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Does renewable energies' usage act as a shield against oil price changes?

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Abstract

The purpose of this dissertation is to contribute to the existing literature on equity markets and energy prices by studying the impact of oil price changes on several American and European companies, taking into consideration their level of renewable energies' usage within the total energy consumption. The results show that in fact there is an overall negative impact of oil price changes. However, when we split the oil price changes in positive and negative ones, it seems that their impact is symmetric, being positive (negative) when the change is negative (positive). Using the level of renewable energies in the estimation models, the conclusion that arrives is that there could be an optimal maximum level of *green* energies' usage, for which the companies can somewhat benefit from a protection against oil price changes, thus hedging against its risk.

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Contents

I. Introduction

Oil price movements seem to have an impact on the economy. The incessant research on this topic relies on the fact that oil is one of the main drivers of economic growth. For example, as Hamilton (1983) concludes, oil price increases are responsible for seven out of eight US recessions in the period between 1948 and 1972. Since the middle of the previous century, many authors study the relation between oil price and economy, either on macroeconomic variables or on financial markets' reactions.

The purpose of the present paper is to contribute to the literature on stock markets and energy prices by studying the impact of oil price changes on individual stocks in the United States and Europe, taking into account the percentage of renewable energies within the total energy consumption of those companies. The expectation is that the companies with a higher renewable energies weight have a lower sensitivity to oil price changes, being them upwards or downwards.

Energy consumption and specially oil consumption is one of the biggest concerns worldwide. This arrives from the need to protect the environment, both due to the carbon emissions to the atmosphere and to the need to preserve earth's natural resources.

As the Energy Information Administration (EIA) concludes in its Annual Energy Outlook in 2013, the total energy consumption will increase almost 56.5% within the period from 2010 to 2040. As it can be seen in Figure 1, the liquids source (mainly including petroleum and natural gas liquids) is the most important one. Nevertheless, EIA forecasts that the source that will present the biggest growth is the renewables' one, with a 2.5% average annual growth rate from 2010 to 2040, which means a total of near 112% growth for the same period.

The sustainable measures that most of the companies are starting to undertake are not only mandatory, but also to improve their Corporate Social Responsibility (CSR), in order to meet the growing customers' requirements. It's important for the companies to adjust to these new needs and so the renewable energies are gaining more and more importance nowadays. The path that everyone wants for the future is the one where we see, across the globe, several (and ultimately all) countries as "green" economies, where the respect for the sustainability of the goods that are indispensable to everyone is the most important goal.

With a total of 108 companies from both the United States and Europe and a pooled ordinary least squares estimation method, three different models are used to test three different hypotheses. The hypotheses and their main conclusions are the following:

- First of all, do oil price changes have an impact on stock returns? The present study shows that indeed there is a negative and significant effect of the oil price movements on the companies' daily returns. These findings are consistent with the majority of the present literature, such as Jones and Kaul (1996), Faff and Brailsford (1999), Papapetrou (2001) and many others.

- Secondly, is this impact equal whether the change is positive or negative and is there any symmetric effect? There is evidence that a positive (negative) oil price change has a negative (positive) and significant impact on stock returns, which are similar to the ones from Nandha and Faff (2008). It is also concluded that these diverse effects are symmetric, unlike the findings from Sadorsky (1999).

- Lastly, is there any evidence that the usage of renewable energies can act as a hedging instrument against the oil price changes? The study's results show that it seems to be an optimal maximum level of *green* energies' usage. In this optimal level companies are less exposed to the oil price changes, since the impact of using renewable energies smoothes the oil price change impact.

As for the remainder of the dissertation, it is organised as follows: Section 2 makes the connection with the current research available; Section 3 explains the data and how it is organised; Section 4 explains the methodology used to perform the present study; Section 5 presents the results; Section 6 presents the concluding remarks.

II. Literature Review

As Merton (1973) states, investors are concerned about unfavourable shifts in the bulk of possible investment choices, in addition to their diversification needs. This fear leads them to seek hedging activity, with which they are able to construct portfolios to be protected against uncertainties in several variables. Oil price is one example in which investors seek to hedge their positions and that is this thesis' main focus.

Since the first OPEC embargo in 1973, with a sharp oil price increase, many authors are trying to find a deeper relationship between macroeconomic output (lately, financial markets) and oil price changes.

The first studies made about this subject were focused on the influence that the oil price movements have in macroeconomic variables, mainly GDP and unemployment. In a pioneering work, Hamilton (1983) shows that oil price increases are responsible for every post World War II US recession, except the one in 1960 (until 1973). Hence, quoting: "(...) the timing, magnitude, and/or duration of at least some of the recessions prior to 1973 would have been different had the oil price increase or attendant energy shortages not occurred". Following Hamilton's approach, others tried to study the same ideas but with different data and different estimation procedures (see, e.g., Gisser and Goodwin 1986 and Lougani 1986).

Using the same data as Hamilton, Gisser and Goodwin (1986) examine whether oil shocks have a different impact on the macro economy before 1973, when comparing to the period after 1973. The expectation is that there will be some differences for the post-Hamilton's study period. Despite reaching the same conclusions as Hamilton for the period before 1973, they cannot find support for a different impact after 1973. So the findings provide the conclusion that, quoting, "the overall relationship between crude oil prices and the U.S. macroeconomy appears to have been remarkably stable over the past 25 years".

The suspicions that oil price changes have a different impact when those are positive changes or negative changes, lead the researchers to innovate in their studies, introducing some conditional variables in the estimation models (see, e.g., Mork 1989 and Ferderer 1996). Mork (1989) shows that oil price increases have had a significantly negative impact on GNP growth in the U.S. while oil price decreases did not lead to increased output growth.

More recently, the hearth of the literature is shifting to the relationship between oil price changes and financial markets. Chen, Roll, and Ross (1986) present one of the first papers where the impact of macroeconomic variables changes on stock returns is investigated. The conclusion is that interest rates, inflation rates, bond yield spreads and industrial production have risk that is priced in the stock market (for the period between 1958 and 1984). However, no evidence that oil price risk is rewarded by the stock market is detected.

In the last years, two papers are followed by almost all the other researchers when conducting studies about this subject: Jones and Kaul (1996) and Huang, Masulis and Stoll (1996).

Using a standard cash-flow dividend valuation model, Jones and Kaul (1996) find a negative and stable relationship between oil prices and aggregate stock returns for the United States, Canada, United Kingdom and Japan (for the period between 1947 and 1991). They detect that the reaction of Canadian and U.S. stock prices to oil price shocks is completely accounted for by the impact of these shocks on real cash flows. However, the magnitude of this impact is not as strong in the UK and Japan markets.

On the other hand, Huang et al. (1996) investigate the relationship between daily oil futures returns and daily US stock returns, using a multivariate vector autoregressive (VAR) model controlling for interest rate, seasonalities and other effects. With the exception of oil company returns, oil futures returns are not correlated with stock market returns (which can be useful to diversification purposes). It is also shown that oil futures returns lead petroleum stock indices and three individual oil stocks by one day.

