. However, the past volatility of the stock sector is transmitted to the oil market as indicated by the statistical significance of the coefficient at 5% level. The stock sector volatility is only driven by its own past innovations. Such result is consistent with the findings of Arouri et al. (2012), suggesting that effective risk management strategies with regard to the concerns associated with oil risk, which is common in that industry, may explain the absence of innovations and volatility spill-overs. The oil - *Basic Materials* stock sector model - shows that the conditional volatility of this sector is only affected by the past volatility of oil market, as indicated by the significance of the h^O_{t-1} coefficient at 5% level. The inverse volatility transmission from the stock to oil market is weekly significant at 10% level. As the *Basic Materials* sector consumes petroleum, rising prices for this commodity may lead to an increase of volatility in the sector by impacting upon supply and demand for its produced products. Similar results were obtained for the *Financials, Technology* and *Telecommunications* stock sectors, which show no evidence of bilateral volatility and innovation transmissions. These empirical results were unexpected and the opposite of those found by Arouri et al. (2012), as oil price fluctuations tend to impact upon investment decisions in these sectors. The absence of spill-over effects can be explained by the effective oil risk management strategies. The results for the oil-*Health Care* stock sector model are surprising. The model shows the existence of

Table 7
Accumulated responses of Dow Jones Stoxx Europe 600 index and nine sector indices to one *Standard Deviation* oil innovations.

Period (weeks)	Oil	Stoxx Europe 600	Automobile and Parts	Basic Materials	Financials	Health Care	Industrials	Oil and Gas	Technology	Telecommunications	Utilities
1	0.0405	0.0085	0.0127	0.0140	0.0086	0.0033	0.0092	0.0168	0.0073	0.0053	0.0068
2	0.0199	0.0055	0.0086	0.0094	0.0062	0.0037	0.0054	0.0101	0.0048	0.0029	0.0042
3	0.0167	0.0042	0.0023	0.0074	0.0038	0.0038	0.0039	0.0082	0.0026	0.0032	0.0032
4	0.0249	0.0049	0.0087	0.0083	0.0049	0.0018	0.0053	0.0100	0.0040	0.0030	0.0043
5	0.0222	0.0057	0.0065	0.0097	0.0062	0.0034	0.0059	0.0107	0.0048	0.0034	0.0045
6	0.0207	0.0048	0.0065	0.0083	0.0046	0.0034	0.0047	0.0094	0.0036	0.0031	0.0036
7	0.0223	0.0050	0.0067	0.0085	0.0051	0.0028	0.0052	0.0099	0.0039	0.0032	0.0043
8	0.0221	0.0053	0.0065	0.0090	0.0056	0.0030	0.0055	0.0101	0.0043	0.0032	0.0042
9	0.0215	0.0050	0.0068	0.0085	0.0049	0.0032	0.0050	0.0097	0.0039	0.0032	0.0039
10	0.0219	0.0052	0.0066	0.0088	0.0053	0.0030	0.0053	0.0100	0.0041	0.0032	0.0042
11	0.0220	0.0051	0.0066	0.0087	0.0053	0.0030	0.0052	0.0099	0.0040	0.0032	0.0041
12	0.0218	0.0051	0.0067	0.0086	0.0051	0.0031	0.0051	0.0098	0.0040	0.0032	0.0040

