Oil Price Volatility and Stock Markets

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Abstract

Primary aim of this research is to contribute to the literature on oil prices and stock markets by studying the relation between oil price volatility and stock market volatility. We use a large sample of developed and emerging stock market indices, based on monthly observations over the period January 1982 – December 2008. Volatility is approximated as realized volatility and our methodology is based on regression analysis. Results indicate that one month lagged oil price volatility has significant predicting power in a considerable number of stock market indices, despite the high persistence of stock market volatility. The explanatory power of our model is maximized with the inclusion of an additional lag of five or ten days, which is consistent with the existence of delayed reaction by investors. Furthermore, sector analysis reveals that oil price volatility has greater influence in non oil related industries than in oil related.

Additionally, we find strong evidence of asymmetric effects of oil prices on stock market returns. The results denote that increases on oil price appear to have a larger (and negative) impact on the stock market indices than the decreases. Moreover, the existence of asymmetric effects on oil price volatility to stock market volatility is not supported by empirical evidence.

Contents

1. Introduction

One of the most important resources of earth is oil. From the last decades of the nineteenth century till now oil dominates in most industry sectors and in every day life. The oil domination can be shown through the oil crises of the last fifty years. The oil crisis of 1973, which was created when OPEC[1] decided an oil embargo to the industrialized economies, in which it was predominant supplier, had as result the market price of oil to increase from $3 per barrel (p.b.) to $12. The combination of the oil embargo and the 1973-74 stock market crash has been regarded as the first economic crash after the Great Depression.

The second oil crisis appeared in the late 1970s when the oil production of Iran stopped because of the Iranian revolution. In order to offset the loss in production, OPEC increased the production of other countries and the overall loss in global oil production was declined to four percent. Nevertheless, this turmoil in oil market had as a result in US market to increase oil prices from $15.85 p.b. to $39.50 in the next 12 months. Another testimony of the oil importance is the Gulf War in the early 1990s. The turmoil in Persian Gulf and the Iraq invasion in August 1990 had as a consequence the explosion of oil prices from $16.10 p.b. to $30.00 p.b.. The last oil crisis in the 2000s happened without the existence of an obvious political event and had as result oil prices to climb from $30 p.b in 2003 to $147.30 p.b in July 2008.

The consequences of the above crises extended to both macroeconomic and microeconomic level. The first have been investigated extensively. For example, Hamilton et al(1983) concludes that Gross National Product(GNP) is negative correlated with oil price increases and Guo et al (2005) find that oil price volatility has a negative effect on the future Gross Domestic Product (GDP) over the period 1984-2004.

On the other hand, there are few studies, which devote their attention to the relation of oil prices and stock markets. Most of these studies are concentrated in the level of prices or returns, and additionally their dataset is constituted from a small number of indices. Recently, Driesprong et al. (2008) conducted a research, which tests the influence of oil prices on a big number of stock indices.

[1] Organization of the Petroleum Exporting Countries

Complementary to the existing literature, this study will investigate the oil dynamics to stock markets in a more extent level, taking into account another important factor, the volatility of oil prices and stock markets. It is argued that volatility of price changes is an accurate measure of rate of information flow in a financial market (Ross,1989), consequently it will be extremely valuable if Oil Price Volatility(OPV) is capable to predict the stock market volatility. Since emerging and developed markets may experience diverse behaviour from investors, we use a broad sample of developed and emerging stock market indices. In addition, our data sample covers a period of almost twenty five years, which include the Gulf War and the recent energy crisis.

The first part of this study is focused on the relation between oil price volatility and stock market volatility over the full sample and over different periods of time. Additionally, since several studies appear to imply that some economic variables capture the effects of oil prices to the economies, a group constituted of macroeconomic and financial variables will be used in order to justify the previous results. Another interesting insight to be investigated is whether the delayed reaction that exists in the markets for the changes in oil prices exists also for the fluctuations in oil volatility. Finally, a detailed analysis of the influence of OPV over the different industries is conducted.

The second part of our research is devoted in the examination of asymmetric effects of oil price volatility and returns to the stock market indices. From literature we know that high levels of oil volatility influences significantly economies (Huang et al., 2005), while low levels of oil volatility do not significantly affect the economic environment. In this study it will be tested whether this asymmetric effect of oil volatility experiences the same pattern for stock markets reactions. Complementary, extending the research of Driesprong et al(2008), the asymmetric effects of oil price returns to the financial markets will be investigated[2].

The main results of the first part of our study reveal the high persistence of stock market volatility. This ensues to the domination of lagged market volatility across different countries. Nevertheless, we find in a considerable number of countries that oil price volatility is statistically capable to predict future stock market volatility. Additionally, the impact of oil price volatility appears to be stronger in non related

[2] Driesprong et al(2008) studied the market reactions due to oil price changes.

industries, such as the financial. As far as the asymmetric effects of oil price are concerned, our results confirm the existence of them in the return level but not in the volatility one.

The remainder paper is structured as follows. Section 2 provides an overview of previous studies on oil price dynamics. In section 3 a description of the dataset is given. Chapter 4 presents the methodology, which we follow in order to investigate the impact of OPV on stock market volatility, and the relative results. Section 5 investigates for asymmetric effects of oil price returns and volatility on the stock market indices. Chapter 6 concludes this paper.

2. Literature Review

In this section a theoretical background and empirical evidence is presented. The studies relevant with our research can be divided in three parts. The first one has to do with researches that either refer to oil volatility and stock market or refer to oil prices and stock markets. The next group has to do with studies that investigate the influence of oil volatility to a macroeconomic level. The last group is more general and presents some useful insights from studies relevant with oil dynamics on macroeconomic level.

2.1 Oil Price and Stock Markets

The researches concentrated on oil price and stock markets can be allocated in three subgroups. The first group is closely related with our study and involves studies, in which references about the relation of oil volatility and stock markets can be found. Nevertheless, most of them are mainly concentrated on oil price returns, hence we present their main findings for both return and volatility level.

The paper by Huang, Masulis and Stoll (1996) is one of the first tries to systematically investigate the association between oil price volatility and stock market volatility. Their analysis is based on daily data of oil futures and SP500 index (as a market index for US) for the period 1979-1990. Their main findings concerning the oil futures returns are that the latter do not appear to have significant correlation with stock markets returns, except in the case of oil company returns. Similar results produce the research they conducted about oil volatility. Specifically, after considering a VAR model that includes oil price, Treasury bill and stock volatilities, they result that oil volatility leads the petroleum stock index volatility but it does not have a significant impact with respect to volatilities of other individual stocks.

Another important paper regarding the oil volatility is the study of Sadorsky(1999). This research uses a model, which includes oil prices, short term interest rates, industrial production and stock market returns (taken by S&P500), for the period 1947-1996. The analysis showed that an oil price shock has a negative and statically significant impact on stock returns. Another interesting insight of this study is the analysis for asymmetric oil price and volatility shocks. More particularly, the results concerning oil price shocks suggest that positive oil price shocks have greater impact on the economy than do the negative ones. Similarly, the explanatory power of positive oil price volatility to the industrial production and stock returns is larger than the one of negative oil volatility. Furthermore, after 1986 the positive oil volatility predicts a larger fraction of the real stock returns than do interest rates.

Complementary to these studies, another research that examines the effects of oil price shocks and oil volatility to stock markets is written by Park and Ratti(2008). They use a broad sample (in comparison with previous studies) of thirteen developed countries over the period 1986-2007. One of their main finding is that oil price shocks account for a statistically significant 6% of the volatility in real stock returns. Furthermore, oil price volatility has a significant negative impact in most of the countries that they test. Moreover, when the oil price shock is included to the same model with oil price volatility then the impact of oil volatility become weaker than before and it is significant in 7 out of 13 countries. Surprisingly, asymmetric effects are only found in the US, while there is no evidence of such asymmetry for none of the European countries.

Besides these studies, in which we find references for the influence of oil price volatility to stock markets, in the existing literature we can also find studies that devote exclusively their attention to which level oil price can forecast stock returns.

Jone and Kaul (1996) belong to the first authors, who examined this relation. In order to capture the reactions of different economies to oil price shocks they use quarterly data of four developed countries (United Kingdom, United States, Japan and Canada). Moreover the oil price shocks are calculated as the percentage change in oil prices. They conclude that oil prices shocks have a negative impact to output and real stock returns in the four considered countries. Furthermore, this negative impact in United States and Canada can be explained from current and expected future flows alone. On the contrary, markets in Japan and United Kingdom appear to be irrational, in the sense that the changes in stock market indexes from oil price shocks cannot be explained either from future cash flows or other financial variables with significant explanatory power.

A similar approach is followed by Papapetrou(2007), who focus on the relationship between oil prices, real stock prices, interest rates, real economic activity and employment for Greece. Using monthly data for the period 1986-1999 and a multivariate Vector –Autoregression approach, she finds that oil prices have significant impact in real stock returns, real economic activity and employment. The impact in real stock returns is negative and lasts for approximately 4 months, while in real economic activity is also negative, but immediate.

More recently, Maghyereh(2004) conducted a research of a broad sample of emerging markets (22 in total) over the period 1998-2004. As he mentions, his results do not demonstrate a significant influence of oil price to stock market indices. Contrariwise his findings are not supported by the research of Basher and Sadorsky(2006). More specifically, they also use a broad sample of emerging economies (but for a longer period) with various frequencies for the data (such as daily, weekly, and monthly) and their results illustrate that oil price risk significantly influences the emerging stock markets returns. In addition, they confirm the existence of asymmetric effects, although the latter depend on the data frequency.

Driesprong , Jacobsen and Maat (2008) belong to the first authors, who use a sample constituted of developed and emerging stock market indices(fifty in total) and parallel they document significant forecasting ability of oil price returns to stock market indices. More particularly, their sample covers a period of almost thirty years and the basic regression model consists of stock market returns and one month lagged oil returns. Their main finding is that changes in oil prices forecast stock returns, especially in stock markets of developed countries.

Additionally, after including in the basic model financial control variables with predictive power on stock returns, such as dividend yield, term and default spread, they conclude that the predictability of oil returns cannot be attributed to these variables, since they are uncorrelated. In addition, they report that their findings are consistent with the gradual information diffusion hypothesis proposed by Hong and Stein(1999).Firstly, because the explanatory power of the above regressions increases, when they introduce lags between stock index returns and lagged oil returns and picks a maximum for a lag of 6 trading day. Secondly, because oil price forecasting power tends to be weaker in industry sectors closely related with oil.

Moreover, another evidence of the relation between oil prices and stock market can be found in the study of Kaul and Seyhun(1990). Particularly, trying to explain the influence of inflation to stock market of New York Stock Exchange(NYSE), they come up with the conclusion that the energy price shocks during the seventies are capable to explain the real supply shocks on stock markets.

Aside from studies, which concentrate on the impact of oil dynamics to stock market indices, some authors conducted detailed researches about the relation of oil price and every section of a stock market separately.

Faff and Brailsfold(1999) devote their attention to the sensitivity of Australian industry equity returns to oil price shocks over the period 1983 -1996. Considering a two factor model that included oil and real market returns, they conclude that in general, oil price returns have an important influence on the cost of many industries. More particular, a significant positive sensitivity is found for the Oil and Diversified Resources industries and a significant negative for the Paper and Packaging, Transport and Banking industries. For the later they argue that this result is probably due to model misspecification.

In addition, Eryigit (2009) examines the dynamic relation among oil price and Instabul Stock Exchange (ISE). He considered the same model as Faff et al (1999) and a sample of 16 sectors in ISE over the period 2004-2008. The conclusion is that oil price has significant effects in several industry sectors (among other Electricity, Wholesale and Retail, Insurance, Metal Products) and it is positive on Wood, Paper and Printing, Insurance and Electricity.