Also using a VAR model, Sadorsky (1999) studies the relationship between oil prices movements and real stock returns in the United States. The author shows that oil price changes (and oil price volatility) affect real stock returns. There is also evidence that oil price volatility shocks have asymmetric effects on the economy. In particular, positive oil price shocks have a greater impact on stock returns and economic activity than do negative ones. Furthermore, the movement of oil price explains more than interest rates for the forecasting variances.

Faff and Brailsford (1999), in an industry focused study, verified a significant positive oil price sensitivity of Australian oil and gas and diversified resources industries. However, industries like paper and packaging and transport appear to confirm significant negative sensitivity to oil price hikes, as expected. Although banks' industry also demonstrates significant negative sensitivity to oil price hikes, it is explained by the risk of exchange rate (confirmed in extra model estimation). Likewise, Sadorsky (2001) shows that stock returns of Canadian oil and gas companies are positively sensitive to oil price increases.

Trying to shift the centre of the literature to other than developed countries, Basher and Sadorsky (2006) conduct a study for 21 emerging markets, estimating the effect of several sources of risk in aggregate stock returns (oil price risk; market risk; and others). Two versions of several models are estimated, one testing the overall oil price change impact (unconditional model) and the other testing both for a positive and a negative oil price change impact (conditional model). According to the study, oil price risk plays an important, significant and positive role in pricing emerging market stock returns in the unconditional models. As for the conditional ones, the main finding is that there seems to be no symmetric effects of oil price changes and the relationship depends on the data frequency used.

More recently, Cong et al. (2008) focus on the Chinese market. The idea is to estimate the effect that oil price shocks have on the stock markets. As to most stock market indices, oil price shocks do not show a statistically significant impact. However, the stock returns of manufacturing index and some oil companies increase due to oil price shocks. In addition, a symmetric effect of oil price shocks on oil companies' stock returns is supported by statistical evidences.

In summary, it seems that there is a relation between oil price and the stock market. The goal of this study is to confirm this relation and to test whether it is different with the presence of different levels of renewable energies usage.

III. Data

The present paper is constructed with the intuition that oil price changes affect stock returns. Thus, the goal is to study the impact of oil price changes on individual stocks (from the United States and Europe), taking into account the percentage of renewable energies within the total energy consumption of those companies.

To conduct the study, 39 companies from the United States and 69 companies from Europe are used. All the companies used are top companies (from S&P500 index and Bloomberg top 250 European companies' index) and the difference in quantity happens due to the constraint of the renewable energies' data availability.

The present study's innovation is the use of the renewable energies' weights variable. As said before, former literature focus on the impact oil price has on macroeconomic variables, mainly on output like GDP (Hamilton 1983; Burbidge and Harrison 1984; Gisser and Goodwin 1986; Lougani 1986 and Mork 1989) and on stock markets, both as a whole and as individual stocks (see, e.g., Chen et al. 1986; Jones and Kaul 1996; Huang et al. 1996; Sadorsky 1999; Basher and Sadorsky 2006). With this innovation, the proposal is to investigate if the renewable energies' weights act as "shield" against the upward/downward movements of the oil price.

Despite all the legislation concerning *green* energies, few companies provide explicit information regarding their total energy consumption and the sources of that energy consumption. This constraint limits the present study to a total number of 108 companies (adding both American and European ones). Moreover, the number of renewable energies' weights for each company is quite different. Taking as example, although Agilent Technologies Inc has information about its the energy consumption and the sources of that energy consumption since 2006, Norfolk Southern Corp only has that information since 2011.

Regarding the companies' industry (as it is shown in Table 1), in the American data set there is a bigger importance (weight within the total number of companies) of Technology companies and Consumer, non-cyclical companies (e.g. pharmaceutical companies), whereas in the European data set the Financial, Industrial and Communications companies are more representative.

The data for this study also consist of daily closing prices on 39 individual stocks from the United States and 69 individual stocks from fourteen different European countries and covers the period from December 1, 2003 to October 24, 2013. Data are taken from Bloomberg platform and are all in U.S. dollars so that investment decisions are made from the perspective of a U.S. investor or an international investor who has a U.S. dollar trading account. The filters that lead to this number of companies and to different time-series for each company are the ones reported above (in relation to the number of renewable energies' weights).

As shown in Table 2, in addition to the companies' daily prices, the corresponding market index daily quotes are used, one from each country.

Always bearing in mind the international capital asset pricing model (CAPM) – Merton (1973) - and its conditions, additional risk factors are collected in order to conduct the study. The data added relate not only to macroeconomic variables, but also to companies' fundamentals. Regarding the macroeconomic ones, the focus is on two major variables: interest rates and oil prices.

In the case of the American companies, the term premium between the generic US 1-month bond yield (short-term) and the generic US 10-years bond yield (long-term) is used, while for the European ones the Euribor 6 months yield (medium-term) is the chosen one. This data is also taken from Bloomberg platform. The difference of the interest rate in use is explained by the fact that there is no average term premium data available for the European countries. According to Chen (1991) and Fama and French (1989), the T-bill premium, which is an indicator of the present state of the economy, tends to be lower during economic downturns and higher during periods of strong growth. Therefore, T-bill rate is expected to be negatively correlated with real economic output growth.

As for the oil prices, the West Texas Intermediate (WTI) one month futures prices[1] is used for the United States companies and the Brent Crude one month futures prices for the European ones. These securities are two of the most traded commodity futures[2] in the world, thus they are used as benchmark worldwide. The data are collected from US Energy Information Administration's database (for the WTI oil futures prices) and from Bloomberg (for the Brent crude futures prices). The evolution of both futures prices is shown in Figure 2.

[1] http://www.eia.gov/ - US Energy Information Administration

[2] The Nymex WTI crude oil futures contract is the most actively traded commodity future anywhere in the world, with annual turnover in 2010 of nearly 170 million lots. (Deutsche Bank – "A user guide to Commodities", May 2011)

In order to have more controlling variables, market to book value ratio is included and the data are also from Bloomberg platform. This ratio is computed daily with the evolution of the market value and the book value is reviewed periodically (depending on the data availability on Bloomberg platform).

As it is reported in Table 3, the used data exhibit that, on average, the American companies have higher and positive daily returns when comparing to the European ones. However, the median value is higher on the European side, being this one positive within both regions. Moreover, the annualised standard deviation is higher on the European companies.

Both on the European and American data sets the daily return from the benchmark index (for United States is S&P500 and for Europe are the main index from each company's country) is higher, with a much lower risk level, when comparing to the companies used for this present study, illustrating the benefits of portfolio diversification.

Regarding the oil price changes, although the daily returns are positive and quite similar for both regions, the annualised standard deviation is higher in the WTI oil price changes than in the Crude oil price changes.

IV. Methodology

The main goal of the models used more recently in the literature is to reach the relation between stock markets and oil price (Chen et al. 1986; Jones and Kaul 1996; Huang et al. 1996; Sadorsky 1999; Basher and Sadorsky 2006; and many others).

In the present study, the models are estimated using a multi-factor regression for each region (United States and Europe) and for the both regions as a whole. The purpose is to estimate the model(s) using a panel data set, where variables of the same cross-sectional unit (in this case, a company) are observed over different points in time. From now on, it is assumed *i* =1, ..., N to be an index of the cross-sectional unit and *t* = 1, ..., T_i to be an index of the period of time for unit *i*.