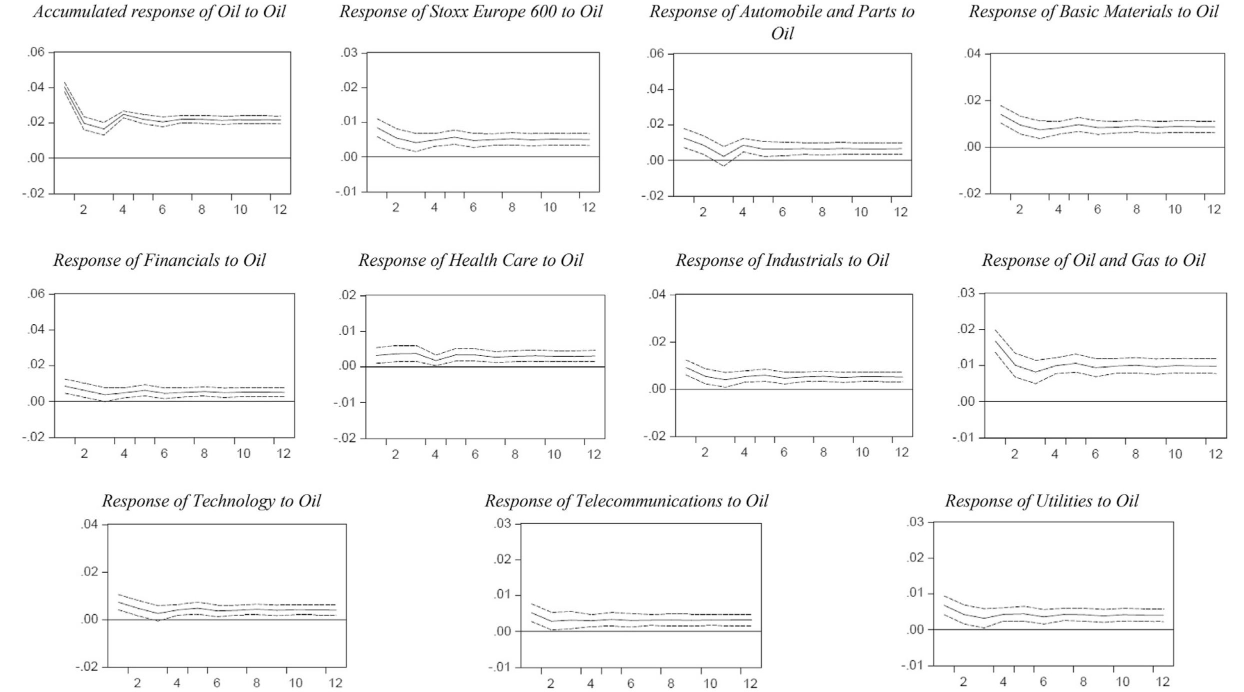

Fig. 3. Accumulated responses of the Dow Jones Stoxx Europe 600 index and nine sector indices to Cholesky One S.D. oil innovations – 2 S.E.

bi-directional volatility transmissions. The spill-over effects from the oil market to *Health Care* stock sector are significant at 5% level and in the inverse direction at 1% level.

Malik and Ewing (2009) suggest that an increase in volatility in the oil market is frequently viewed as a great uncertainty in the economy. Taking this into consideration, the empirical finding implies that the *Health Care* stock sector is bound to uncertainty in the economy; hence, it seems that performance of companies in the *Health Care* stock sector is dependent on prices of oil. In addition, the spill-over effect from the *Health Care* stock sector to oil market appears to lead to changes in the usage of energy. In addition, the oil market is affected by the innovations in the stock market at 1% significance level. The findings for *Industrials* and *Utilities* stock sectors show the absence of bilateral spill-over effects as indicated by the insignificance of coefficients. Such a result is somewhat unexpected because companies operating in these sectors are one of the main consumers of oil-related products. According to Malik and Ewing (2009), this may be explained by the effective hedging strategies against the impacts of oil price fluctuations and by proper management of dependence on oil. As indicated by the significance of the coefficient of $(\varepsilon_{t-1}^{O})^2$ at 5% level, the *Oil and Gas* stock sector is affected by innovations originated in the oil market. Such innovations increase the sector's volatility. However, there is no evidence suggesting that the oil market's past volatility is transmitted to the *Oil and Gas* sector because the coefficient related to h_{t-1}^{O} is insignificant. On the other hand, according to the empirical findings, the behaviour of oil market volatility is independent from changes (volatility and innovations) occurring in the *Oil and Gas* stock sector.

When comparing sectors, the findings show that the past volatility of *Automobiles, Basic Materials* and *Health Care* sectors exert significant impact on the values of oil market volatility. In all other cases, they do not have any effects. The past innovation of only *Health Care* sector significantly affects the oil market volatility. In contrast, the past innovations of the oil market do not have any effect on the volatility of stock sectors, except for the *Oil and Gas* stock sector. Changes in the volatility of oil market only spill over into the *Basic Materials* and *Health Care stock* sectors, while the results obtained for constant conditional correlations are positive and statistically significant, but weak in general, except for *Basic Materials* and *Oil and Gas* stock sectors.