Furthermore, an interesting research was conducted by Cong, Wei, Jiao and Fan(2008). Based on monthly data from 1996 to 2007 and a multivariate VAR model, which included interest rates, industrial production, real stock returns and oil price, the influence of the latter to several sectors of Chinese is tested. Regarding the oil price shocks, they appear to significantly affect manufacturing index and two oil companies. The existence of asymmetric effects cannot be confirmed by statistical evidence, with only exception the manufacturing sector. Similarly, oil price volatility has a significant impact in mining, petrochemicals and manufacturing index.

To sum up, from the above studies several points can be noticed. Firstly, the great majority of the authors uses linear approximation in order to investigate the predictive power of oil price and volatility to stock markets. Secondly, considering the studies which use a sample of one country stock market index, we can say that their findings vary. Many of them find significant impact of oil price to specific stock market index but some of them cannot verify their theory in their empirical results. Nevertheless, most of the studies, who use a broad sample of stock market indices from many different countries, conclude that oil price -in most of the occasions- clearly has considerable predictive power on them, either in the return or in the volatility level.

Thirdly, writers, who center on the impact of oil price to different industries of a country, find that oil price influences oil related companies but also has some impact on financial and banking industry. Lastly, we must note that different types of data (daily, monthly or quarterly) are (in a degree) responsible for different results across the studies.

2.2 Oil Price Volatility and the Macroeconomy

The literature concerning the relation between oil price and macroeconomy can be separated in two groups. The first group, which is more close to this study, concerns the impact of oil price volatility to macroeconomic variables such as inflation, production growth and employment.

Ferdered(1996) tries to investigate the influence of oil price volatility to the economy and to explain the asymmetric puzzle of oil shocks and macroeconomic factors. For his research he uses daily data and a VAR model. One of his principal findings is that oil price volatility contains significant statistical information about the industrial production growth, which, as it is mentioned, is uncorellated with other economic variables. Furthermore, part of the asymmetric effect between oil price shocks and output growth can be explained by the response of the economy to oil price volatility.

Similar results to Ferdered's study are found by Guo and Kliensen(1996). With the use of daily data, two oil future time series and a linear approach, they argue that oil price volatility has a negative and significant impact to future GDP and employment. In addition, as in Ferderer's research, the usual economics and financial variables are uncorrelated with oil price volatility, which implies that oil price volatility is driven by exogenous elements. Finally, their analysis confirms the existence of nonlinear effect, meaning that increases in oil price volatility matter more than decreases. The results from Guo et al are supported by the Uri's studies (1996[a.b]), which argue that oil price shocks have negative and significant statistical impact to employment[3] in United States and this impact lasts for almost three years till exhausting.

[3] and in the second paper to the agricultural employment

Recently Rafiq et al(2008) contributed further to the literature, by investigating the impact of oil price volatility on economic activities in the Thai economy. They argue that Thailand is an importing oil country, with limited oil reserves and with a great growth record (in the last years), hence it is a representative emerging economy. They use a basic VAR model, and power transformations of it, and quarterly data over the period 1993-2006. They approach oil price volatility as the realized volatility and, similarly to previous studies, it is found that it has significant impact to the usual macroeconomic variables. Additionally, it noticed that for the post crisis period the impact of oil price volatility is transmitted to budget deficit.

Summarizing, from this part of the literature, it deserves to remark that in all of the studies historical oil price volatility is approximated as the standard deviation of previous oil prices. In addition, oil price volatility factor is responsible for future movements on output growth(or industrial production) and employment of a country. Also, the impact of high oil price volatility to the macroeconomic factors is larger in comparison to low oil price volatility.

2.3 Oil Price Shocks and Macroeconomy

Apart from these studies, which extensively test the oil volatility dynamics to macroeconomy, there are several other researches that devote their attention on the impact of oil price shocks to macroeconomy.

For example Cunado and Gracia(2000) assess the dynamic relationship between oil prices, inflation and economic growth(expressed as industrial output) for fifteen European countries over the period 1960-1999. What they first conclude from their research is that the results depend on the currency that oil price is expressed. In particular, when the national oil price is used the impact of oil is higher (probably due to the effect of exchange rates in macroeconomic variables). Secondly there is a short run relationship between oil shocks and economic activity. And thirdly, oil prices “granger”- cause fluctuations to the industrial production and this effect is mainly due to oil price increases and not the opposite.

Moreover Jimenez-Rodriguez and Sanchez (2004) examine the oil and macroeconomic relation from a quite different aspect. Particularly, their sample is constituted of OECD[4] countries, and the results from oil importer and exporter countries are examined separately. In that way, they conclude that positive oil price shocks have negative impact on oil importing economies, while oil exporting economies benefit from them. Exception is the UK, where a rise in oil price has a significant negative impact. On the other hand, oil price decreases have a negative impact on US and Canada‘s real economic growth, while for the oil exporter countries they find significant results only for the UK .

Expanding the study of Rodriguez et al, Hamilton(2000) examines the existence of non linear relation between oil price shocks and GDP growth. His sample concerns the US economy and he finds that oil price increases are more significant for forecasting GDP than oil price decreases. He also notices that the predictability of oil price increases is smaller if the previous oil prices are declining and volatile.

Finally, the research of Farzanegan and Markwardt(2007) is concentrated to the oil effects on Iranian economy (an oil exporter country). As it is expected there are positive consequences to industrial output from oil price increases and negative from oil price decreases. Furthermore, the inflation is positively affected from both oil price increases and decreases.

This part of literature verifies and extends the results of the previous studies relative to oil price volatility. Specifically, again the existence of a strong statistical relationship between oil price and the usual macroeconomic factors is certified. Moreover, asymmetric effects of oil price to the economy are observed and the different behavior between oil exporter and oil importer is authenticated.

[4] OECD: Organisation for Economic Co-operation and Development is comprised of 30 countries.

3. Data

3.1 Stock Market Data

The sample of the stock market data is constituted by monthly data for 18 developed and 15 emerging value weighted market indices. The rationale of the above selection has to do mainly with two reasons. Firstly, since oil dynamics have different affects in the macroeconomy of oil exporters and importer countries, it is possible this difference to be extended to the stock market indices. Secondly, nowadays through the development of technology and the diversified energy sources, developed countries are considerably more energy efficient than they were twenty or thirty years ago, hence it is possible to be less sensitive to oil price dynamics (Basher et al,2006). On the other side, emerging countries are in the position, in which developed countries were twenty years ago and thus they are more depending on oil (Basher et al.,2006). From the above become obvious that is worthwhile to investigate the influence of OPV in a more extent level by including indices of developed and emerging countries.

Analysis starts on January 1982 and ends on December 2008. The reason behind selecting this period is the data availability. In addition, the data frequency is monthly because as it is mentioned from the relative literature, monthly data appear to be less noisy than daily data. (Driesprong et al, 2008). Monthly log returns are calculated as the average of the daily log returns of every month.

Equivalently:

$$r_k^j = \sum_{i=1}^{n} \left[\log(P_t^j / P_{t-1}^j) \right] \Big/ n \quad (1)$$

where r is the monthly return of the j country for the k month, n is the number of days for the k month, and P is the price of the j’s country stock market index.

There are several different approximations of volatility such as the realized, the conditional, the implied and the stochastic volatility.(Taylor, 2005). Nevertheless it is stated that conditional and stochastic volatility depend greatly on the model specifications, and additionally for the implied volatility further assumptions concerning the market price of volatility risk must be taken into account (Andersen et al, 2001).

On the other hand realized volatility is an unbiased and highly efficient estimator of volatility of returns (Andersen et al.,2001). In this study, the latter approach is used as a measure of the stock market volatility and oil price volatility. According to Taylor (2005), realized volatility is the standard deviation of a set of previous returns:

$$vol = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} (r_{t-i} - \overline{r})^2} \quad (2)$$

where n is the number of trading periods, r the returns and $\overline{r}$ the average return of the considering period.

Table 1 shows the summary statistics of the monthly volatility of stock indices over the entire sample. Several points deserve mentioning. Firstly, developed countries appear to be less volatile (average volatility 0.47%) than the emerging ones (average 0.75%). This is possible to occur due to data availability, since for most of the emerging countries data are available from the late 80s. Moreover Brazil has the maximum volatility of 13.8% on the September 1990. In order to test if the series are following normal distribution, the individual skewness and the kurtosis were computed. The skewness of all the series is positive, suggesting that the series do not follow normal distribution and they have long right tail.

Table 1: Descriptive statistics of stock price indices' volatility.

Developed	Starting Date	Num. of Obs.	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	ρ(1)
AUSTRALIA	Jan-82	324	0.4%	2.7%	0.1%	0.2%	5.1	43.9	51%
AUSTRIA	Jan-82	324	0.4%	2.9%	0.1%	0.3%	3.7	24.9	70%
BELGIUM	Jan-82	324	0.4%	2.2%	0.1%	0.3%	2.8	14.1	68%
CANADA	Jan-82	324	0.4%	2.2%	0.1%	0.3%	3.5	20.3	67%
DENMARK	Jan-82	324	0.4%	2.3%	0.1%	0.2%	3.2	21.9	58%
FRANCE	Jan-82	324	0.5%	2.2%	0.1%	0.3%	2.6	12.2	66%
GERMANY	Jan-82	324	0.5%	2.1%	0.1%	0.3%	2.1	8.3	63%
HONG_KONG	Jan-82	324	0.6%	3.8%	0.2%	0.4%	3.1	19.0	48%
ITALY_$	Jan-82	324	0.6%	2.6%	0.2%	0.3%	2.7	15.3	56%
JAPAN	Jan-82	324	0.5%	2.6%	0.1%	0.3%	2.9	18.7	54%
NETHERLANDS	Jan-82	324	0.5%	2.2%	0.1%	0.3%	2.6	12.0	70%
NORWAY	Jan-82	324	0.5%	2.7%	0.2%	0.3%	3.7	21.3	57%
SINGAPORE	Jan-82	324	0.5%	3.2%	0.2%	0.3%	3.6	26.8	44%
SPAIN	Jan-82	324	0.5%	2.3%	0.1%	0.3%	2.2	10.6	61%
SWEDEN	Jan-82	324	0.6%	1.8%	0.2%	0.3%	1.7	6.6	65%
SWITZERLAND	Jan-82	324	0.4%	2.0%	0.1%	0.3%	2.7	13.4	56%
UK	Jan-82	324	0.4%	2.1%	0.2%	0.2%	3.4	19.5	64%
USA	Jan-82	324	0.4%	2.6%	0.1%	0.3%	4.2	28.4	60%
Emerging									
ARGENTINA	Jan-88	252	1.1%	7.2%	0.3%	0.8%	3.0	16.7	73%
BRAZIL	Jan-88	228	1.0%	13.8%	0.0%	1.2%	6.4	58.6	33%
CHINA	Jan-93	192	0.8%	3.1%	0.2%	0.4%	1.8	7.9	60%
CZECH_REPUBLIC_$	Jan-95	168	0.6%	3.8%	0.2%	0.4%	4.3	32.8	55%
EGYPT	Jan-95	168	0.6%	2.1%	0.1%	0.3%	1.1	5.3	62%
FINLAND	Jan-82	324	0.7%	2.2%	0.0%	0.5%	1.3	4.1	71%
HUNGARY_$	Jan-95	168	0.8%	4.0%	0.3%	0.5%	3.2	17.8	55%
INDIA	Jan-93	192	0.6%	2.1%	0.2%	0.3%	1.6	6.1	50%
INDONESIA	Jan-88	252	0.7%	5.3%	0.1%	0.5%	3.6	25.7	40%
KOREA	Jan-88	252	0.8%	2.4%	0.3%	0.4%	1.4	4.9	72%
MEXICO	Jan-88	252	0.6%	2.1%	0.3%	0.3%	1.9	8.0	50%
NEW_ZEALAND_$	Jan-82	324	0.6%	2.5%	0.0%	0.3%	2.4	11.4	19%
PORTUGAL	Jan-88	252	0.4%	1.9%	0.1%	0.2%	2.1	10.2	54%
RUSSIA	Jan-95	168	1.2%	4.7%	0.3%	0.8%	2.0	7.9	65%
TAIWAN	Jan-88	252	0.8%	2.2%	0.3%	0.4%	1.5	5.7	71%

As far as the kurtosis is concerned for the market index time series, this appears to be far indifferent from three (which is the kurtosis of normal distribution). This implies that the distribution of the series is peaked (leptokurtic) relative to the normal. In addition, there is evidence of significant positive autocorrelation in these index series, which for the first order exceeds 70% for 6 countries and in average for all the countries is almost 60%.