The data in use to conduct the study is organised as an unbalanced panel data. This type of panel data is where there are a different number of observations in for each cross section unit. In this study what happens is that each company has a different number of observations over time, that is $T_i \neq T_j$, being the total number of observations for this panel data $n = \sum_{i=1}^{N} T_i$.

Following Basher and Sadorsky's (2006) approach, market returns' coefficients, oil price changes' coefficients and other controlling variables' coefficients (like market to book value ratio) are aimed to be estimated. The biggest innovation to literature is the additional factors for the model that are related to the renewable energies' weights on the total energy consumption for each company. The basic unconditional multi-factor model to be estimated is the following:

$$R_{it} = \alpha_{it} + \beta_{mit} Market\ Returns_{it} + \beta_{mbit} Market\ to\ BV_{it} + \beta_{l1Mit} Lag\ 1\ Month_{it} + \beta_{l12Mit} Lag\ 12\ Months_{it} + \beta_{intit} Int.Rate_{it} + \sum_{j}^{5} \beta_{REjit} D_{jit} + \beta_{oit} Oil\ Price_{it} + \varepsilon_{it} \quad (1)$$

In Equation (1), R_{it} is the daily return of company *i* on the specific *t* day, β_{mit} is the daily return of the market index on day *t*, β_{mbit} is the Market to Book Value ratio of company *i* at the *t* day, β_{l1Mit} is the daily return of company *i* with a lag of 1 month, β_{l12Mit} is the daily return of company *i* with a lag of 12 months (without including the first prior month), β_{intit} is the term premium daily value (for United States) or the Euribor 6 months daily value (for Europe), β_{oit} is the daily return of the respective oil futures (WTI oil futures as well as Brent crude futures, depending on the company's region) and the random error term ε_{it} is assumed to be independently and identically distributed with zero mean and constant variance.

The factor $\sum_j^5 \beta_{REjit} \times D_{jit}$ needs a special explanation so it is treated separately. D_j is a dummy variable that takes the value of one if the value of the renewable energies' weight from the previous year is, in day *t*, from one of the following intervals: 1st – [1%;10%[; 2nd – [10%;30%[; 3rd – [30%;50%[; 4th – [50%;70%[; 5th - [70%;100%]. The interval [0%;1%[is taken out of the equation to avoid multicollinearity. Take as example, at the date of January 3, 2007, Agilent Technologies Inc has a value of one in the Dummy for the interval [1%;10%[, since the value that the company reported in the previous year annual report (2006) for the weight of the renewable energy consumption within the total energy consumption was 3.72% and the remaining Dummies have the value of zero. The data consist in final annual values and are taken from Bloomberg platform and hand-collect from companies' individual reports. In Table 4 is reported the number of observations for each interval of renewable energies' consumption.

The intuition behind the usage of this group of dummies is that, with the increase in the renewable energies' weights, the coefficients for each dummy *Beta* demonstrate an increasing and final positive value. The expectation is that the companies with more renewable energies weight within the total energy consumption are less exposed against the oil price changes. Moreover, it is anticipated that the higher the value of renewable energies' weight, the higher will be the dummy *Beta* coefficients.

The second model to be estimated is similar to the first one presented above. The same variables are included; however an extra innovation is used in order to get new insights. Following Basher and Sadorsky (2006), who conclude that the impact of oil price change is different when the analysis focus on positive and negative changes individually, a conditional relationship between realized returns and risk factors can be specified as following:

$$R_{it} = \alpha_{it} + \beta_{mit} Market\ Returns_{it} + \beta_{mbit} Market\ to\ BV_{it} + \beta_{l1Mit} Lag\ 1\ Month_{it} + \beta_{l12Mit} Lag\ 12\ Months_{it} + \beta_{intit} Int.Rate_{it} + \sum_j^5 \beta_{REjit} D_{jit} + \beta_{poit} D_{6t}\ Oil\ Price_{it} + \beta_{noit}(1 - D_{6t})\ Oil\ Price_{it} + \varepsilon_{it} \quad (2)$$

Where D_{6t} is a dummy variable that takes on a value of one (zero) if oil futures prices returns are positive (negative). The intuition behind the estimation of this new model is that oil futures prices have different effects both on macroeconomic variables and on stock markets, depending if they are positive (increase in price) or negative (decrease in price). This means that symmetric effects of oil prices changes both in macroeconomic variables (Mork 1989; Mork et al. 1994; Lee et al. 1995; Ferderer 1996; Jones et al. 2004; and many others) and in financial markets (Sadorsy 1999; Basher and Sadorsky 2006; Nandtha and Faff 2008; and others) are expected and should be tested. Thus a priori, it is expected that β_{poit} and β_{noit} have negative and positive signs, respectively. Symmetry between up and down oil price changes is tested from the hypothesis $\beta_{poit} + \beta_{noit} = 0$ versus the alternative, $\beta_{poit} + \beta_{noit} \neq 0$.

With the aim of recognizing further conclusions, one more model is estimated. This new model has the intention to test if the conclusions from Equation (2) are robust and indeed the renewable energies' weights are a way to hedge, above all, against the upward movements in the oil price. Following the previous model, interaction variables were added in order to realize the specific effect of each interval of renewable energies' weights both in upward and downward movements of oil prices. The model is specified as follows:

$$R_{it} = \alpha_{it} + \beta_{mit} Market\ Returns_{it} + \beta_{mbit} Market\ to\ BV_{it} + \beta_{l1Mit} Lag\ 1\ Month_{it} + \beta_{l12Mit} Lag\ 12\ Months_{it} + \beta_{intit} Int.Rate_{it} + \sum_{j=1}^{5} \beta_{REjit} D_{jit} + \beta_{poit} D_{6t} Oil\ Price_{it} + \beta_{noit}(1 - D_{6t})\ Oil\ Price_{it} + \sum_{j=1}^{5} \beta_{REpojit} \times D_{jit} \times D_{6t} \times Oil\ Price_{it} + \sum_{j=1}^{5} \beta_{REnojit} \times D_{jit} \times (1 - D_{6t}) \times Oil\ Price_{it} + \varepsilon_{it} \quad (3)$$

Where both $\beta_{REpojit}$ and $\beta_{REnojit}$ are added to the previous model, assuming that the effects of oil price change on the stocks' returns are also dependent on the renewable energies' weights and not only on which way the movement of the price is. The intuition behind the estimation of this new model is that the renewable energies' weights can have different impacts whether the oil futures prices changes are upwards or downwards.

From intuition, it is expected that $\beta_{REopjit}$ and $\beta_{REonjit}$ have negative and positive signs, respectively (and across all the j renewable energies' weights). Symmetry between up and down oil price changes is tested from the hypothesis $\beta_{poit} + \beta_{noit} = 0$ versus the alternative, $\beta_{poit} + \beta_{noit} \neq 0$.