4.3. Oil and gas companies' financial performance

4.3.1. GMM estimation results – listed firms

Table 9 reports the results for one and two-step difference and system GMM models for listed European oil and gas companies. The standard errors associated with two-step difference and system GMM models are lower than the standard errors associated with one-step models, but with large discrepancies in some instances.[2] Moreover, the coefficients are mostly significant, thus confirming the efficiency of two-step models. The estimates for the two-step difference and system GMM models are sensible, significant and have mostly

[2] Results available upon request.

Table 8
VAR(1)-GARCH(1,1) estimates. Panel A: Oil and *Stoxx Europe 600*.

Panel A		
Variables	Oil	Stoxx Europe 600
Mean equation		
C	0.0008 (0.5953)	0.0021** (0.0394)
AR(1)	0.2166*** (0.0000)	−0.0909* (0.0799)
Variance equation		
C	0.0000 (0.3803)	0.0000 (0.1155)
$(\varepsilon_{t-1}^{S})^2$	0.0140 (0.8829)	0.2364*** (0.0001)
$(\varepsilon_{t-1}^{O})^2$	0.0540 (0.2066)	−0.0715 (0.5197)
h_{t-1}^{S}	−0.4455 (0.3474)	0.5615 (0.2033)
h_{t-1}^{O}	1.3585** (0.0155)	0.2095 (0.5373)
Constant conditional correlation (CCC)		
Oil	1.0000	
Stoxx Europe 600	0.2497*** (0.0000)	1.000
AIC	−8.5946	

Panels B to J: Oil and *Sector Indices*

Variables	Panel B		Panel C		Panel D		Panel E		Panel F	
	Oil	*Automobile and Parts*	*Oil*	*Basic Materials*	*Oil*	*Financials*	*Oil*	*Health Care*	*Oil*	*Industrials*
Mean equation										
C	0.0006 (0.6579)	0.0047*** (0.0067)	0.0009 (0.5236)	0.0030** (0.0316)	0.00053 (0.7168)	0.0014 (0.2712)	0.0004 (0.7568)	0.001459 (0.1081)	0.0007 (0.6231)	0.0031** (0.0133)
AR(1)	0.2062*** (0.0000)	−0.0605 (0.2926)	0.2131*** (0.0000)	−0.1374*** (0.0059)	0.2151*** (0.0000)	−0.0600 (0.2502)	0.2105*** (0.0000)	0.000573 (0.9913)	0.2063*** (0.0000)	−0.1045** (0.0428)
Variance equation										
C	0.0000 (0.1723)	0.0002 (0.1819)	0.0000 (0.2287)	0.0000** (0.0469)	0.0000 (0.3971)	0.0000 (0.6121)	0.000** (0.0366)	3.36E-05* (0.0533)	0.0000 (0.2709)	0.0000* (0.0711)
$(\varepsilon_{t-1}^{S})^2$	0.0212 (0.7801)	0.3047*** (0.0000)	0.0139 (0.8552)	0.2419*** (0.0000)	0.0152 (0.8821)	0.1818*** (0.0036)	0.1275*** (0.0000)	0.125995** (0.0144)	0.0187 (0.8281)	0.1895*** (0.0004)
$(\varepsilon_{t-1}^{O})^2$	0.0514 (0.2319)	−0.0453 (0.8196)	0.0516 (0.2028)	−0.0752 (0.2601)	0.0585 (0.1842)	−0.0719 (0.7363)	0.0800*** (0.0062)	−0.029033 (0.6297)	0.0540 (0.2050)	0.0135 (0.9118)
h_{t-1}^{S}	−0.5362** (0.0323)	0.4932 (0.4465)	−0.5273* (0.0723)	0.3849 (0.1141)	−0.4048 (0.4499)	1.0498 (0.4460)	0.8259*** (0.0000)	0.289873 (0.3294)	−0.4800 (0.1720)	0.2512 (0.6140)
h_{t-1}^{O}	1.4386*** (0.0000)	0.1810 (0.6777)	1.4385*** (0.0001)	0.4124** (0.0357)	1.3122** (0.0377)	−0.1719 (0.8811)	−0.0770* (0.0507)	0.540294** (0.0433)	1.3853*** (0.0011)	0.4609 (0.2343)
CCC										
Oil	1.0000		1.0000		1.0000		1.0000		1.0000	
Sector Index	0.1825*** (0.0001)	1.0000	0.3245*** (0.0000)	1.000000	0.1517*** (0.0009)	1.0000	0.1008** (0.0203)	1.0000	0.2310*** (0.0000)	1.0000
AIC	−7.4496		−7.9695		−7.9613		−8.8583		−8.1920	