3.2 Oil Price Data

In this study two oil prices is used. The first one is the longest available oil price series for Brent Crude Oil from January 1982 to December 2008. Brent crude oil is a light (low density), sweet (low sulphur content) crude oil produced in 19 separate oil fields in the North Sea. It serves as a benchmark for approximately 40-50 million barrels of crude oil produced daily, which is more than the half of the daily total crude oil consumption (Levin et al,2003). Crude oil is traded in both spot and future exchange markets. There are various spot markets, which are determined by the different qualities and by the different geographical regions, which they cover (for example Rotterdam/Northwest Europe, New York Harbor/U.S. Northeast). On the other hand, future exchange markets such as New York Mercantile Exchange and International Petroleum Exchange (IPE) in London are open outcry exchange markets. Recently IPE was renamed to ICE futures and the trading was changed on electronic platform. One of main trading commodities of ICE is the Brent Crude Oil futures. The second oil price series is coming from IPE (ICE) and concerns crude oil futures for a time period covering almost twenty years (December 1988 till December 2008). Oil price returns and volatility are measured like the stock market index returns and volatility respectively.

Table 2: Summary Statistics of volatility of the two oil price series

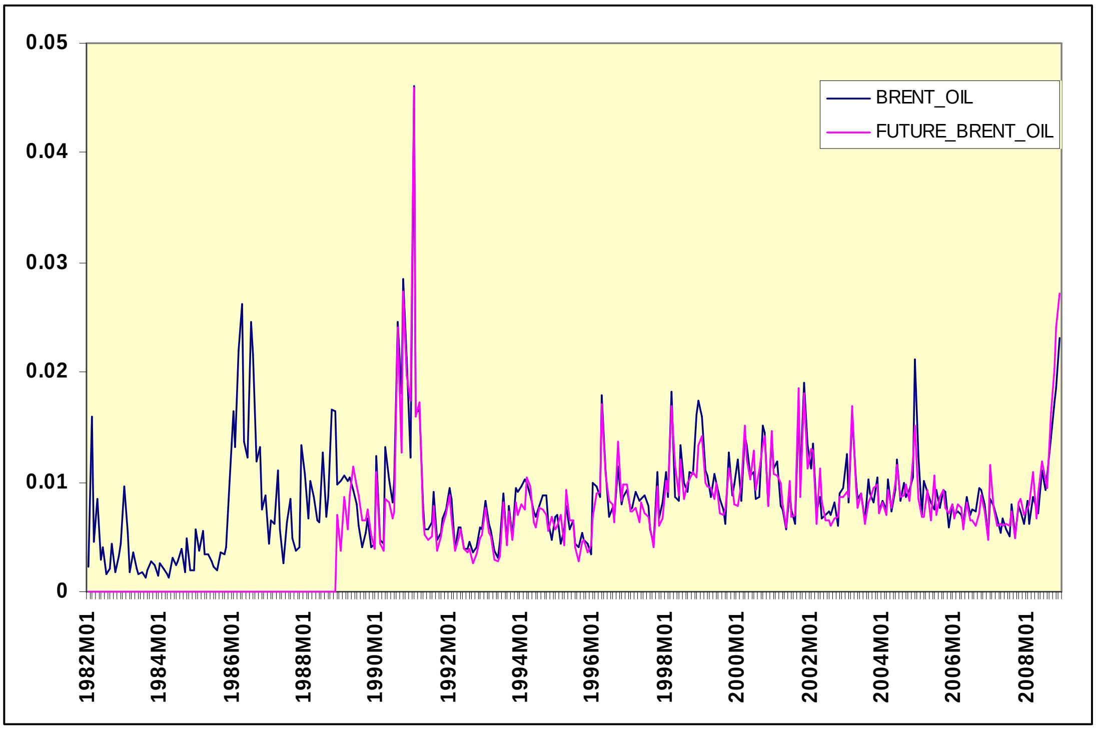
	BRENT_OIL	FUTURE_BRENT_OIL
Starting Date	Jan-82	Dec-88
Num. of Obs.	324	241
Mean	0.8%	0.9%
Maximum	4.6%	4.6%
Minimum	0.1%	0.3%
Std. Dev.	0.5%	0.5%
Skewness	2.3	3.3
Kurtosis	14.3	22.5
ρ(1)	57%	51%

Cross Autocorrelation

	BRENT_OIL	FUTURE_BRENT_OIL
BRENT_OIL	100%	93%
FUTURE_BRENT_OIL	93%	100%

Table 2 presents the descriptive statistics of the volatility of the two oil price series. As it can be seen the two series are highly cross correlated (93%), something that is expected. Furthermore, the two series similarly with the stock market indices appear to have positive skewness (long right tail) ,excess kurtosis(leptokurtosis) and high first order autocorrelation(54% in average).

Figure 1: Oil price and Future oil price Volatility



Furthermore, Figure 1 depicts the oil price and future oil price volatility over the period 1982-2008. As it can be seen, the two series appear to move closely together and especially in periods of extreme volatility, such as on 1991(Gulf War) or on 2008 (energy crisis).

4. Methodology and Results

4.1 Impact of Oil Price Volatility on Stock Markets

In this section the impact of oil price volatility on stock markets is discussed.

Our basic regression model is constructed, by extending Driesprong et al (2008) model to the volatility level. In other words, we have:

$$\ln(vol_t^i) = \alpha + \beta \cdot \ln(vol_{t-1}^{oil}) + \gamma \cdot \ln(vol_{t-1}^i) + \varepsilon_t \quad (3)$$

with $\varepsilon_t = \ln(vol_t^i) - E_{t-1}[\ln(vol_t^i)]$

where vol_t^i is the volatility of the i stock market index of month t, vol_{t-1}^{oil} is the oil price volatility for the month t-1, ε_t the usual error term and α,β and γ are constants. The null hypothesis of no oil volatility effect is rejected when β is significant.

Three things deserve mention here. Firstly in the above model the logarithm of volatility is used for symmetry reasons (due to high skewness and excess kurtosis)(Andersen et al,2001). Secondly, since stock market volatility is highly autocorrelated, the lagged stock market volatility is included to model (3). Thirdly, all the reported t-statistics and p-values are consistent with the presence of heteroskedasticity and autocorrelation of unknown form (Newey- West, 1987).

Table 3 presents the results for the equation (3) for all the countries and for both oil price series. For the series concerning the volatility of Brent Oil, the results are divided. In 10 out of 18 developed markets the coefficients of OPV are positive, while in the emerging markets we find positive coefficients for 12 out of 15 countries. A positive coefficient implies that an increase in this month's OPV leads to higher stock market volatility next month. For the developed countries, in five of them the coefficient is significant in 5% or 10% level, while for the emerging markets only three of them appear to have a significant coefficient for OPV. In all countries (except New Zealand), the lagged market volatility coefficient is significant at 1% level, indicating its persistence and that previous month volatility is a good forecasting variable for the next month's volatility. Of course this is a presumable result, since as it is demonstrated in the previous section, market's volatility is highly autocorrelated.[5]

In addition, based on the oil future volatility series we find results quite different from the OPV. Particularly, in none of the developed countries the coefficient of oil future volatility is significant, while five emerging markets have significant coefficients of oil future volatility. Nevertheless, these results stem from the fact that we have available data for oil futures from December 1988. An additional test between OPV from December 1988 (and not from January 1982) confirms the above claim, where most of the results are identical.

Another interesting insight concerns the major oil exporter countries (in our sample Norway, Mexico and Russia (McCown et al, 2006)). One would expect that OPV, in economies that oil plays a major role, would also have significant forecasting power. Nevertheless, in all of them the coefficient is insignificant in usual levels and even in the case that lagged market volatility is not included in the model; the coefficients for Norway and Mexico remain insignificant. It must also be noticed that in two of them (Norway and Mexico) the coefficients are negative indicating that higher oil volatility leads to lower market volatility.

In conclusion, it can be argued that because of the high persistence of stock market volatility, the stock market's lagged volatility factor dominates in our basic regression model. Nevertheless, the factor of OPV cannot be ignored, even when the lagged stock market volatility is included. Even in this case the explanatory power of OPV is significant in a considerable number of country indices (mainly developed). This is consistent with Sadorsky's (1999) study, where he concludes that crude oil volatility has some impact on economic activity. Furthermore, similarly with Huang et al(1996), it is found that OPV does not exhibit a significant lead with respect to the volatility of US stock market index.

[5] Complementary, an additional test is conducted, where the lagged market volatility is omitted. In this case oil price volatility is significant in 2o countries for the usual levels. Nevertheless, as we can see from the results of equation (3) , this is due to the fact that OPV is picking the persistence of market volatility and not to a genuine forecasting power. Hence in the following study the model in relation (3) will be used. The analytical results can be found in the section 1 of the Appendix.

***Table 3*: Results of the basic model (3) for developed and emerging market indices, with the use of crude oil and future crude oil series. The first column of each panel refers to the coefficient (β) of OPV, the second column to corresponding t-statistic, the third to the p-value of the t-statistic and the fourth to the total R-squared. *(**) indicates that the result is significant in 5%(10%) level.**

	Crude Brent Oil				Future Brent Oil			
	Coefficient	t-Statistic	Prob.	R-squared	Coefficient	t-Statistic	Prob.	R-squared
AUSTRALIA	0	-0.15	88%	31%	-0.03	-0.57	57%	34%
AUSTRIA	0.12	2.74*	1%	53%	0.03	0.49	63%	38%
BELGIUM	0.03	0.97	33%	44%	0.00	0.05	96%	50%
CANADA	0	0.19	85%	47%	-0.01	-0.14	89%	54%
DENMARK	0	0.16	88%	31%	0.03	0.55	58%	37%
FRANCE	0.04	1.21	23%	42%	-0.03	-0.63	53%	44%
GERMANY	0.06	1.99*	5%	45%	0.06	1.08	28%	46%
HONG KONG	-0.07	-2.02*	4%	40%	0.01	0.16	87%	41%
ITALY($)	0	0.02	98%	33%	-0.04	-0.70	49%	38%
JAPAN	0.06	1.64**	10%	37%	-0.02	-0.33	74%	36%
NETHERLANDS	0	-0.14	89%	50%	0.04	0.70	48%	56%
NORWAY	-0.01	-0.39	70%	23%	-0.05	-0.71	48%	26%
SINGAPORE	0.05	1.22	22%	31%	0.08	1.07	29%	34%
SPAIN	0.04	1.25	21%	43%	-0.01	-0.17	86%	43%
SWEDEN	0.04	1.39	17%	44%	0.04	0.64	52%	47%
SWITZERLAND	0.08	1.94*	5%	37%	-0.02	-0.33	74%	34%
UK	-0.02	-0.71	48%	45%	0.02	0.44	66%	51%
USA	0.02	0.92	36%	48%	0.08	1.51	13%	54%
ARGENTINA	0.01	0.08	93%	51%	0.02	0.24	81%	51%
BRAZIL	-0.05	-0.92	36%	59%	-0.02	-0.42	68%	59%
CHINA	-0.01	-0.06	95%	41%	0.06	0.80	43%	41%
CZECH_REPUBLIC_$	0.08	0.93	35%	28%	0.18	1.82**	7%	29%
EGYPT	0.12	1.01	31%	45%	0.11	0.87	39%	45%
FINLAND	0.12	1.26	21%	30%	0.01	0.26	79%	57%
HUNGARY_$	0.02	0.16	87%	24%	0.04	0.33	74%	24%
INDIA	0.12	1.39	16%	28%	0.18	2.12*	4%	29%
INDONESIA	0.16	1.73**	9%	33%	0.24	2.84*	0%	39%
KOREA	0.01	0.1	92%	51%	0.03	0.43	67%	53%
MEXICO	-0.04	-0.65	52%	25%	-0.01	-0.15	88%	23%
NEW_ZEALAND_$	0.16	2.2*	3%	4%	0.12	2.24*	3%	24%
PORTUGAL	0.08	1.07	29%	35%	0.07	1.14	25%	38%
RUSSIA	0.06	0.47	64%	41%	0.14	1.39	17%	42%
TAIWAN	0.09	1.89**	6%	46%	0.09	1.94*	5%	46%

4.2 Sub period Results

The empirical results of the previous section 4.1 are based on the full sample. A different approach is to investigate the influence of OPV to the stock market's volatility not to the full sample but in different subsamples. Thus the full sample is divided to three equal subperiods. The first sub-sample covers the period from January 1982 till December 1990, the second one extends from January 1991 till December 1999 and the third one is from January 2000 till December 2008. By this way its sub sample has equal number of observations and additionally the different trends of OPV over different periods of time (1980s, 1990s and 2000s) can be revealed in a better way.