The estimation strategy is to use ordinary least squares (OLS) to estimate Equation (1), (2) and (3) with the pooled data. This estimation is called pooled OLS. This is a pooled regression model since we pool all the observations in OLS regression. The model is implicitly assuming that the coefficients (including the intercepts) are the same for all the individuals. Moreover, the estimated coefficients' standard errors are heteroscedasticity-consistent standard errors, named after Huber (1967) and White (1982) - Huber-White robust standard errors.

V. Empirical result

The pooled regression results for unconditional, conditional and conditional with interaction models exploring the link between returns, oil price changes and renewable energies' weights are presented in Table 5 and Table 6.

V.I. Unconditional Model

Starting with the analysis of the most straightforward model in this study, the main conclusion that transversely stands out from the three data sets (United States, Europe and both together) is the fact that the oil price changes have indeed an impact on the companies' returns. This impact is negative and statistically significant at least at the 5% level for the three data sets, which is according to the main findings of the overall literature that focus both on the macroeconomic and financial markets effects of oil price changes, but in opposition to the ones from Basher and Sadorsky (2006), given that the authors show that oil price risk factor has a positive impact and significant at the 10% level on emerging stock market returns. Nevertheless there are some differences across those data sets' results.

First of all, European companies show a stronger impact of oil price change (more negative). The coefficient of the oil price change for the European companies is negative and statistically significant at the 1% level, while the American companies' coefficient, despite being also negative, is only significant at the 5% level.

This difference may appear because of the type of companies within both data sets. Since the type of industries included are quite similar, the major difference from one data set to the other is on the type of company included from the Energy industry. Each region has only one company from this sector; nonetheless they have different activities. On the US side, there is an oil extracting company that provides a positive oil price change impact on returns, diminishing the negative impact of the other companies on the final coefficient. Whereas, the European one is Vestas Wind Systems, a well known Danish developer of wind turbines, which has almost no exposure against oil price.

Secondly, the *"action"* seems to occur on the renewable energies' weights intervals of [30%, 50%[(across all data sets). The coefficients are negative and statistically significant at least with a 10% level for the interval of [30%; 50%[. These results lead to the conclusion that the companies that have between 30% and 50% renewable energies within the company's total energy consumption present, *coeteris paribus*, lower returns that the ones with other levels of renewable energies weights.

Moreover, both regions as a whole and the European companies alone exhibit positive and statistically significant, at the 10% level, coefficients for the renewable energies' weight interval [50%, 70%[. The evolution from the lower interval to this one is quite important and confirms that using renewable energies can have a positive impact on stock returns, eventually smoothing the negative impact from oil price changes.

It seems that there is a maximum optimal level of renewable energies' usage, since before and after the [50%, 70%[interval there is no positive effect of betting on renewable energies.

V.II. Conditional Model

In order to do a deeper investigation and extract some more insights it is important to analyse the Conditional model output.

In this model, the addition is the differentiation of the impact from the positive and negative oil price changes. The main findings with this model are the symmetric and significant effects of the oil price changes. The positive changes have a negative and statistically significant at the 5% level coefficient, while the negative ones have a positive and statistically significant at the 1% level coefficient for both regions as a whole.

These results are according to intuition that is this study's foundation and with the findings of Nandha and Faff (2008), who also conclude oil price increases and decreases have a symmetric impact on stocks' returns (in the authors' study, a worldwide approach is used); however they are not aligned with the findings from Sadorsky's (1999) study and Basher and Sadorsky's (2006) conditional model, since these authors show that the oil price changes impact was asymmetric and with a stronger impact arriving from the oil price increases.

The results that were extrapolated from this model are somewhat different from the ones of Mork 1989, not on the way the oil price changes impact the returns (or macroeconomic variables) but on the strength of that impact. The main difference is that in the present study, the negative changes have an impact (positive), which is already a different conclusion, and in a more significant way than the positive ones. Summing up, it is important to take into account that if an oil price increase is a bad news for a company, an oil price decrease is likely to have a positive impact on its share price.

Performing a more specific analysis on the American and European data sets separated, it is possible to reach different conclusions. The American market only presents negative oil price changes' impact (statistically significant at the 5% level), while the European market exhibits an impact both when the oil price changes are positive and negative.

On this last case, the positive changes are more significant than the negative ones (which is the opposite of the American data set): the positive oil price changes have a negative impact on stock returns, which is statistically significant at the 1% level; whereas the impact of negative changes is positive and statistically significant at the 5% level. Additionally, the hypothesis of these impacts being jointly equal to zero is rejected at the 1% level and it was not rejected the hypothesis of these impacts being symmetric, as it is shown on Table 7.

The differences of the oil price changes' effects suggest the existence of an optimal level of renewable energies usage of each company. The findings exhibit a higher value of impact of an oil price change on the companies' returns when they have between 50 to 70% weight of renewable energies within their total energy consumption. This happens whether the oil price change is upwards or downwards.

The conclusion is that the companies that have a renewable energies' weight ranked on the interval [50%; 70%[are less exposed to the oil price changes, as it is shown in Figure 3. This seems to corroborate the intuition of the present study that the renewable energies act as a *"shield"* against the oil price changes. These findings are present in both regions as a whole and separated analysis.

In Figure 3 is possible to see how stock returns from the United States and Europe (both together and on a stand-alone basis) are affected by oil price changes (whether positive or negative), for different renewable energies' weights intervals. The main goal is to show the variation of stock returns with different levels of oil price changes, taking into account the interval of renewable energies' usage. Using the estimated coefficients from the equation (2), the idea behind the Figure's construction is the following: $\Delta R_{it} = \sum_{j}^{5} \beta_{REjit} D_{jit} + \beta_{poit} D_{6t}\ Oil\ Price_{it} + \beta_{noit}(1 - D_{6t})\ Oil\ Price_{it}$.

V.III. Conditional Model with interaction variables

With this model, an extra step is taken with the inclusion of interaction variables between the oil price changes (both positive and negative) and the 5 intervals of renewable energies' weights.

Considering both regions as a whole, the same symmetric effects of the oil price changes are found with this model. It seems that those results are robust and present independently of the model used. A positive (negative) oil price change as a negative (positive) impact on the companies' stock returns. These impacts are both statistically significant at the 1% level. The negative oil price changes still seem to have a bigger impact that the positive ones.

When comparing with second model, the effect of the [30%; 50%[interval of renewable energies' weight is diluted with the usage of the interaction variables. However, the effect of the [50%; 70%[interval is still present and with a negative and statistically significant impact at the 10% level.

Regarding the interaction variables' coefficients, the results are almost all according to the intuition. Given that the effects of the oil price changes are quite significant, the intuition for the additional variables is that they could smooth this impact by having the opposite effect on the companies stocks' returns. Moreover the overall impact of the oil price changes should become less and less significant with the increase on the renewable energies' weights.

The estimated coefficients show that the variables of renewable energies' weights have the opposite impact of oil price changes, thus diluting the impact of these last ones on the stock returns, at least up to the [30%; 50%[renewable energies' weight interval. These findings are according to the intuition and corroborate the idea of using renewable energies to reduce the exposure to the oil price changes.