International Review of Economics and Finance 61 (2019) 270–288

Variables	Panel G		Panel H		Panel I		Panel J	
	Oil	Oil and Gas	Oil	Technology	Oil	Telecommunications	Oil	Utilities
Mean equation								
C	0.0008 (0.5660)	0.0007 (0.6031)	0.0006 (0.6881)	0.0022 (0.0845)	0.0004 (0.7782)	0.0008 (0.4557)	0.0005 (0.7271)	0.0012 (0.2933)
AR(1)	0.2292*** (0.0000)	−0.1162*** (0.0127)	0.2040*** (0.0000)	−0.0862* (0.0584)	0.2029*** (0.0000)	−0.0464 (0.3629)	0.2017*** (0.0000)	−0.0626 (0.2128)
Variance equation								
C	0.0000 (0.5815)	0.0000* (0.0964)	0.0000 (0.5197)	0.0000 (0.3969)	0.0000 (0.4223)	0.0000 (0.7008)	0.0000 (0.2363)	0.0000** (0.0275)
$(\varepsilon_{t-1}^{S})^2$	−0.0020 (0.9876)	0.2484*** (0.0000)	0.0012 (0.9926)	0.0456 (0.2194)	0.0174 (0.8751)	0.1188** (0.0168)	0.0339 (0.6746)	0.1832*** (0.0000)
$(\varepsilon_{t-1}^{O})^2$	0.0619 (0.1325)	−0.1368* (0.0528)	0.0723* (0.0932)	0.0009 (0.9913)	0.0614 (0.1499)	−0.0743 (0.4959)	0.0432 (0.3031)	−0.0290 (0.6477)
h_{t-1}^{S}	−0.3947 (0.6577)	0.5336** (0.0315)	−0.3618 (0.6522)	1.5032*** (0.0023)	−0.3404 (0.6094)	1.2524 (0.2785)	−0.4506 (0.1957)	0.3461 (0.2810)
h_{t-1}^{O}	1.3180 (0.1973)	0.3220 (0.1073)	1.2720 (0.1731)	−0.5661 (0.1813)	1.2424 (0.1102)	−0.3523 (0.6980)	1.3500*** (0.0012)	0.3989 (0.1136)
CCC								
Oil	1.0000		1.0000		1.0000		1.0000	
Sector Index	0.4381*** (0.0000)	1.0000	0.1864*** (0.0001)	1.0000	0.1391*** (0.0021)	1.0000	0.2008*** (0.0000)	1.0000
AIC	−8.2805		−8.119		−8.5578		−8.4922	

Notes: Oil is oil price returns, Sector Index is sector stock returns and CCC is *constant conditional correlations*. P-values are in parenthesis. *, **, and *** indicate significance at the 10%, 5% and 1% levels, respectively.

Table 9
One and two-step difference GMM and system GMM models for *listed* Western European Oil and Gas companies. The sample consists of 137 Oil and Gas listed firms for the period 2005 to 2014. *ROE* is defined as net income divided by shareholder funds. *SIZE* is the natural logarithm of total assets. *GEARING* is defined as non-current liabilities divided by shareholder funds. *Profitability* is measured by EBIT over total assets. *OIL* is the Brent crude oil spot price (EUR per barrel). *Dummy* 1 has the value one during the final stage of the recent global financial crisis (2008–2009) and zero otherwise. *Dummy* 2 has the value one during the geopolitical crisis (2014) and zero otherwise. *T-statistics* in parenthesis. *, ** and *** indicate significance at 10%, 5% and 1% levels.

	Expected sign	One-step difference GMM	Two-step difference GMM	One-step system GMM	Two-step system GMM
ROE(− 1)	+	0.0166 (0.21)	0.0145*** (5.22)	0.2082** (2.30)	0.2105*** (26.06)
OIL	+	0.0009 (0.51)	0.0006*** (4.09)	0.0008 (0.63)	0.0009*** (3.82)
Size	+	0.0028 (0.09)	0.0015 (0.19)	−0.0044 (−0.51)	−0.0041*** (−3.10)
Gearing	–	−0.1314* (−1.95)	−0.1356*** (−24.68)	−0.0202 (−0.84)	−0.0194*** (−3.11)
Profitability	+	0.8586*** (4.27)	0.8833*** (37.83)	0.7271*** (3.67)	0.7305*** (29.30)
*Dummy*1 × *OIL*	–	−0.0021** (−2.30)	−0.0016*** (−9.19)	−0.0024*** (−2.66)	−0.0019*** (−10.60)
*Dummy*2 × *OIL*	–	−0.0008 (−1.06)	−0.0005*** (−4.10)	−0.0019*** (−3.08)	−0.0017*** (−11.39)
Observations		615	615	755	755
Groups/Unique Firms		116	116	124	124
Arellano-Bond test for AR(2)		−0.45	−0.37	1.30	1.17
Hansen test of over. restrictions (Chi-Sq.)		73.79	73.79	82.08	82.08
Lags used in instrumentation (endogenous variables)		2	2	3	3