Panel A of Table 4 displays the results of the equation (3) over the first subperiod. We must notice that for Brazil, China, Czech Republic, Egypt, Hungary, India and Russia we don't have results because of non available data. As far as the other indices are concerned, we notice that OPV appears to be statistical significant to the indices of seven developed countries. For the emerging markets, two out of eight appear to have significant oil volatility factors. In comparison with the full sample results it can be noticed that OPV influences in a larger portion the volatility of stock markets and additionally two more countries (Canada and Netherlands) appear to be statistical significant.

Panel B and C presents the OPV coefficients for the second and the third sub period respectively. In both sub periods, OPV does not affect significantly the stock market's volatility. This is further supported from the fact that in only three countries the coefficient is statistically significant in the usual levels. Nevertheless, the R-squared has a different behavior. While in the second subperiod R-squared is close to the full sample R-squared, in the third subperiod and for the developed countries appears to be much larger. One explanation of the above result is that stock market's volatility is more persistent in the third sub period, assumption that is supported from the fact that for most of the countries the autocorrelation of market's volatility is higher in the third subperiod than in the other two sub samples and in full sample.

Table 4:Sub period results for the regression model (3). The indication *,**, means that coefficient is significant in 1%,5%,10% level*.**

	PANEL A	1rst Sub Period			PANEL B	2ond Sub Period			PANEL C	3rd Sub Period		
	coefficient	t-stat	prob	R^2	coefficient	t-stat	prob	R^2	coefficient	t-stat	prob	R^2
AUSTRALIA	0.03	0.91	37%	12%	0.08	1.10	27%	10%	-0.17	-1.61	11%	60%
AUSTRIA	0.13	2.41	2%	56%	0.00	0.07	95%	27%	0.09	0.65	52%	42%
BELGIUM	0.04	0.88	38%	20%	0.09	1.15	25%	38%	-0.26	-2.15	3%	54%
CANADA	-0.08	-2.46	2%	25%	0.08	1.21	23%	43%	-0.01	-0.11	91%	53%
DENMARK	-0.05	-1.36	18%	10%	-0.04	-0.55	58%	36%	0.01	0.11	91%	39%
FRANCE	0.07	1.59	12%	24%	-0.03	-0.43	67%	23%	-0.08	-0.69	49%	60%
GERMANY	0.07	1.93	6%	35%	0.10	1.14	26%	34%	-0.04	-0.35	73%	56%
HONG_KONG	-0.14	-3.36	0%	27%	-0.01	-0.13	90%	43%	-0.02	-0.18	86%	54%
ITALY_$	0.04	1.13	26%	25%	-0.08	-1.00	32%	14%	-0.11	-0.95	35%	50%
JAPAN	0.08	1.84	7%	31%	-0.10	-1.66	10%	24%	-0.04	-0.31	75%	38%
NETHERLANDS	-0.05	-1.76	8%	22%	0.08	1.30	20%	54%	-0.12	-1.08	28%	57%
NORWAY	0.03	1.07	29%	7%	-0.11	-1.11	27%	26%	-0.13	-0.95	35%	38%
SINGAPORE	0.05	1.09	28%	11%	0.07	0.70	48%	43%	-0.07	-0.51	61%	41%
SPAIN	0.04	0.84	40%	36%	0.03	0.30	76%	20%	-0.05	-0.49	62%	59%
SWEDEN	0.01	0.38	71%	20%	-0.05	-0.60	55%	32%	0.09	0.96	34%	58%
SWITZERLAND	0.13	2.72	1%	29%	0.04	0.48	63%	24%	-0.20	-1.39	17%	48%
UK	-0.04	-1.43	16%	18%	0.05	0.86	39%	44%	-0.09	-0.76	45%	56%
USA	0.01	0.38	71%	17%	0.09	1.11	27%	48%	0.03	0.30	77%	61%
ARGENTINA	-0.19	-1.46	15%	43%	-0.04	-0.46	65%	41%	0.23	1.75	8%	32%
BRAZIL					-0.01	-0.24	81%	56%	-0.07	-0.69	49%	29%
CHINA					0.02	0.17	86%	32%	-0.04	-0.37	71%	50%
CZECH_REPUBLIC($)					0.14	1.17	25%	27%	0.03	0.23	82%	24%
EGYPT					0.02	0.09	93%	27%	0.26	1.80	7%	35%
FINLAND	0.00	0.04	97%	0%	-0.04	-0.54	59%	25%	0.04	0.40	69%	63%
HUNGARY($)					0.09	0.48	63%	18%	-0.01	-0.10	92%	30%
INDIA					0.20	1.88	6%	25%	0.02	0.15	88%	30%
INDONESIA	-0.18	-0.62	54%	3%	0.19	1.66	10%	57%	0.04	0.29	77%	18%
KOREA	0.11	0.87	39%	13%	0.01	0.10	92%	53%	0.03	0.23	82%	57%
MEXICO	-0.03	-0.25	80%	18%	-0.06	-0.72	48%	13%	0.02	0.21	83%	41%
NEW_ZEALAND($)	0.16	1.72	9%	2%	0.12	1.30	20%	19%	0.03	0.31	76%	38%
PORTUGAL	-0.02	-0.12	91%	7%	0.11	0.98	33%	40%	0.04	0.35	73%	48%
RUSSIA					0.21	1.23	22%	29%	0.06	0.43	67%	37%
TAIWAN	0.25	3.38	0%	51%	0.03	0.52	61%	29%	0.13	1.12	26%	43%

4.3 Delayed Reaction

In our basic model (equation 3) we tested the explanatory power of the previous month (t-1) OPV on this month's (t) stock market volatility. Nevertheless, it is possible the investors to react to OPV fluctuations with a bigger delay than one month. In this section we investigate the existence of this delay by introducing extra lags between the two variables.

More particularly, Driesprong et al(2008) argue that the inclusion of the last five oil prices of the month (t-2) maximize the explanatory power of their model in comparison of the inclusion of the last five oil prices of the month (t-1). Furthermore, Huang et al(1996) find considerable different coefficients for different lags of oil price and in similar result come Jones et Kaul(1996). From the above becomes clear that investors react with a delay to oil price changes, even though that it is not clear which is the optimal lag.

Consequently, it possible the delayed reaction to oil price changes to extent to OPV. Differently since volatility is a measure of information flow (Ross,1989), the reaction to high or low OPV can be captured from the market in different periods of time. In other words, introducing an extra lag between the already one month lagged OPV and stock returns may increase the significance of the former to the latter. The choice of lag is somehow arbitrary, for instance the lag specification to the above studies is different to all of them. Huang et al use daily data and they introduce daily lags, on the contrary Jones et Kaul use quarterly data and quarterly lags, while Driesprong et al use monthly data but daily lag. In this study the latter approximation is adopted since it seems to be more rational and additionally can include a variety of lags (from one day till month or more). Thus for the lag introduction the following method is applied: For example for one day lag, the monthly OPV is recalculated using the equation (2) and contemporaneously including the oil price of the last day of the month(t-2) and excluding the oil price of the last day of the month(t-1). The same procedure, as above, is followed to calculate the lagged OPV for one to fourteen days.

Since our sample is constituted from 33 countries and for every country, the coefficients for OPV are computed for 14 different lags, it looks worthless to report the almost five hundred coefficients with their relative's t-stats and p values.

Table 5: Results of basic regression model for 0, 5 and 10 days lag. All the t-statistics and p-value are consistent on the present of heteroscedasticity and autocorrelation of unknown for.

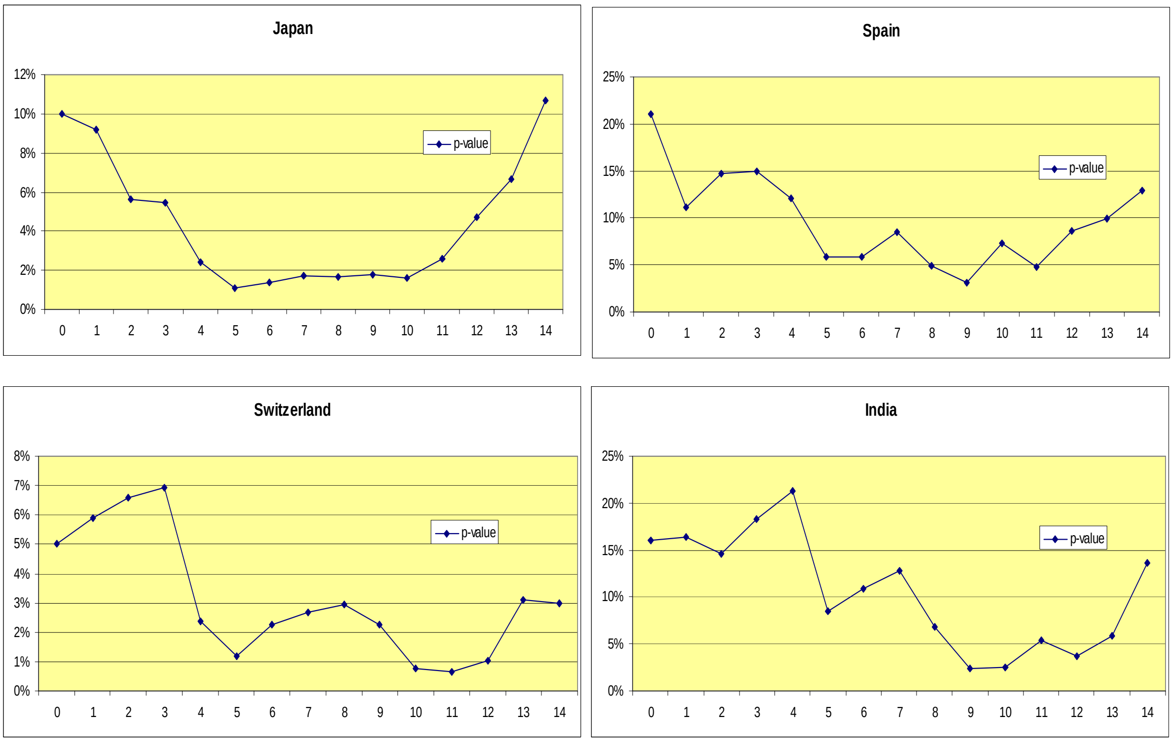
	No Day Lag			Five Days Lag			Ten Days Lag		
Developed	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
AUSTRALIA	0	-0.15	88%	0.01	0.41	69%	0.00	0.14	89%
AUSTRIA	0.12	2.74*	1%	0.15	3.45	0%	0.14	3.17	0%
BELGIUM	0.03	0.97	33%	0.05	1.56	12%	0.06	1.85	7%
CANADA	0	0.19	85%	0.02	0.81	42%	0.02	0.70	48%
DENMARK	0	0.16	88%	0.02	0.60	55%	0.00	0.01	99%
FRANCE	0.04	1.21	23%	0.07	2.37	2%	0.08	2.84	0%
GERMANY	0.06	1.99*	5%	0.09	3.54	0%	0.09	3.04	0%
HONG_KONG	-0.07	-2.02*	4%	-0.05	-1.63	10%	-0.03	-1.18	24%
ITALY_$	0	0.02	98%	0.02	0.84	40%	0.03	1.10	27%
JAPAN	0.06	1.64**	10%	0.08	2.56	1%	0.07	2.43	2%
NETHERLANDS	0	-0.14	89%	0.02	0.74	46%	0.01	0.38	70%
NORWAY	-0.01	-0.39	70%	0.01	0.35	72%	0.01	0.39	70%
SINGAPORE	0.05	1.22	22%	0.06	1.71	9%	0.04	1.02	31%
SPAIN	0.04	1.25	21%	0.07	1.90	6%	0.06	1.80	7%
SWEDEN	0.04	1.39	17%	0.05	1.90	6%	0.03	1.25	21%
SWITZERLAND	0.08	1.94*	5%	0.09	2.53	1%	0.09	2.69	1%
UK	-0.02	-0.71	48%	0.01	0.39	69%	0.02	0.86	39%
USA	0.02	0.92	36%	0.04	2.13	3%	0.04	2.15	3%
Emerging									
ARGENTINA	0.01	0.08	93%	0.05	0.75	45%	0.03	0.43	67%
BRAZIL	-0.05	-0.92	36%	0.00	0.05	96%	0.01	0.29	77%
CHINA	-0.01	-0.06	95%	0.04	0.43	66%	0.05	0.58	56%
CZECH_REPUBLIC_$	0.08	0.93	35%	0.10	1.10	27%	0.14	1.68	10%
EGYPT	0.12	1.01	31%	0.18	1.43	15%	0.25	2.42	2%
FINLAND	0.12	1.26	21%	0.16	1.67	10%	0.14	1.43	15%
HUNGARY_$	0.02	0.16	87%	0.08	0.75	46%	0.19	1.92	6%
INDIA	0.12	1.39	16%	0.16	1.73	8%	0.19	2.26	2%
INDONESIA	0.16	1.73**	9%	0.12	1.47	14%	0.16	1.84	7%
KOREA	0.01	0.1	92%	0.02	0.36	72%	0.02	0.34	73%
MEXICO	-0.04	-0.65	52%	-0.02	-0.36	72%	-0.03	-0.67	50%
NEW_ZEALAND_$	0.16	2.2*	3%	0.16	2.01	5%	0.17	2.03	4%
PORTUGAL	0.08	1.07	29%	0.09	1.21	23%	0.09	1.21	23%
RUSSIA	0.06	0.47	64%	0.07	0.58	56%	0.07	0.59	55%
TAIWAN	0.09	1.89**	6%	0.09	1.74	8%	0.09	1.67	10%