Nevertheless, the others renewable energies' weights intervals provide the conclusion that having level of renewable energies higher than 50% has no impact whatsoever on diluting the effect of oil price changes on the companies' returns, as reported in Figure 4, which is similar to Figure 3, but the estimated coefficients used are from model (3). The idea behind this Figure also includes the additional interaction variables, as follows: $\Delta R_{it} = \sum_{j}^{5} \beta_{REjit} D_{jit} +$

$\beta_{poit} D_{6t}\ Oil\ Price_{it} + \beta_{noit}(1 - D_{6t})\ Oil\ Price_{it} + \sum_{j=1}^{5} \beta_{REpojit} \times D_{jit} \times D_{6t}\ \times Oil\ Price_{it} +$
$\sum_{j=1}^{5} \beta_{REnojit} \times D_{jit} \times (1 - D_{6t})\ \times Oil\ Price_{it}$

These findings are similar also when the analysis is made only considering the European companies. However, the American companies show other results. Although the same findings were expected, the dilution effect only happens on the [1%; 10%[interval (both for positive and negative oil price changes) and on the [30%; 50%[and the [50%; 70%[, when the oil price changes are negatives. The type of company, its industry, the weight of energy costs within its total costs, the kind of incentives and benefits present in both regions for the usage and consumption of renewable energies can be on the genesis for these differences.

At what the market returns concerns, the estimated coefficient is positive and statistically significant at the 1% level (with t-values above 80.00) across the three models and for both regions and for the jointly analysis, which is consistent with the capital asset pricing model. The range of values of the market coefficients is between 0.99 and 1.1.

As for the controlling variables included across all the models, only the Market to Book value ratio is always significant (at 1% level), taking a positive value within the three models and for both regions. Regarding the interest rate, returns lagged one month and returns lagged 12 months, none of the estimated coefficients is significant, therefore these specific controlling terms are not important drivers of stocks' returns, both in Europe and in United States.

VI. Conclusions

The present study had three main objectives: first, to determine whether or not the oil price changes indeed have an impact on the companies' stock returns, as it was confirmed by most the researchers that focused on this topic. The results show that the conclusions that many researchers reached with their studies are still hold true, using a more recent data and different companies. As in Jones et al (1996) and other studies, a negative and significant relationship was found between oil price changes and stock returns.

Secondly, the goal was to verify if the oil price changes impact on stock returns was different being them upwards or downwards, as Sadorsky (1999) concluded. With the present study, the results exhibit a different impact on stock returns depending on whether the oil price changes are positive or negative. With a positive oil price change, the effect on stocks' returns is negative and significant, whereas with a negative oil price change, the effect is also significant but positive. Furthermore, linked with the findings of Cong et al (2008), there seems to be a symmetric impact with this conditional analysis of the oil price changes. These findings were against the ones that Basher and Sadorsky (2006) had with their study, where they found no evidence of a symmetric impact of oil price changes.

The third and last objective was to prove that the usage of Renewable Energies in fact protects the companies against the oil price movements. The results show that the companies can benefit by having up to 70% of renewable energies' weight within their total energy consumption. The conditional model used provides evidence for these conclusions and corroborates the initial intuition. Nevertheless, the last model estimated, where interaction variables were included, illustrates other maximum value for the renewable energies usage. The coefficients from the interaction variables have their significance increasing up to the interval of [30%; 50%[of renewable energies' weight and then the values lose importance on explaining the companies' returns.

Some findings from this study can lead to further investigation. One example is that the impact of oil price changes is, as Faff and Brailsford (1999) show, different from industry to industry. The constraint on available information of the renewable energies usage made this analysis difficult to be carried out with the innovation of this study.

Finally, the different findings from the simple conditional model and the one with interactions lead to an ambiguous conclusion of which interval of renewable energies' weights seems to be the maximum for what the companies are more protected against oil price changes. With the forthcoming of 2020, the targets that many countries and also companies defined must be close to being achieved, so the conclusions in a couple of years can, and most probably will, be more accurate when it comes to the best usage of Renewable Energies to dilute the impact of the oil price changes.

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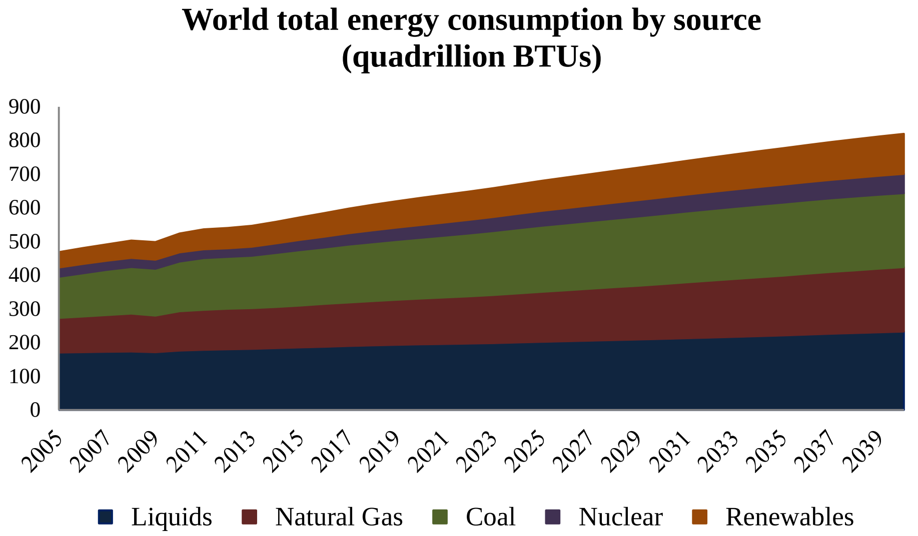
VIII. Appendices