expected signs as discussed previously. Furthermore, all the coefficients associated with the two-step system GMM model have expected signs, apart from *Size* and are statistically significant at 1% level. The empirical results clearly indicate that the accounting returns of listed Western European oil and gas firms are positively impacted by crude oil prices. The statistical significance of the lagged dependent variable's coefficient hence indicates considerable persistence over time. This result is consistent with what Dayanandan and Donker (2011) have found in relation to listed oil and gas firms in North America.

The coefficient for *Size* is statistically significant with a negative sign, implying that an increase in size affects the return on equity negatively for listed oil and gas firms. *Gearing* is statistically significant with expected sign. Such a result is consistent with findings of Dowen (1995), McConnell and Servaes (1995), Short and Keasey (1999), Weir, Laing, and McKnight (2002), Haniffa and Hudaib (2006) and Dayanandan and Donker (2011) suggesting that gearing is perceived by the market as unsuccessful mechanism to monitor management, since the performance of firm is negatively impacted by it. As was expected, *Profitability* is also statistically significant and has expected positive sign, thus suggesting that it influences accounting returns positively. The performance of listed Western European oil and gas companies was negatively impacted by interactive dummy variables for recent financial and geopolitical crises (*Dummy*1 × *OIL* and *Dummy*2 × *OIL*), as indicated by the significance of associated coefficients at 1% level. It is important to mention that *Profitability* and the first interactive dummy variables are also statistically significant across all four models. The Arellano-Bond test for autocorrelation (AR [2]) with the null hypothesis that autocorrelation in fist-differenced errors is absent, and Hansen test of over-identifying restrictions with the null hypothesis that over-identifying restrictions are valid and instruments are uncorrelated with error terms, are not rejected across all GMM models. These results indicate that all models are correctly specified.

4.3.2. GMM estimation results – unlisted firms

To our knowledge, there has been virtually no research regarding the impact of petroleum prices on accounting performance measures for Western European unlisted oil and gas companies. Therefore, the obtained empirical results are in some sense unique. Estimation results of one and two-step difference and system GMM models for unlisted Western European oil and gas companies are reported in Table 10. The results obtained validate the efficiency of the two-step difference and system GMM models, as indicated by the significance of coefficients and lower standard errors. The picture for unlisted oil and gas firms is different compared to listed firms. Most of the explanatory variables are statistically insignificant across all models, and particularly in the two-step system GMM. The empirical findings clearly indicate that return on equity for unlisted Western European oil and gas firms are not affected by crude oil prices.

The lagged dependent variable's coefficient in the case of unlisted firms is also statistically significant. The coefficients of *Size* and *Gearing* are insignificant and show that, during the period of study, they did not affect the financial performance of unlisted oil and gas firms. *Profitability* as in the case of listed firms, also had statistically significant positive impact on the financial performance, which is not surprising. The interactive dummy variable associated with the global financial crisis (*Dummy*1 × *OIL*) did not have an impact on the accounting performance measure of unlisted firms and points to their resistance during this economic contraction. However, as was anticipated, the interactive dummy variable that represents the geopolitical crisis (*Dummy*2 × *OIL*) negatively affected the financial performance of oil and gas firms in Western Europe. The null hypotheses associated with the second order of Arellano-Bond test for autocorrelation and Hansen test of over-identifying restrictions are not rejected, thus indicating the correct specification of all GMM models.