However, Table 5 presents the results for 0, 5 and 10 days lag. The last two appear to have the most interesting results. In total, the lag inclusion improves significantly the results of the basic model. Furthermore, the lag of five and ten days seems to be the optimal lag for most of the countries. In the case of the five days lag we find significant results for 14 countries(10 developed and 4 emerging), while for ten days lag the explanatory power of OPV is significant to the usual levels for 15 countries(8 developed and 7 emerging markets).

The coefficients of OPV for all the countries (except Hong Kong and Mexico) are positive, indicating that higher volatility of oil prices results to higher volatility of market indices. Similarly, with the results with no lag, Mexico and Norway appear not be influenced from the oil price fluctuations.

The above results are more clearly demonstrated in Figure 2. The latter depicts the p-value of OPV coefficient of four countries (Japan, Spain, Switzerland and India) as function of the additional days lag.

Figure 2: P-value of the OPV coefficient for Japan, Spain, Switzerland and India as a function of 0 to 14 day lag.



From the above figure we can see that for the lag of 5 and 10 days[6] the oil price volatility coefficient has the lowest p-value, indicating that is statistical significant in smaller level. More specifically, the p-value in general follows this trend: it is declining after having included a three days lag, it reaches a minimum level for five

[6] In the case of Spain the optimal lags are 5 and 9 days.

days lag, it follows a period (between the 5 and 9 days lag) of fluctuations and finally it reaches again a minimum at the 10^{th} (or 9^{th}) days lag. After the tenth day, p-value starts slowly to increase and after a month (20 trading days) the magnitude of OPV is further weaken.

Similar attitude with the p-value of OPV coefficient has the R-squared of equation (3). The trend that R-squared follows is almost identical with the p-value trend. Of course this is something that is expected since the only factor which changes in equation (3) is the OPV. Specifically, R-squared reaches a maximum for five and ten days lag, and the relative increase is close to 5%.

4.4 Control Variables

In this section we will examine if the previous section results can be assessed by using other economic variables. Since many economic variables can predict stock returns, and since others are closely related to oil price, it would be worthwhile to test if the predicting power of OPV to stock market indices is related to these control variables or not. The control variables, which we use, are divided in two groups: the macroeconomic and financial variables.

The macroeconomic variables are constituted of real cash flow and inflation. For real cash flow, there are evidences that can significantly explain the effect of oil price shocks to stock market index, (even though this result is not robust in every country) (Jones et al,1996). In this study real cash flow is approximated as the first difference of the logarithm of index of industrial production (IP).

In addition, as far as the inflation is concerned, it is stated that it has significant predictive power on stock returns especially in volatile periods.(Chen et al 1986)

On the other hand, there are several researches, relative to which financial variables have significant predictive power on stock market index. It is obvious, that possible correlation and lead lag relation of these variables with OPV would negatively influence the significance of the previous section results. The financial variables, which are used for the current study, are dividend yield , term and default spread and short term interest rate. For the latter, Ang et al(2007) find that they can significantly predict stock returns.

For instance, there are several studies relative to the forecasting power of dividend yields(DY).For example Lewellen(2004) concludes that DY appear to have significant explanatory power on stock returns, independently of the tested period, while Fama and French(1988) argue that DY explain a significant fraction of stock returns' variance (especially for longer horizon) . Complementary to these studies, Ang et al(2007) declare that a combination of DY and short term interest rates predicts stock market returns in short term.

Moreover, Default Spread(DS) is defined as the difference of a portfolio of corporate bonds and a portfolio of long term government bonds .Equivalently, we have:

$$DT_t = CB_t - GB_t \quad (4)$$

where DT is the default spread and CB, GB are the corporate and government bonds. Default Spread is considered as measure of risk aversion and also a good forecasting variable for stock returns (Chen et al, 1986).

In the same manner, Term Spread(TS) is a measure of the unanticipated return on long term bonds and it is computed as the difference between long term government bonds and short term Treasury bill (5). In other words TS is :

$$TS_t = LG_t - SB_t \quad (5)$$

Table 6 contains a short list of the control variables, which we use. The second column presents the countries, for which they are available. All the control variables were collected from DataStream, and either were already in monthly time series, or they were transformed from daily to monthly time series. For USA all the six variables are available, while for other 9 countries the five of them are available (except Default Spread). In general, for most of the countries are available the Dividend Yield, the 3month Interest Rate, the Real Cash flow and the Inflation variable.

Table 6: List of the economic variables and availability across the countries.

Control Variable	*Available*
Dividend Yield	for all countries, except Singapore, Egypt and Mexico
3 month Interest Rate	for all countries, except Brazil Czech and Mexico
Real Cash Flow (Industrial Production)	for all countries, except Hong Kong, Netherlands and Russia
Term Spread	for 9 developed countries(Australia, Canada, Denmark, Japan, Singapore, Spain, Sweden,UK and USA)
Default Spread	for USA
Inflation	for all countries, except four emerging markets

As first step, we compute the cross correlations between the control variables and the crude oil volatility. Table 7 reports these cross correlations, for the US market (where are available all the variables), and the average correlations across countries.

Table 7: Cross correlations between OPV and economic variables (in percentage)

	Brent Oil	Future Brent Oil
Control Variables for all the countries(average)		
Dividend Yield	0%	16%
3 month Interest Rate	-9%	-6%
Real Cash Flow	3%	3%
Term Spread	-7%	-3%
Inflation	-7%	10%
Control Variables for US market		
Dividend Yield	-25%	-1%
3 month Interest Rate	-20%	3%
Real Cash Flow	21%	11%
Inflation	-6%	18%
Term Spread	-21%	-3%
Default Spread	32%	26%

Across the countries we can see that all the control variables appear to be low correlated with Brent Oil and Future Brent Oil volatility. Individually, the dividend yield variable of New Zealand has the maximum correlation with Brent Oil volatility (39%), while Hungary has the largest negative correlation across the countries (-27%). Moreover the UK's real cash flow is 27% correlated with Brent Oil volatility and this is the maximum price, while the minimum (negative) correlation is found for Mexico. As far as the inflation is concerned, we find that the largest positive correlation for OPV and inflation is for India (82%) and the minimum for France (-34%). For the 3 month interest rate, the largest correlation between OPV and short term interest rate is for Australia (14%) and the minimum for Austria (-35%). In addition, the largest correlation between term spread and Brent oil volatility is 27% for Singapore and the shorter is -34% for Japan. Finally, concerning the US market individually (since all the control variables are available), we can notice that all the variables are low correlated with the Brent Oil and Future Oil Volatility , and three(two) of them appear to have negative correlation with Brent Oil (Future Oil) volatility.

Additionally to the cross correlation test, we recalculate the basic regression model of section 4.1, including now all the control variables (wherever they are available). In other words we have:

$$\ln(vol_t^i) = c_1 + c_2 \cdot \ln(vol_{t-1}^{oil}) + c_3 \cdot \ln(vol_{t-1}^i) + c_4 \cdot DY_{t-1} + c_5 \cdot \ln(IP_{t-1} / IP_{t-2}) + c_6 \cdot NF_{t-1} + \\ + c_7 \cdot TS_{t-1} + c_8 \cdot R_{t-1} + c_9 \cdot DF_{t-1} + \varepsilon_t \quad (6)$$

with $\varepsilon_t = \ln(vol_t^i) - E_{t-1}[\ln(vol_t^i)]$

where the DY,IP, R,NF,TS, and DF are the dividend yield, industrial production, 3month interest rates, the inflation, the term and the default spread respectively, c_i(i=1,2….9) are constant terms and ε the usual error term.

Table 8 presents the average results for the equation 6 across the countries. In the average, it must be noticed that all of the usual economic variables appear not to have significant explanatory power on market volatility.

Table 8: Average results across the countries of regression model (6)

(Results are consistent on heteroscedasticity and autocorrelation of unknown form.)

Panel A	Dividend Yield	Industrial Production	Inflation	Term Spread	Short term Interest Rate
coefficient	-0.20	0.66	0.45	-0.33	0.98
t-stat	-0.03	0.00	0.02	-0.01	0.02
p-value	0.43	0.34	0.45	0.43	0.36
R-squared	0.43				

However, individually[7], as for the US market volatility, as we can see from Table 9, besides the lagged market volatility, the Short Term Interest rate, Term and Default Spread have a significant forecasting power. Furthermore, comparing the results of section 4.1 of the countries, which are significantly influenced from OPV with the outcome of equation (6), we conclude that in most cases (with the exception of Hong Kong) the forecasting ability of OPV is captured by the economic variables we use. Table 9 reflects the results for these countries. As it can be seen dividend yield is significant factor in four countries(Japan, Hong Kong, Switzerland and Indonesia),

[7] The analytical results for every country can be found in the Appendix

short term interest rate in three (Hong Kong, Indonesia and Taiwan), inflation in two(Austria and Germany), and finally industrial production in one(Germany).

To sum up, it can be argued that the usual economics variables captures the effect of OPV to stock markets. However, it is not one or a specific combination of economic variables responsible for this result. Different stock market indices are influenced by different economics variables and hence the existence of a specific trend across the different indices cannot be supported.

Table 9: Individual results from equation 6, for the eight countries that are significantly influenced by OPV and for US market, where all the economics variables are available*. *(Results are consistent on heteroscedasticity and autocorrelation of unknown form.)