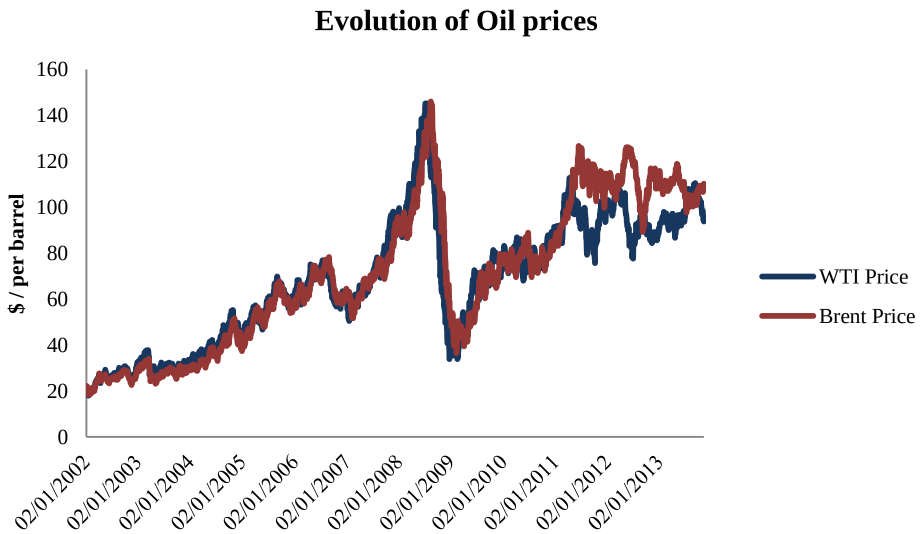
A. Figures

1. World total energy consumption by source

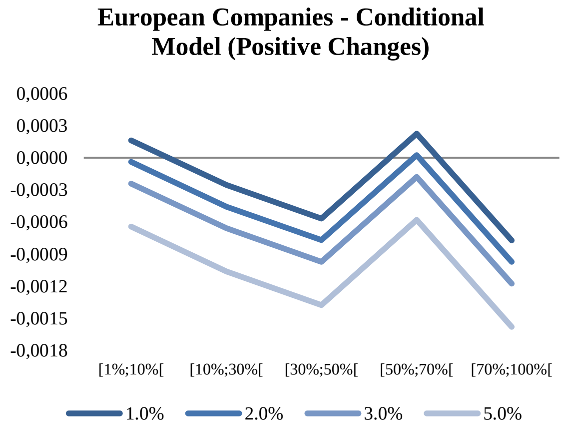


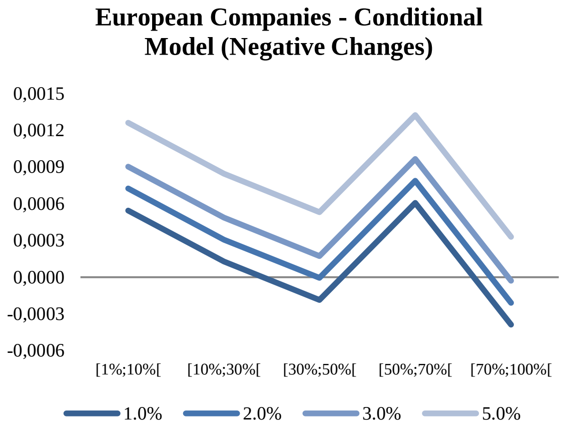
Source: EIA| Annual Energy Outlook 2013; Projections: EIA| Annual Energy Outlook 2013

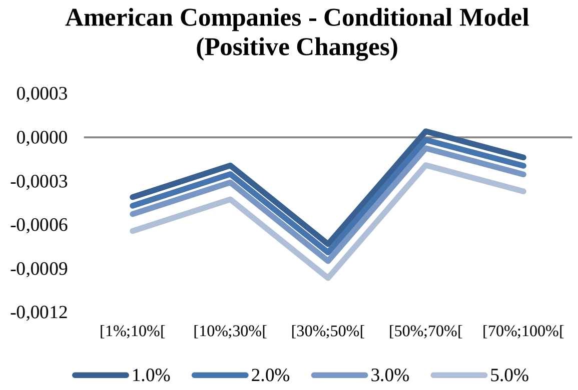
2. Evolution of oil futures contracts price (WTI one month futures contracts and Brent Crude one month futures contracts)

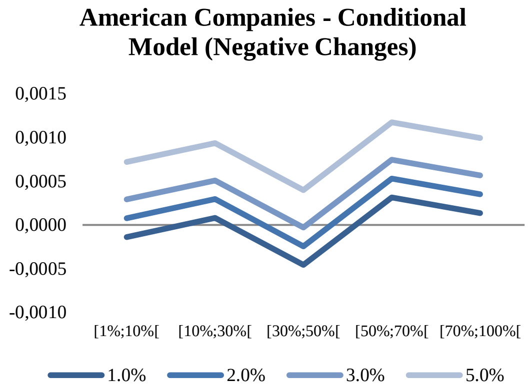


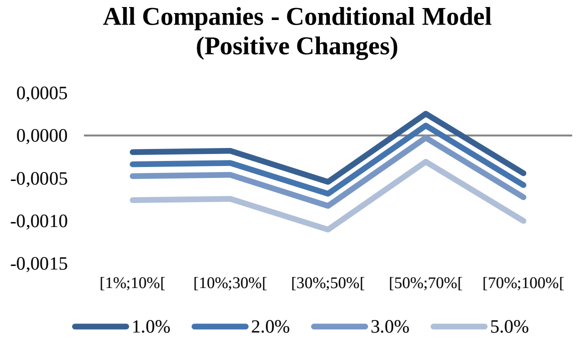
3. Impact of oil price changes on stock returns – Conditional Model, *coeteris paribus* (sensitivity analysis)