The estimates of panel least squares, fixed effects and random effects models for both listed and unlisted Western European oil and

Table 10
Estimates of one and two-step difference GMM and system GMM models for *unlisted* Western European Oil and Gas companies. The sample consists of 531 Oil and Gas unlisted firms for the period 2005 to 2014. *ROE* is defined as net income divided by shareholder funds. *SIZE* is the natural logarithm of total assets. *GEARING* is defined as non-current liabilities divided by shareholder funds. *Profitability* is measured by EBIT over total assets. *OIL* is the Brent crude oil spot price (EUR per barrel). *Dummy* 1 has the value one during the final stage of the recent global financial crisis (2008–2009) and zero otherwise. *Dummy* 2 has the value one during the geopolitical crisis (2014) and zero otherwise. *T-statistics* in parenthesis. *, ** and *** indicate significance at 10%, 5% and 1% levels.

	Expected sign	One-step difference GMM	Two-step difference GMM	One-step system GMM	Two-step system GMM
ROE(−1)	+	0.0777 (0.89)	0.1404*** (5.14)	0.4467*** (4.42)	0.4737*** (15.21)
OIL	+	0.0008 (0.57)	−0.0005 (−0.55)	0.0004 (0.40)	0.0000 (0.03)
Size	+	−0.0443 (−0.77)	0.0082 (0.23)	−0.0018 (−0.28)	−0.0001 (−0.02)
Gearing	–	−0.1006** (−2.09)	−0.0814** (−2.45)	−0.0013 (−0.10)	−0.0022 (−0.28)
Profitability	+	0.4760** (2.39)	0.6494*** (4.70)	0.5326*** (3.99)	0.5715*** (10.84)
*Dummy*1 × *OIL*	–	0.0010 (1.57)	0.0006 (1.23)	0.0010 (1.53)	−0.0001 (−0.17)
*Dummy*2 × *OIL*	–	−0.0011 (−1.63)	−0.0011* (−1.92)	−0.0006 (−0.93)	−0.0011*** (−2.73)
Observations		2022	2022	2514	2514
Groups/Unique Firms		381	381	442	442
Arellano-Bond test for AR(2)		0.83	0.80	1.16	1.06
Hansen test of over. restrictions (Chi-Sq.)		32.12	32.12	56.63	56.63
Lags used in instrumentation (endogenous variables)		2	2	2	2

gas firms are presented in Table 11. The results obtained by these models are generally insignificant, have opposite signs and low explanatory power, as revealed by R-squared. The poor performance of such models was documented by Dayanandan and Donker (2011). On the other hand, the fixed effects model has higher explanatory power, as indicated by R-squared, and generates the results close to the GMM models, particularly in the case of listed firms. Majority of the explanatory variables, apart from *Gearing* and *Oil*, are statistically significant and have expected signs.

Overall, the empirical findings clearly show that crude oil prices have a statistically significant positive impact on the accounting performance measure of listed Western European oil and gas companies. These results suggest that the predominant factor in driving the performance of listed oil and gas firms is the commodity price. On the other hand, the results imply that crude oil prices do not affect the

Table 11
Estimates of panel least squares, fixed effects and random effects models for *listed* and *unlisted* Western European Oil and Gas companies. The sample consists of 137 listed and 531 unlisted Oil and Gas firms for the period 2005 to 2014. *ROE* is defined as net income divided by shareholder funds. *SIZE* is the natural logarithm of total assets. *GEARING* is defined as non-current liabilities divided by shareholder funds. *Profitability* is measured by EBIT over total assets. *OIL* is the Brent crude oil spot price (EUR per barrel). *Dummy* 1 has the value one during the final stage of the recent global financial crisis (2008–2009) and zero otherwise. *Dummy* 2 has the value one during the geopolitical crisis and zero otherwise.*P-values* in parenthesis. *, ** and *** indicate significance at 10%, 5% and 1% levels.