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	AUSTRIA			**GERMANY**			**HONG KONG**		
Oil Price Volatility	0.08	0.61	0.54	-0.01	-0.16	0.87	-0.06	-1.75	0.08
Stock market Volatility	0.52	6.73	0.00	0.60	10.24	0.00	0.60	11.22	0.00
Dividend Yield	0.04	0.62	0.54	0.00	0.00	1.00	-0.04	-2.08	0.04
Industrial Production	0.00	1.42	0.16	0.01	2.10	0.04	-	-	-
Inflation	0.08	1.66	0.10	-0.07	-2.71	0.01	0.00	-0.94	0.35
TermSpread	-	-	-	-	-	-	-	-	-
Short term Interest Rate	0.06	1.43	0.16	0.02	1.42	0.16	0.03	3.31	0.00
R-squared	0.49			0.47			0.42		

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	JAPAN			**SWITZERLAND**			**INDONESIA**		
Oil Price Volatility	-0.08	-1.45	0.15	0.01	0.25	0.80	-0.11	-0.76	0.45
Stock market Volatility	0.52	9.35	0.00	0.55	8.57	0.00	0.44	5.02	0.00
Dividend Yield	0.21	2.02	0.04	-0.11	-1.62	0.10	0.01	0.16	0.88
Industrial Production	-0.01	-1.20	0.23	-	-	-	0.00	-0.16	0.87
Inflation	0.02	0.65	0.51	0.00	0.11	0.91	0.00	-0.41	0.68
TermSpread	-0.06	-1.34	0.18	-	-	-	-	-	-
Short term Interest Rate	0.00	-0.12	0.90	-0.01	-0.44	0.66	0.01	4.06	0.00
R-squared	0.36			0.34			0.40		

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	USA			**NEW ZEALAND**			**TAIWAN**		
Oil Price Volatility	0.02	0.73	0.46	0.04	0.72	0.47	0.13	1.09	0.28
Stock market Volatility	0.52	8.84	0.00	0.40	6.26	0.00	0.57	8.14	0.00
Dividend Yield	-0.08	-1.38	0.17	0.07	2.90	0.00	-0.01	-0.30	0.77
Industrial Production	0.00	1.53	0.13	0.00	0.99	0.33	0.01	1.48	0.14
Inflation	0.01	0.56	0.58	0.00	0.15	0.88	-0.01	-0.72	0.47
TermSpread	0.07	2.54	0.01	-	-	-	-	-	-
Short term Interest Rate	0.07	3.35	0.00	0.00	-0.01	1.00	0.04	1.99	0.05
Default Spread	0.26	4.17	0.00	-	-	-	-	-	-
R-squared	0.52			0.23			0.41		

4.5 Sector Analysis

In this section the predictive power of OPV across different industry sectors is discussed.

Since different industry sectors of a stock market index experience diverse behavior from investors, one would expect OPV effects to differ across the various industries, and especially across oil related and non- related industries. The model, which is used, is a direct extension of Faft et al (1999) and Eryigit (2009) model, to the volatility level.[8] More specifically we have:

$$\ln(vol_t^{k,i}) = c_1 + c_2 \cdot \ln(OPV_{t-1}) + c_3 \cdot \ln(vol_{t-1}^{i}) + \varepsilon_t \quad (7)$$

Where $vol_t^{k,i}$ is the volatility of the k-industry sector of i-country in time t, OPV the oil price volatility, c_i (i=1, 2, 3) are constants and ε_t the usual error term.

Each stock market index is divided in ten different sectors (Oil and Gas, Basic Materials, Industrial, Consumer Goods, Consumer Services, Healthcare, Technology, Utilities, Financial and Telecommunications). All data were obtained from DataStream sector indices, since MSCI sector indices are not available. The data sample covers the great majority of the industries of the developed and emerging countries, with few exceptions (such as Germany, France and Finland).

Table 10 reports the OPV coefficients for different industry sectors. Coefficients are the average over different countries. The results suggest that the impact of OPV is weaker in industries closely related with oil. Specifically, in the sector Oil and Gas we find significant results in only two out of fifteen countries and similar are the results for the Utilities sector (three countries have significant OPV coefficients). Not considerably different results we find for the Basic Material and the Industrial sector, where OPV can predict their future volatility in seven and six countries respectively. On the contrary, the effect of OPV appears to be stronger in three non –oil related industries. Particularly for the industries of Financial, Consumer Services and Healthcare, we find significant coefficients in 11, 10 and 8 cases respectively.

[8]Both authors use an extended market model, with the inclusion of oil price.

Table 10: Summary statistics of sector volatility and oil price volatility effect.

The table reports the average coefficients, t-stat and p-value of ten industry sectors over different countries. The 5th column reports the number of the countries, in which the industry sector has available data and the 6th the number of the countries in which OPV has significant coefficient in the usual levels(1,5,10%). All the p-values and t-stats are consistent on the present of heteroscedasticity and autocorrelation of unknown form.

	coefficient	t-stat	p-value	Number of avalaible countries	Significant Number of countries
Oil and Gas	-0.01	-0.26	0.51	15	2
Basic Materials	-0.02	-0.31	0.33	22	7
Industrial	-0.07	0.00	0.34	25	6
Consumer Goods	-0.03	0.12	0.36	27	6
Consumer Services	0.04	0.38	0.39	27	10
Healthcare	-0.03	-0.35	0.30	20	8
Telecommunications	0.03	0.19	0.34	21	4
Technology	0.16	0.97	0.36	18	5
Utilities	-0.02	-0.35	0.38	16	3
Financial	0.04	0.58	0.30	27	11

In conclusion, the sector analysis suggests that the oil price volatility has greater and significant impact in non-oil related industries than in oil-related industries. Since there are few empirical evidences for OPV impact on different industries sectors, our results can be compared only with researches that examine the impact of oil price in different industries sectors. If we examine every country separately, our results for Australia (not reported) are consistent with the Faff et al(1999) study who find significant oil price impact in Australian oil and financial industries. Additionally, our results are in the same line as Driesprong et al (2008) outcomes, who conclude that oil price influences significantly non related industries(such as the financial and consumer services).

5. Asymmetric Effects

This part of the study is focused in the existence of asymmetric effects of oil price dynamics to the stock market indices. More particularly, many authors claim the existence of asymmetric effects of oil price either to macroeconomic factors, (such as industrial production and output growth)(Ferderer,1999 ; Sadorsky 1999), or to stock indices of specific countries and sectors (Cong et al, 2008; Sadorsky, 1999). Furthermore, similar results are found as far as OPV is concerned. Guo et al find that increases in OPV raise unemployment, while Cong et al(2008) claim that increases in OPV are probably responsible for raising the stocks in petrochemicals and mining index of China. In comparison to the existent literature this is one of the few studies that research the existence of asymmetric effects of oil price returns and volatility on a large sample of stock market indices. As a first step, we will try to further extend the Driesprong et al study by investigating the impact of positive and negative oil price returns to stock markets. Secondly, we will examine if periods of large OPV affect more stock markets than periods of low OPV.

5.1 Asymmetric effects of Oil Price Returns

In order to investigate the asymmetric effects of oil price returns to the stock indices, we will decompose the oil price returns (OPR) in two variables. The first variable (OPR^+) will include the positive OPR (and will be zero elsewhere) and the second one (OPR^-) will include the negative OPR (and will be zero elsewhere).

The summary statistics for the variables OPR^+ and OPR^- are also calculated. Over the full sample, we find that 53% of returns are positive and 47% are negative. Moreover, the absolute price of average and positive returns is equal and close to zero.

In order to examine for asymmetric effects we use the following model:

$$r_t^i = c_1 + c_2 \cdot OPR_{t-1}^- + c_3 \cdot OPR_{t-1}^+ + c_4 \cdot r_{t-1}^i + \varepsilon_t \qquad (8)$$

where r_t^i is the index return in time t for the i country, c_i (i=1,..4) the constant terms and ε_t the usual error term.

The results of the equation 8 are depicted in table 11. The coefficient of lagged returns is significant to the usual levels for almost every country index. In addition, the negative oil price returns have significant coefficients for five countries (3 developed and 2 emerging markets). On the other hand positive oil returns appear to significantly influence market returns in 12 countries (6 developed - 6 emerging markets, while 2 are in common with negative oil returns).

Furthermore, we must also notice that for the countries that (positive or negative) oil returns are significant factor, the relative coefficients in both cases are negative. The latter indicates that oil price increases influence negatively the stock market index of a country, while oil price decreases lead to positive returns of the supposed index.

From the above results, it can be said that increases in oil price appear to have a larger impact in the stock market indices than the decreases.

Table 11: Results of equation (8) for developed and emerging markets. The first panel reports the coefficients of negative OPR and the second of the positive. Last column presents the relative R-squared. All the results are consistent on heteroscedasticity and autocorrelation of unknown form.

	OPR^-			OPR^+			R-squared
Developed	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	
AUSTRALIA	0.00	-0.07	94%	-0.04	-0.70	48%	0%
AUSTRIA	-0.01	-0.10	92%	-0.03	-0.49	62%	7%
BELGIUM	-0.06	-0.97	33%	-0.05	-1.20	23%	7%
CANADA	0.01	0.12	91%	-0.04	-1.02	31%	2%
DENMARK	-0.04	-0.53	60%	-0.03	-0.65	51%	1%
FRANCE	-0.08	-1.31	19%	-0.08	-1.42	16%	4%
GERMANY	-0.06	-0.85	39%	-0.14	-2.31**	2%	4%
HONG_KONG	-0.04	-0.67	51%	0.08	1.09	28%	1%
ITALY_$	-0.23	-2.54*	1%	-0.13	-2.08**	4%	9%
JAPAN	-0.03	-0.49	62%	0.00	0.06	95%	1%
NETHERLANDS	-0.03	-0.57	57%	-0.10	-2.05	4%	3%
NORWAY	0.04	0.50	62%	-0.06	-0.92	36%	3%
SINGAPORE	-0.06	-0.91	37%	0.04	0.51	61%	1%
SPAIN	-0.15	-2.38*	2%	-0.01	-0.29	77%	4%
SWEDEN	-0.10	-2.25*	3%	-0.14	-2.03**	4%	6%
SWITZERLAND	-0.01	-0.14	89%	-0.11	-2.24**	3%	5%
UK	-0.05	-1.06	29%	-0.09	-2.16**	3%	3%
USA	-0.01	-0.13	90%	-0.10	-2.63*	1%	3%
Emerging							
ARGENTINA	0.17	0.93	36%	-0.43	-1.88**	6%	4%
BRAZIL	0.15	1.11	27%	-0.73	-3.08*	0%	14%
CHINA	-0.14	-1.24	22%	0.10	0.65	52%	1%
CZECH_REPUBLIC_$	0.05	0.45	65%	0.01	0.05	96%	1%
EGYPT	0.12	1.12	26%	-0.30	-2.58*	1%	10%
FINLAND	-0.09	-0.89	37%	-0.19	-2.04**	4%	8%
HUNGARY_$	0.15	1.02	31%	-0.03	-0.23	82%	1%
INDIA	0.06	0.56	58%	-0.24	-2.56*	1%	3%
INDONESIA	-0.23	-1.75**	8%	0.18	0.96	34%	3%
KOREA	-0.32	-2.17*	3%	0.12	1.13	26%	5%
MEXICO	-0.08	-1.04	30%	-0.03	-0.37	71%	1%
NEW_ZEALAND_$	-0.04	-0.49	63%	-0.09	-1.12	26%	1%
PORTUGAL	-0.02	-0.29	78%	-0.13	-1.96*	5%	4%
RUSSIA	-0.11	-0.41	68%	0.32	1.04	30%	4%
TAIWAN	-0.11	-0.70	48%	-0.05	-0.40	69%	2%

5.2 Asymmetric effects of Oil Price Volatility

In the case of OPV, we work in a similar way as with OPR. Since volatility includes only positive prices, it is not possible to take a threshold price of zero. To overcome this issue we pick as threshold price the average price of OPV for the period 1982 - 2008. In this way, we have two variables, OPV^+ which has OPV prices above the mean (and is zero elsewhere) and OPV^-, which includes the price of OPV below the mean(and is zero elsewhere). Summary statistics over the full sample for OPV indicate that, the periods of low oil volatility are 22% more than periods of high oil price volatility. Especially in the first subperiod the oil price volatility is moving under the threshold price in almost 75% of our monthly observations.