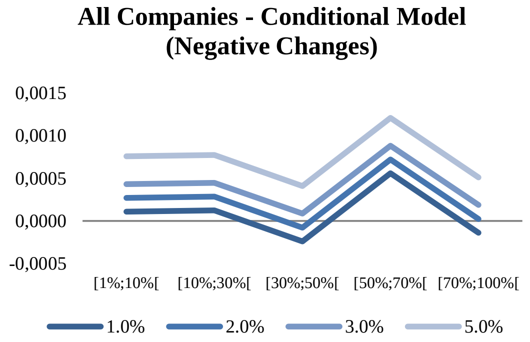




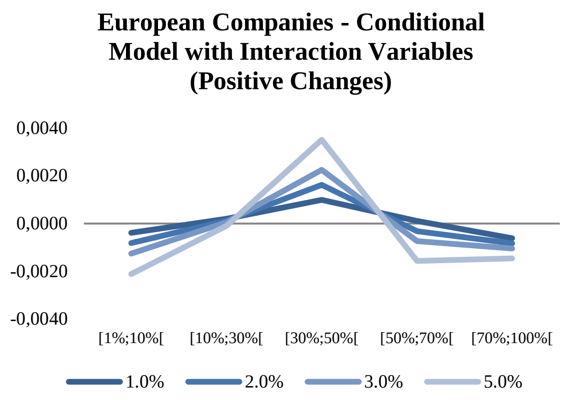


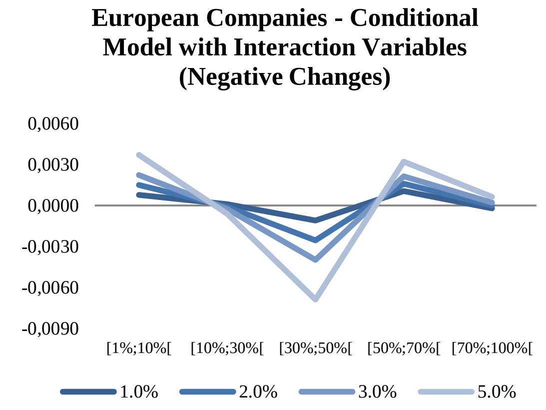


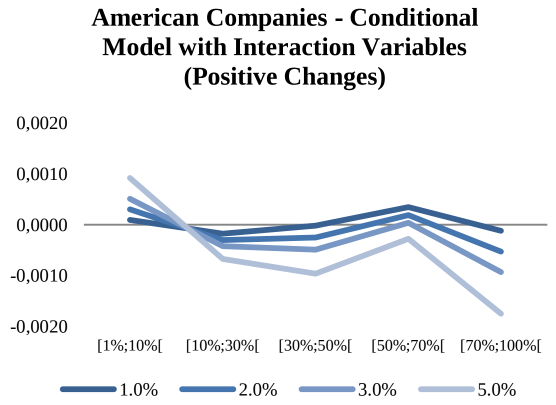


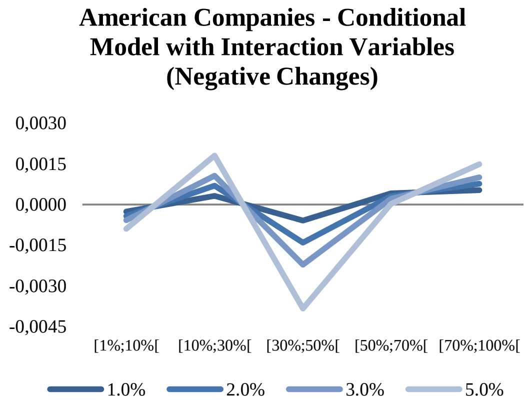


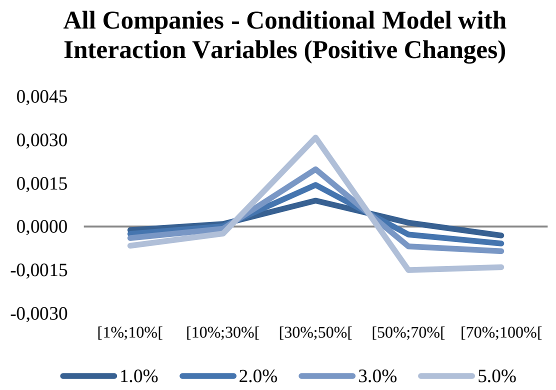
4. Impact of oil price changes on stock returns – Conditional Model with interactions, *coeteris paribus* (sensitivity analysis)

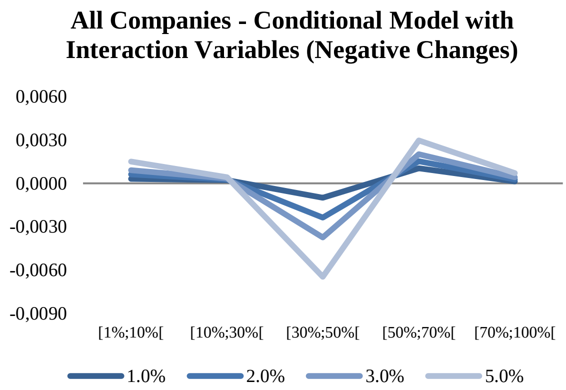












B. Tables

1. Companies per Industry

Reported are the number of companies and weights of each industry within the study.

Industry	American Companies		European Companies	
	# of Companies	%	# of Companies	%
Basic Materials	3	7.7%	4	5.8%
Consumer, Non-cyclical	8	20.5%	13	18.8%
Financial	7	17.9%	17	24.6%
Industrial	4	10.3%	10	14.5%
Communications	4	10.3%	12	17.4%
Consumer, Cyclical	4	10.3%	5	7.2%
Utilities	1	2.6%	5	7.2%
Technology	7	17.9%	2	2.9%
Energy	1	2.6%	1	1.4%
Total	39	100%	69	100%

2. Market Indices by country

Reported are the country, market index and Bloomberg ticker for the companies used in the study.

Country	Market Index	Bloomberg Ticker
Austria	Vienna Stock Exchange Austrian Traded Index	ATX Index
Belgium	BEL 20 Index	BEL20 Index
Denmark	OMX Copenhagen 20 Index	KFX Index
Finland	OMX Helsinki Index	HEXP Index
France	CAC 40 Index	CAC Index
Germany	Deutsche Borse AG German Stock Index DAX	DAX Index
Italy	FTSE MIB Index	FTSEMIB INDEX
Netherlands	AEX-Index	AEX Index
Norway	Oslo Stock Exchange Benchmark Index	OSEBX Index
Portugal	PSI 20 Index	PSI20 Index
Spain	IBEX 35 Index	IBEX Index
Sweden	OMX Stockholm 30 Index	OMX Index
Switzerland	Swiss Market Index	SMI Index
United Kingdom	FTSE 100 Index	UKX Index
United States	S&P 500 Index	SPX Index

3. Descriptive Statistics

Reported are the number of observations, the mean, median, maximum, minimum, annualised standard deviation, skewness and kurtosis values for the main used variables in the study.

	European Companies				United States Companies			
Region	Daily returns	Stock Indices	6M Euribor	Brent Price	Daily returns	Stock Index	Term Premium	WTI Price
Count	92850	92849	92850	92850	48614	48614	48614	48614
Mean	-0.0012%	0.0004%	1.7310%	0.0249%	0.0229%	0.0235%	2.4234%	0.0232%
Median	0.05%	0.06%	1.254%	0.070%	0.039%	0.080%	2.469%	0.081%
Maximum	26.10%	15.09%	5.45%	12.71%	45.63%	10.96%	3.98%	16.41%
Minimum	-44.64%	-13.70%	0.29%	-10.95%	-89.25%	-9.47%	-0.79%	-13.07%
Annualised St. Dev.	39.61%	29.50%	22.45%	32.57%	37.25%	22.63%	14.13%	37.82%
Skewness	-0.228	-0.015	1.305	-0.197	-1.318	-0.308	-0.734	0.105
Kurtosis	12.260	7.850	3.488	7.001	67.969	11.066	3.767	8.653

4. Renewable Energies' Weights – Data

Reported are the number of observations and respective weights of each renewable energies' weight interval.

Renewable Energies' Weights	American Companies		European Companies	
	# of observations	%	# of observations	%
[0%; 1%[	34	17.3%	62	16.7%
[1%; 10%[	77	39.3%	125	33.7%
[10%; 30%[	65	33.2%	96	25.9%
[30%; 50%[	5	2.6%	53	14.3%
[50%; 70%[	6	3.1%	27	7.3%
[70%; 100%[	9	4.6%	8	2.2%
Total	196	100.0%	371	100.0%

5. Regression' coefficients of the three models and for both regions

Reported are the coefficients, significance levels and t-statistics for the regressions with stock returns as the dependent variable. Reported are also the adjusted R^2 and the jointly significance F-Test coefficient and significance level. *, ** and *** denote coefficients significant at the 1%, 5% and 10% significance levels respectively.