	Expected sign	Listed Firms			Unlisted Firms		
		Panel least squares	Fixed effects	Random effects	Panel least squares	Fixed effects	Random effects
Constant	+/−	−0.061408 (0.6106)	−0.721891*** (0.0032)	−0.145337 (0.2940)	0.218516** (0.0408)	0.332503* (0.0945)	0.335356*** (0.0059)
Size	+	0.018388*** (0.0112)	0.075334*** (0.0005)	0.022945** (0.0289)	−0.003344 (0.6416)	−0.007244 (0.6711)	−0.008374 (0.3697)
Gearing	–	0.016503 (0.4147)	−0.016065 (0.5361)	0.002448 (0.9105)	0.037273*** (0.0002)	0.011646 (0.4188)	0.023877** (0.0330)
Profitability	+	0.730163*** (0.0000)	0.827803*** (0.0000)	0.792231*** (0.0000)	0.666461*** (0.0000)	0.679719*** (0.0000)	0.624467*** (0.0000)
OIL	+	−0.002329* (0.0840)	−0.002665** (0.0342)	−0.001907 (0.1042)	−0.001219 (0.2329)	−0.001847* (0.0677)	−0.001585* (0.0961)
*Dummy*1 × *OIL*	–	−0.003041*** (0.0019)	−0.002819*** (0.0008)	−0.002822*** (0.0007)	0.000654 (0.3798)	0.000700 (0.3082)	0.000772 (0.2542)
*Dummy*2 × *OIL*	–	−0.002292*** (0.0050)	−0.002497*** (0.0005)	−0.002224*** (0.0014)	−0.000877 (0.1576)	−0.001291** (0.0311)	−0.001061* (0.0621)
Observations		918	918	918	3101	3101	3101
R-squared		0.347586	0.614719	0.319699	0.122792	0.403096	0.093729
Adjusted R-squared		0.343289	0.545299	0.315219	0.121091	0.289127	0.091972
F-statistic		80.89203*** (0.0000)	8.855059*** (0.0000)	71.35227*** (0.0000)	72.18353 (0.0000)	3.536888 (0.0000)	53.33174 (0.0000)
Hausman Test (Chi-Sq. Statistic)				12.452471** (0.0526)			11.563146* (0.0725)

accounting performance measure of unlisted Western European oil and gas firms. All the other explanatory variables significantly affect accounting returns of listed firms and, in the case of unlisted firms, profitability is the main driver of the financial performance. It is noticeable that the geopolitical crisis had a negative impact on accounting measures of performance of both listed and unlisted firms.

5. Conclusions

The aim of this paper are threefold: i) to investigate the impact oil price fluctuations on stock markets in Europe represented by the Dow Jones Stoxx Europe 600 index and nine stock sector indices; ii) to examine the volatility transmission between oil and European stock markets; and iii) to study the relationship between the crude oil prices and financial performance of Western European oil and gas companies, both listed and unlisted, over the period 2005–2014.

Our empirical findings are presented at three levels. First, the impulse response functions show high reactions of the sectors in Europe, where oil is used as one of the main inputs/outputs, to one standard deviation innovations generated from the petroleum price returns. Second, the estimation results of the VAR(1)-GARCH (1,1) model indicates that, in most cases, one-period lagged petroleum and stock market returns affect their current values, implying that past returns help to predict future trends better. With regard to volatility spill-overs for each pair of oil and stock market indices, the findings vary from one sector to another. It was found that in the case of *Automobile and Parts, Basic Materials* and *Health Care* stock sectors, the volatility transmits from the stock markets to oil market, and only in the case of *Basic Materials* and *Health Care* stock sectors it runs in the reverse direction. In only a few instances can the presence of volatility spill-over effects be explained by the effectiveness of hedging strategies with respect to oil price risks. It is, however, important to highlight that the stock and oil markets appear to be mostly sensitive to past own innovation and volatilities. Third, the return on equity for listed oil and gas firms in Western Europe are positively and significantly affected by crude oil prices. For unlisted Western European oil and gas companies, our results suggests that their financial performance is not influenced by crude oil prices, which implies the existence of other factors that drive their performance. The geopolitical crisis (2014) negatively affected petroleum prices and the accounting performance of both listed and unlisted firms. However, the recent financial crisis (2008–2009) only had a statistically significant negative impact on listed firms. In addition, results suggest that, in the case of listed firms, most of the explanatory variables have statistically significant impact on return on equity, which is consistent with existing literature.

The findings obtained should be of interest to market participants. As indicated by empirical results, the reaction of stock markets to changes in the crude oil price varies across sectors. Therefore, identification by individual and institutional investors the sensitiveness of various sectors suggests that some of them can provide opportunities for diversification in times of oil price fluctuations (rises or falls). Thus, in the existence of risk in oil price, the results can be used to develop efficient and profitable investment strategies. In addition, a better understanding by the risk managers of oil and gas firms of the links between accounting measure of performance and crude oil prices, firm size, leverage and profitability can lead to the development of effective risk management strategies with regard to the concerns associated with oil risk and, hence, they may improve the firms' financial performance.

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