Likely, with oil price returns the regression model, which we use, is an extension of the basic model of section 4.1. More particularly we have:

$$\ln(vol_t^i) = c_1 + c_2 \cdot \ln(OPV_{t-1}^-) + c_3 \cdot \ln(OPV_{t-1}^+) + c_4 \cdot \ln(vol_t^i) + \varepsilon_t \quad (9)$$

where vol_t^i is the volatility of the index of i country in time t, c_i (i=1…4) the constant terms and ε_t the error term.

Table 12 presents the results for the regression model (9). As in the section 4.1 we find significant results for OPV for 8 countries. In all of them the OPV under the threshold price is significant factor, and the same result (with the exception of Germany) holds for oil price volatility above the threshold price.

Moreover, the p-value is a little bit shorter for OPV^- , but the coefficients of OPV^+ and OPV^- are almost identical. The above results attest that high and low oil volatility do not have significant different effects to stock markets and hence the existence of asymmetric effect cannot be supported.

Table 12: Results of equation (8) for developed and emerging markets. The first panel reports the coefficients of "negative" OPV and the second of the "positive". Last column presents the relative R-squared. All the results are consistent on heteroscedasticity and autocorrelation of unknown form.

	OPV^-			OPV^+			R-squared
Developed	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	
AUSTRALIA	-0.02	-0.50	62%	-0.02	-0.54	59%	31%
AUSTRIA	0.16	2.51*	1%	0.18	2.31*	2%	53%
BELGIUM	0.03	0.80	42%	0.04	0.67	50%	44%
CANADA	-0.01	-0.27	79%	-0.01	-0.36	72%	47%
DENMARK	-0.04	-1.19	24%	-0.06	-1.31	19%	31%
FRANCE	0.06	1.43	15%	0.07	1.34	18%	43%
GERMANY	0.07	1.73***	8%	0.07	1.45	15%	45%
HONG_KONG	-0.13	-3.04*	0%	-0.15	-2.88*	0%	40%
ITALY_$	0.02	0.58	56%	0.03	0.66	51%	34%
JAPAN	0.10	2.01**	5%	0.11	1.92***	6%	37%
NETHERLANDS	0.01	0.43	67%	0.02	0.50	62%	50%
NORWAY	-0.01	-0.15	88%	0.00	-0.07	94%	23%
SINGAPORE	0.01	0.13	90%	-0.01	-0.16	87%	31%
SPAIN	0.05	1.16	25%	0.06	1.03	31%	43%
SWEDEN	0.04	1.13	26%	0.04	0.92	36%	44%
SWITZERLAND	0.11	1.99**	5%	0.12	1.83***	7%	37%
UK	-0.01	-0.41	68%	-0.01	-0.28	78%	45%
USA	0.01	0.39	70%	0.01	0.23	82%	48%
Emerging							
ARGENTINA	-0.06	-0.71	48%	-0.08	-0.81	42%	52%
BRAZIL	-0.06	-0.74	46%	-0.06	-0.67	50%	59%
CHINA	-0.02	-0.22	82%	-0.03	-0.24	81%	41%
CZECH_REPUBLIC_$	0.04	0.39	70%	0.04	0.29	77%	28%
EGYPT	0.16	1.01	31%	0.17	0.98	33%	45%
FINLAND	0.14	1.26	21%	0.15	1.21	23%	30%
HUNGARY_$	0.01	0.07	94%	0.01	0.06	95%	24%
INDIA	0.19	1.73***	9%	0.21	1.70***	9%	28%
INDONESIA	0.23	1.87***	6%	0.24	1.84***	7%	33%
KOREA	0.01	0.16	87%	0.02	0.17	87%	51%
MEXICO	-0.07	-0.93	36%	-0.08	-0.92	36%	25%
NEW_ZEALAND_$	0.17	1.66	10%	0.17	1.47	14%	4%
PORTUGAL	0.04	0.48	63%	0.03	0.33	74%	36%
RUSSIA	-0.16	-1.02	31%	-0.21	-1.20	23%	43%
TAIWAN	0.14	2.28**	2%	0.16	2.19**	3%	47%

6. Conclusions

In this study, we focus on the relation between oil price volatility and stock market volatility. Our sample is constituted of 33 stock market indices (of 18 developed and 15 emerging countries), one crude oil price series and one future crude oil price series, and it covers the period from January 1982 till December 2008. Our methodology is based in regression analysis and all the reported estimation errors are consistent on heteroskedasticity.

The results of our basic model indicate that to most stock market indices, the one month lagged oil price volatility does not exhibit a significant impact. The most important reason for this result is the high autocorrelation in stock market volatility, which in many cases exceeds 70%. Nevertheless, oil price volatility is not a factor that can be ignored. Despite the high persistence of market volatility, there is a number of countries, which demonstrate significant influence by oil price volatility.

Additionally, the inclusion of daily lags between monthly stock index volatility and lagged monthly oil price volatility improves the previous results. The explanatory power of these regressions reaches in two maximum for 5 and 10 days lags and then slowly decreases. Particularly, the inclusion of these lags leads to significant results in almost half stock market indices of our sample.

Furthermore, by dividing our sample in three equal subperiods, we conclude that in the first sub period (early 80s till early 90s) oil price volatility has significant forecasting power on the stock market volatility. Nevertheless, the explanatory power of oil prices is much weaker in the second (1991-1999) and third subperiod (2000-2008).

Moreover, the inclusion of the usual economics variables in the basic regression model captures the influence of oil price volatility on stock market indices. However, the economic variables that capture the oil price volatility are not the same across the indices. Different indices are influenced by different combination of economic variables.

Another interesting insight of our study is the examination of the predictive power of oil price volatility to oil and non oil related industries across different countries. Our main conclusion is that the forecasting ability of oil price volatility is significantly larger in non oil related than in oil related industries.

In the last section the existence of asymmetric effects of oil price returns and oil price volatility is discussed. Our main finding is that indices are (negatively) influenced in a larger degree from oil price increases, than from oil price decreases. On the contrary, we find almost identical coefficients for high and low volatility and hence the existence of asymmetric effects of OPV on stock market returns is not supported by empirical evidence.

However, there are some limitations in this study that can be improved by further research. For example, this study only considers the historical volatility. Therefore it would be interesting to see whether other volatility approximations lead to similar results. Furthermore, besides accounting for linear relation between oil price and stock market volatility , it is also possible to implement non linear model in order to investigate non linearity in the above relation. Finally, as far as the asymmetric effects of oil price are concerned, it would be interesting the computation of an optimal threshold, which will vary across different countries and periods.

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Appendix

1. Basic Regression Model without lagged Stock Market Volatility

In our basic model (in section 3.1) the lagged market volatility is included. The rationale for this decision (as it also reported in the main body of this study) is the high autocorrelation of stock market volatility. This high autocorrelation is present in our results, since in most of the cases the past stock market volatility can significantly predicts the future. In this part, we conduct an alternative test, where in our model the factor of past stock market volatility is ignored. We have to mention, again, that the results do not reveal a genuine forecasting power of OPV, but an ability to capture the high persistence of market's volatility. Hence, we present them here in order to compare them with the results of section 4.1 and to present in a more clear way the high persistence of stock market volatility.

The model that is been used is the following:

$$\ln(vol_t^i) = \alpha + \beta \cdot \ln(vol_{t-1}^{oil}) + \varepsilon_t \quad (1)$$

The results from equation (1) are presented in the following table. In 20 stock market indices (10 developed and 10 emerging countries) OPV appear to have significant coefficients in the usual statistical levels.

Table 1: Results for equation (1).All the t-stats and p- values are consistent in the presence of heteroscedasticity. * indicates significance in the usual statistical levels.

	coefficient	t-stat	prob	R^2
AUSTRALIA	0.02	0.44	66%	0%
AUSTRIA	0.42	3.91*	0%	17%
BELGIUM	0.22	3.65*	0%	6%
CANADA	0.11	1.37	17%	2%
DENMARK	0.04	0.79	43%	0%
FRANCE	0.20	3.59*	0%	7%
GERMANY	0.28	5.50*	0%	11%
HONG KONG	-0.10	-1.43	15%	1%
ITALY($)	0.06	0.95	34%	1%
JAPAN	0.20	3.27*	0%	6%
NETHERLANDS	0.07	1.07	29%	1%
NORWAY	0.03	0.59	56%	0%
SINGAPORE	0.19	3.20*	0%	5%
SPAIN	0.22	3.57*	0%	7%
SWEDEN	0.17	2.68*	1%	4%
SWITZERLAND	0.29	4.24*	0%	11%
UK	0.06	1.03	30%	1%
USA	0.16	2.61*	1%	4%
ARGENTINA	0.09	0.61	54%	0%
BRAZIL	0.15	0.63	53%	1%
CHINA	0.24	1.48	14%	3%
CZECH_REPUBLIC($)	0.33	2.06*	4%	6%
EGYPT	0.47	2.13*	3%	7%
FINLAND	0.31	2.52*	1%	6%
HUNGARY($)	0.23	1.27	21%	3%
INDIA	0.30	2.18*	3%	5%
INDONESIA	0.35	2.44*	2%	5%
KOREA	0.30	2.81*	1%	7%
MEXICO	0.03	0.35	73%	0%
NEW_ZEALAND($)	0.18	2.46*	1%	3%
PORTUGAL	0.38	3.46*	0%	7%
RUSSIA	0.41	2.35*	2%	6%
TAIWAN	0.32	3.09*	0%	8%

2. Oil Price and Stock Markets

In our main body of our study we investigate the impact of OPV to the stock market volatility. In this part we conduct some additional tests with various combinations of oil price and stock market returns and volatility. The following tables present the results for these tests.

2.1 Oil Price Volatility and Stock Returns

Firstly, we investigate the forecasting power of one month lagged OPV to stock market returns. For this reason we use the following model:

$$ret_t^i = \alpha + \beta \cdot \ln(vol_{t-1}^{oil}) + \varepsilon_t \quad (2)$$

where ret_t^i is the return of the stock market index of the i-country for the t-month, α,β are constants and ε is the usual error term.

Table 2 presents the results for equation (2) and as it can be seen, in only one index OPV can significantly forecast the future returns.

Table 2: Results for equation (2).All the t-stats and p- values are consistent in the presence of heteroscedasticity. * indicates significance in the usual statistical levels.

	Coefficient	t-Statistic	Prob.	R-squared
AUSTRALIA	0	0	64%	0%
AUSTRIA	0	0	65%	0%
BELGIUM	0	-1	50%	0%
CANADA	0	0	67%	0%
DENMARK	0	0	77%	0%
FRANCE	0	0	94%	0%
GERMANY	0	-1	55%	0%
HONG KONG	0	1	41%	0%
ITALY($)	0	0	83%	0%
JAPAN	0	0	88%	0%
NETHERLANDS	0	0	88%	0%
NORWAY	0	-1	61%	0%
SINGAPORE	0	2*	5%*	1%
SPAIN	0	1	34%	0%
SWEDEN	0	0	96%	0%
SWITZERLAND	0	0	83%	0%
UK	0	0	99%	0%
USA	0	0	94%	0%
ARGENTINA	0	1	25%	1%
BRAZIL	0	-1	30%	1%
CHINA	0	1	58%	0%
CZECH_REPUBLIC_$	0	0	99%	0%
EGYPT	0	0	71%	0%
FINLAND	0	0	97%	0%
HUNGARY_$	0	-1	55%	0%
INDIA	0	1	45%	0%
INDONESIA	0	0	91%	0%
KOREA	0	2	12%	1%
MEXICO	0	1	31%	0%
NEW_ZEALAND_$	0	0	84%	0%
PORTUGAL	0	0	89%	0%
RUSSIA	0	1	42%	0%
TAIWAN	0	2	13%	1%

2.2 Oil Price Returns and Stock Market Volatility

In addition, to the previous tests, which examine the impact of OPV, we further investigate the influence of oil price dynamics to stock markets, by testing the impact of oil price returns to stock market volatility. In this case the appropriate model has the following form:

$$\ln(vol_t^i) = \alpha + \beta \cdot ret_{t-1}^{oil} + \varepsilon_t \quad (3)$$

Table 3: Results for equation (3).All the t-stats and p- values are consistent in the presence of heteroscedasticity.* indicates significance in the usual statistical levels.