Returns	European Companies			American Companies		
	Unconditional Model	Conditional Model	Conditional Model w/ Interactions	Unconditional Model	Conditional Model	Conditional Model w/ Interactions
Constant	-0.0002 (-1.23)	-0.0002 (-1.03)	-0.0003 (-1.77)***	-0.0005 (-1.91)***	-0.0007 (-2.24)**	-0.0008 (-2.18)**
Market Returns	1.0039 (198.59)*	1.0039 (196.69)*	1.0038 (197.34)*	1.0671 (82.10)*	1.0686 (82.39)*	1.0681 (82.06)*
Market to BV Ratio	0.0001 (4.84)*	0.0001 (4.86)*	0.0001 (4.95)*	0.0002 (3.96)*	0.0002 (4.12)*	0.0002 (4.13)*
Returns Lag 1 Month	0.0031 (0.86)	0.0031 (0.85)	0.0031 (0.87)	-0.0053 (-0.68)	-0.0051 (-0.65)	-0.0049 (-0.63)
Returns Lag 12 Months	-0.0008 (-0.35)	-0.0008 (-0.35)	-0.0007 (-0.30)	0.0002 (0.07)	0.0002 (0.07)	0.0004 (0.11)
Interest Rate	0.0001 (0.02)	0.0004 (0.08)	0.0001 (0.03)	0.0062 (0.78)	0.0049 (0.62)	0.0047 (0.60)
[1%;10%[	0.0001 (0.62)	0.0004 (0.62)	0.0000 (0.15)	-0.0004 (-1.50)	-0.0004 (-1.47)	-0.0001 (-0.29)
[10%;30%[	-0.0001 (-0.32)	-0.0001 (-0.33)	0.0003 (1.05)	-0.0001 (-0.57)	-0.0001 (-0.56)	0.0000 (-0.14)
[30%;50%[	-0.0004 (-1.64)***	-0.0004 (-1.64)***	0.0004 (1.03)	-0.0007 (-1.73)***	-0.0007 (-1.64)	0.0002 (0.33)
[50%;70%[	0.0004 (1.73)***	0.0004 (1.73)***	0.0005 (1.39)	0.0001 (0.17)	0.0001 (0.25)	0.0005 (0.83)
[70%;100%[	-0.0006 (-1.42)	-0.0006 (-1.43)	-0.0004 (-0.71)	-0.0001 (-0.34)	-0.0001 (-0.23)	0.0003 (0.56)
Oil Price	-0.0190 (-4.52)*			-0.0132 (-2.04)**		

5. Regression' coefficients of the three models and for both regions (continued)

Returns	European Companies			American Companies		
	Unconditional Model	Conditional Model	Conditional Model w/ Interactions	Unconditional Model	Conditional Model	Conditional Model w/ Interactions
Oil Price Positive Change		-0.0202 (-2.91)*	-0.0504 (-3.83)*		-0.0058 (-0.55)	-0.0416 (-2.41)**
Oil Price Negative Change		0.0179 (2.36)**	0.0712 (5.21)*		0.0214 (2.14)**	0.0763 (3.33)*
[1%;10%[& Positive change			0.0074 (0.44)			0.0622 (2.45)*
[1%;10%[& Negative change			0.0022 (0.14)			-0.0922 (-3.32)*
[10%;30%[& Positive change			0.0432 (2.16)**			0.0291 (1.20)
[10%;30%[& Negative change			-0.0884 (-4.09)*			-0.0393 (-1.47)
[30%;50%[& Positive change			0.1134 (3.98)*			0.0179 (0.40)
[30%;50%[& negative change			-0.2155 (-7.52)*			-0.1576 (-2.96)*
[50%;70%[& Positive change			0.0085 (0.31)			0.0261 (0.64)
[50%;70%[& Negative change			-0.0176 (-0.67)			-0.0859 (-1.72)***
[70%;100%[& Positive change			0.0292 (0.61)			0.0009 (0.02)
[70%;100%[& Negative change			-0.0504 (-1.22)			-0.0524 (-1.37)
Adjusted R^2	0.54995	0.54994	0.55229	0.41369	0.41371	0.41454
$H_o: B_0 = ... = B_n = 0$	4132.88 *	3799.75 *	2182.99 *	808.17 *	741.91 *	455.29 *

6. Regression' coefficients of the three models, for both regions as a whole

Reported are the coefficients, significance levels and t-statistics for the regressions with stock returns as the dependent variable. Reported are also the adjusted R^2 and the jointly significance F-Test coefficient and significance level. *, ** and *** denote coefficients significant at the 1%, 5% and 10% significance levels respectively.

Returns	Both Regions as a whole		
	Unconditional Model	Conditional Model	Conditional Model w/ Interactions
Constant	-0.0002 (-1.79)***	0.0001 (0.48)	-0.0004 (-2.49)**
Market Returns	1.0177 (203.77)*	1.0178 (203.28)*	1.0166 (204.33)*
Market to BV Ratio	0.0001 (6.27)*	0.0001 (6.33)*	0.0001 (6.40)*
Returns Lag 1 Month	0.0005 (0.15)	0.0005 (0.16)	0.0006 (0.16)
Returns Lag 12 Months	-0.0005 (-0.24)	-0.0005 (-0.24)	-0.0003 (-0.18)
Interest Rate	0.0010 (0.29)	0.0009 (0.25)	0.0015 (0.42)
[1%;10%[	-0.0001 (-0.44)	-0.0001 (-0.44)	0.0000 (0.06)
[10%;30%[	0.0000 (-0.30)	0.0000 (-0.30)	0.0002 (0.85)
[30%;50%[	-0.0004 (-2.01)**	-0.0004 (-1.99)**	0.0003 (1.08)
[50%;70%[	0.0004 (1.83)***	0.0004 (1.85)***	0.0005 (1.67)***
[70%;100%[	-0.0003 (-1.18)	-0.0003 (-1.17)	0.0000 (-0.08)
Oil Price	-0.0151 (-4.14)*		

6. Regression' coefficients of the three models, for both regions as a whole (continued)

Returns	Both regions as a whole		
	Unconditional Model	Conditional Model	Conditional Model w/ Interactions
Oil Price Positive Change		-0.0140 (-2.27)**	-0.0464 (-4.40)*
Oil Price Negative Change		0.0162 (2.67)*	0.0704 (5.72)*
[1%;10%[& Positive change			0.0328 (2.22)**
[1%;10%[& Negative change			-0.0409 (2.69)*
[10%;30%[& Positive change			0.0380 (2.42)**
[10%;30%[& Negative change			-0.0658 (-4.01)*
[30%;50%[& Positive change			0.1009 (3.85)*
[30%;50%[& negative change			-0.2068 (-7.66)*
[50%;70%[& Positive change			0.0054 (0.23)
[50%;70%[& Negative change			-0.0220 (-0.92)
[70%;100%[& Positive change			0.0188 (0.63)
[70%;100%[& Negative change			-0.0560 (-1.98)**
Adjusted R^2	0.50614	0.50614	0.50743
$H_o: B_0 = ... = B_n = 0$	4602.16 *	4220.52 *	2414.65 *

7. Hypothesis' test for jointly significance and asymmetric impacts

Reported are the coefficients, significance levels and p-values for the jointly significance test and symmetry test. Model 2 corresponds to Conditional Model and Model 3 corresponds to Conditional Model with Interaction Variables. *, ** and *** denote coefficients significant at the 1%, 5% and 10% significance levels respectively.

Returns	Both regions as a whole		European Companies		American Companies	
	Model 2	Model 3	Model 2	Model 3	Model 2	Model 3
$H_0: B_{Poit} = B_{Noit} = 0$	8.64	39.66	10.45	31.22	2.82	13.03
	(0.000)*	(0.000)*	(0.000)*	(0.000)*	(0.060)***	(0.000)*
$H_0: B_{Poit} + B_{Noit} = 0$	0.22	1.28	-0.19	0.95	0.97	1.05
	(0.824)	(0.200)	(0.851)	(0.344)	(0.332)	(0.296)