	Coefficient	t-Statistic	Prob.	R-squared
AUSTRALIA	-13.9	-0.9	38%	1%
AUSTRIA	1.1	0.0	97%	0%
BELGIUM	-5.0	-0.3	79%	0%
CANADA	-13.8	-0.7	50%	0%
DENMARK	-7.2	-0.4	67%	0%
FRANCE	-11.3	-0.7	51%	0%
GERMANY	-3.3	-0.2	85%	0%
HONG KONG	-13.7	-0.9	35%	0%
ITALY($)	-14.9	-0.9	36%	1%
JAPAN	-8.9	-0.5	64%	0%
NETHERLANDS	-1.0	-0.1	95%	0%
NORWAY	-18.7	-1.0	30%	1%
SINGAPORE	-8.1	-0.5	62%	0%
SPAIN	-0.7	0.0	97%	0%
SWEDEN	-9.7	-0.5	59%	0%
SWITZERLAND	-4.6	-0.3	79%	0%
UK	-7.3	-0.4	68%	0%
USA	-5.8	-0.3	77%	0%
ARGENTINA	-20.7	-1.1	29%	1%
BRAZIL	-6.5	-0.2	85%	0%
CHINA	-27.7	-1.2	21%	1%
CZECH_REPUBLIC_$	-34.6	-1.3	18%	3%
EGYPT	-15.9	-0.6	52%	0%
FINLAND	-12.9	-0.6	56%	0%
HUNGARY_$	-33.6	-1.3	20%	3%
INDIA	-10.4	-0.5	63%	0%
INDONESIA	13.2	0.6	56%	0%
KOREA	-15.3	-0.9	39%	1%
MEXICO	-12.9	-0.8	42%	0%
NEW_ZEALAND_$	-34.9	-2.1*	3%*	2%
PORTUGAL	-16.9	-0.9	39%	0%
RUSSIA	-33.1	-1.3	19%	2%
TAIWAN	-9.7	-0.6	58%	0%

where ret_{t-1}^{oil} is the oil price return for the month t-1, α,β are constants and ε is the usual error term. The table below presents the results of the previous regression model. The results reveal an insignificant relation between the two variables, while in only one index (this of New Zealand) oil price returns appear to have significant forecasting power on stock market volatility.

3. Table of the economic variables for all the countries

Table 4: Individual results from equation 6(section 4.4), for the all the countries. (Results are consistent on heteroscedasticity and autocorrelation of unknown form.)

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	AUSTRALIA			**AUSTRIA**			**BELGIUM**		
Oil Price Volatility	-0.05	-1.05	0.30	0.08	0.61	0.54	-0.02	-0.32	0.75
Stock market Volatility	0.57	7.29	0.00	0.52	6.73	0.00	0.68	10.95	0.00
Dividend Yield	-0.03	-0.62	0.54	0.04	0.62	0.54	0.00	0.11	0.92
Industrial Production				0.00	1.42	0.16	0.00	-0.03	0.98
Inflation	0.01	0.49	0.63	0.08	1.66	0.10	0.02	0.48	0.63
TermSpread	0.01	0.53	0.60						
Short term Interest Rate	0.01	0.51	0.61	0.06	1.43	0.16	-0.02	-1.37	0.17
Default Spread									
R-squared	0.33			0.49			0.49		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	CANADA			**DENMARK**			**FRANCE**		
Oil Price Volatility	-0.01	-0.12	0.91	0.01	0.24	0.81	-0.02	-0.41	0.68
Stock market Volatility	0.63	7.11	0.00	0.51	8.87	0.00	0.62	10.11	0.00
Dividend Yield	0.08	0.62	0.54	-0.01	-0.15	0.88	-0.01	-0.33	0.74
Industrial Production	0.00	-0.74	0.46	0.01	3.75	0.00	0.01	1.65	0.10
Inflation	0.04	0.71	0.48	0.05	1.85	0.07	-0.01	-0.89	0.37
TermSpread	0.00	-0.07	0.95	0.00	-0.33	0.74			
Short term Interest Rate	0.06	0.93	0.35	0.03	2.64	0.01	0.01	0.69	0.49
Default Spread									
R-squared	0.49			0.43			0.44		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value

	GERMANY			HONG KONG			ITALY		
Oil Price Volatility	-0.01	-0.16	0.87	-0.06	-1.75	0.08	-0.06	-0.42	0.67
Stock market Volatility	0.60	10.24	0.00	0.60	11.22	0.00	0.59	7.52	0.00
Dividend Yield	0.00	0.00	1.00	-0.04	-2.08	0.04	-0.02	-0.49	0.63
Industrial Production	0.01	2.10	0.04				-0.02	-1.34	0.18
Inflation	-0.07	-2.71	0.01	0.00	-0.94	0.35	0.14	2.05	0.04
TermSpread									
Short term Interest Rate	0.02	1.42	0.16	0.03	3.31	0.00	0.04	1.48	0.14
Default Spread									
R-squared	0.47			0.42			0.51		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value

	JAPAN			NETHERLANDS			NORWAY		
Oil Price Volatility	-0.08	-1.45	0.15	0.00	-0.05	0.96	-0.08	-1.39	0.16
Stock market Volatility	0.52	9.35	0.00	0.70	13.79	0.00	0.48	4.80	0.00
Dividend Yield	0.21	2.02	0.04	-0.03	-0.92	0.36	0.02	0.64	0.52
Industrial Production	-0.01	-1.20	0.23				0.00	1.83	0.07
Inflation	0.02	0.65	0.51	0.02	0.97	0.33	0.01	0.48	0.63
TermSpread	-0.06	-1.34	0.18						
Short term Interest Rate	0.00	-0.12	0.90	-0.02	-1.40	0.16	0.02	1.55	0.12
Default Spread									
R-squared	0.36			0.53			0.27		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value

	SINGAPORE			SPAIN			SWEDEN		
Oil Price Volatility	-0.16	-1.00	0.32	-0.07	-1.28	0.20	0.15	1.76	0.08
Stock market Volatility	0.63	9.43	0.00	0.65	11.07	0.00	0.67	13.01	0.00
Dividend Yield				-0.03	-0.61	0.54	-0.04	-1.02	0.31
Industrial Production	-0.01	-1.06	0.29	0.00	0.11	0.92	0.01	2.45	0.02
Inflation	0.05	1.69	0.09	-0.03	-0.82	0.41	0.02	1.18	0.24
TermSpread	-0.04	-0.79	0.43	-0.04	-1.36	0.17	-0.01	-0.40	0.69
Short term Interest Rate	-0.01	-0.22	0.83	0.00	-0.06	0.95	0.02	0.86	0.39
Default Spread									
R-squared	0.46			0.45			0.55		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value

	SWITZERLAND			UK			USA		
Oil Price	0.01	0.25	0.80	-0.04	-0.80	0.42	0.02	0.73	0.46

Volatility									
Stock market Volatility	0.55	8.57	0.00	0.69	11.25	0.00	0.52	8.84	0.00
Dividend Yield	-0.11	-1.46	0.15	0.02	0.39	0.70	-0.08	-1.38	0.17
Industrial Production				0.01	0.84	0.40	0.00	1.53	0.13
Inflation	0.00	0.11	0.91	0.01	0.40	0.69	0.01	0.56	0.58
TermSpread				-0.04	-1.70	0.09	0.07	2.54	0.01
Short term Interest Rate	-0.01	-0.44	0.66	-0.02	-0.88	0.38	0.07	3.35	0.00
Default Spread							0.26	4.17	0.00
R-squared	0.34			0.52			0.52		

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	ARGENTINA			**BRAZIL**			**CHINA**		
Oil Price Volatility	0.04	0.50	0.62	-0.03	-0.34	0.73	-0.01	-0.15	0.88
Stock market Volatility	0.39	5.15	0.00	0.62	9.63	0.00	0.61	10.05	0.00
Dividend Yield	0.07	3.20	0.00	-0.01	-0.51	0.61	-0.04	-2.46	0.01
Industrial Production	0.00	2.21	0.03	0.00	0.86	0.39	-0.02	-2.79	0.01
Inflation	0.00	1.56	0.12	0.00	3.17	0.00			
TermSpread									
Short term Interest Rate	0.00	1.04	0.30						
Default Spread									
R-squared	0.34			0.43			0.44		

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	CZECH REPUBLIC			**EGYPT**			**FILAND**		
Oil Price Volatility	0.01	0.04	0.97	0.21	0.87	0.39	0.00	0.02	0.98
Stock market Volatility	0.43	3.97	0.00	0.60	5.46	0.00	0.71	15.36	0.00
Dividend Yield	0.01	0.53	0.60				-0.06	-2.10	0.04
Industrial Production	0.00	0.66	0.51	0.00	0.06	0.95	0.00	2.09	0.04
Inflation							-0.01	-0.43	0.67
TermSpread									
Short term Interest Rate	0.08	3.51	0.00				0.01	0.35	0.72
Default Spread									
R-squared	0.29			0.46			0.62		

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
	HUNGARY			**INDIA**			**INDONESIA**		
Oil Price Volatility	-0.01	-0.06	0.95				-0.11	-0.76	0.45

	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
Stock market Volatility	0.49	6.01	0.00	0.02	0.11	0.92	0.44	5.02	0.00
Dividend Yield	0.02	0.60	0.55	-1.04	-2.99	0.01	0.01	0.16	0.88
Industrial Production	0.00	-0.14	0.89	0.00	0.12	0.91	0.00	-0.16	0.87
Inflation				0.06	0.47	0.64	0.00	-0.41	0.68
TermSpread									
Short term Interest Rate	-0.01	-0.74	0.46	-0.06	-0.61	0.55	0.01	4.06	0.00
Default Spread									
R-squared	0.24			0.42			0.40		

	KOREA			**MEXICO**			**NEW ZEALAND**		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
Oil Price Volatility	0.01	0.07	0.95	0.22	1.32	0.19	0.04	0.72	0.47
Stock market Volatility	0.75	15.76	0.00	0.42	3.82	0.00	0.40	6.26	0.00
Dividend Yield	-0.05	-1.21	0.23				0.07	2.90	0.00
Industrial Production	0.00	0.57	0.57	0.03	3.60	0.00	0.00	0.99	0.33
Inflation	0.00	0.01	0.99	0.03	0.35	0.72	0.00	0.15	0.88
TermSpread									
Short term Interest Rate	0.00	0.48	0.64				0.00	-0.01	1.00
Default Spread									
R-squared	0.56			0.46			0.23		

	PORTUGAL			**RUSSIA**			**TAIWAN**		
	coefficient	t-stat	p-value	coefficient	t-stat	p-value	coefficient	t-stat	p-value
Oil Price Volatility	0.04	0.42	0.67	0.08	0.60	0.55	0.13	1.09	0.28
Stock market Volatility	0.56	5.47	0.00	0.60	8.39	0.00	0.57	8.14	0.00
Dividend Yield	0.06	1.01	0.32				-0.01	-0.30	0.77
Industrial Production	-0.01	-2.43	0.02				0.01	1.48	0.14
Inflation							-0.01	-0.72	0.47
TermSpread									
Short term Interest Rate	0.12	3.42	0.00	0.00	1.23	0.22	0.04	1.99	0.05
Default Spread									
R-squared	0.56			0.40			0.41		