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Master Essay II:

Oil Volatility Spillovers

to the US and EU Industries

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Abstract

This essay examines the volatility spillover effects from oil price shocks across different US and EU industries, using a GJR-GARCH(1,1) model. We conclude that the European industries are much more sensitive to oil and stock market shocks compared to their US counterparts. In US, oil news have significant effect only on *Basic Materials, Industrials, Utilities* and *Consumer Services* and coefficient significance depends much on the estimation sample. In contrast, all the EU industry returns are significantly influenced by oil shocks. The most sensitive are *Basic Materials* and *Industrials*, while the least affected are *Telecommunications*, *Healthcare* and *Consumer Goods*. However, variance ratios show that the share of oil shocks in an industry's total volatility remains very small (0-0.46% for US sectors and 0.23-1.55% for EU) compared to the innovations from the broad US and EU stock markets. For futures contracts these ratios are higher, and namely 0.03-2.73% and 0.21-4.66% respectively.

Keywords: Volatility Spillovers, Oil Prices, Industries

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1. Introduction

1.1 Background

"One thing is clear; the era of easy oil is over. What we all do next will determine how well we meet the energy needs of the entire world in this century and beyond".

(David J. O'Reilly, Ex- Chairman and CEO, Chevron Corporation)

Although the financial crisis is sluggishly drawing back, new challenges recently arose for the global economy. According to the World Economic Forum's most recent report on the global risk factors, one of the greatest economic concerns is the "Extreme Energy Price Volatility".[1] Thus, a very vivid proof for this statement is the recent turmoil in Egypt, Bahrain and Libya, which disrupted the local oil production and made global energy prices surge immediately. In addition, the uncertainty about the spreading of political unrest to other oil-producing countries remains at high levels. That definitely pushes energy prices upwards, with deep negative implications for any country. We should also remember that USA is not only the world's leading economy, but also a large energy consumer. Of course, that makes it particularly sensitive to oil/gas price shocks.

Due to the great dependence of an economy on the energy sector, over the last decade there has been an interest by researchers in observing the impact of oil and other energy sources on the financial and stock markets. Although extensive research exists in this area, most of the studies have not observed the issue on an industry level. In contrast, our paper specifically assesses the effect of oil price shocks on the main US and EU industries. We present a summary of the most recent studies the next chapter.

There are two conflicting views regarding how rising energy prices affect the equity markets. On one hand, business costs increase, which can potentially depress operating margins and erode

[1] Global Risks 2011, World Economic Forum, 6th ed., January 2011, http://www.weforum.org/issues/global-risks

profits[2]. Consequently, stock valuations might fall. However, judging from the risk-return prospective, thinner corporate margins also imply more risk for companies dependent on oil prices. So, their investors might demand a higher return compensation, determining managers to increase returns on equity. Additionally, higher energy prices push up inflation and the risk-free rate, which increase the required return on all stocks (and other securities)[3].

1.2 Problem Discussion

Since our essay will focus on an industry analysis, we start by explaining how different economic sectors are likely to be affected by oil prices. A first obvious conclusion is that wholesalers, retailers, restaurants and transportation companies (all included in the *Consumer Services* industry) are highly exposed to higher gasoline and fuel costs. Other affected sectors include *Consumer Goods* (requiring food and product shipments), *Basic Materials* (plastics and chemicals are made using petroleum, paper and metal industries) and *Industrials* (more expensive construction materials, higher cost for packaging businesses etc.). In brief, any economic area will feel the oil price burden, because all firms pay utility bills, and need packages, business travels, office supplies, professional services like training, consulting (requiring "on location" travel) etc. However, some companies may easier transfer this cost increase to consumers, while others cannot and the firm's competitive advantage plays an important role in determining its bargaining power.

Both academic literature and the recent financial crisis extensively prove the high degree of integration between markets. Although, there are numerous advantages from market co-movements, a great concern remains the "contagion" effect during periods of financial turmoil. In our current essay we will consider the transmission of volatility across markets and industries, which is of great relevance to policy makers, companies, investors and other interested parties. Volatility spillover is a very topical issue in the current research, but in our view very little

[2] According to microeconomic theory we assume that producers cannot pass the entire cost increase on consumers and have to bear part of it themselves.
[3] Oil price increases are not necessarily associated with a recession, but could also imply a booming economy with a higher demand for fuel. In any case, the risk-free rate is supposed to rise.

attention has been paid to such an important issue like the reaction of different economic sectors to extremely volatile energy prices. Awareness about how responsive different industries are to oil price shocks might have important implications for the global capital allocation and predictability of equity prices.

1.3 Purpose

Given the limited number of studies considering the transmission of energy shocks on equity returns, our study is aimed to fill the corresponding research gap in the volatility spillover field. In addition, most previous studies focus on economic regions or national markets rather than industry equity indices. We believe that a separate view on each economy sector is very important for investors and a broad-market analysis is not enough.

From the geographic prospective, our analysis is grounded on two major equity markets: the US and the EU, as being the most liquid. Since the introduction of the euro currency on 1 January 1999 changed much the integration of the European equity market, we decided to focus on the sample period following immediately after this date and up to present.

Thus, the purpose of our study is to

1) Compare the volatility spillovers from oil price shocks across different US and EU industries (before and after the economic crisis);
2) Compare the size of spillover effects between the two regions: US and EU;
3) Compare the volatility spillovers from spot and futures oil prices.

1.4 Limitations

As our study is focused only on US and EU, results cannot be generalized to other regions like Asia or Emerging markets. Also, in order to avoid day-of-the-week effect we employ data with weekly frequency, which might underestimate the volatility in equity markets compared to higher data frequency.

1.5 Target Group

Our essay is targeted to students, researchers, investors and other individuals interested in volatility spillovers across markets and industries.

1.6 Outline

The remainder of the essay is organized as follows:
Chapter 2 introduces the reader to the most relevant research in the area of volatility spillovers and energy prices.

Chapter 3 presents the stepwise methodology we employ in our study and motivates the selection of the data sample.

Chapter 4 presents the data sample and analyzes it main features.

Chapter 5 offers the empirical results after applying the methodology described in Chapter 3, along with their interpretation.

Chapter 6 offers concluding remarks for the present essay and some possible extensions.

2. Previous Research

The section starts with a brief presentation of the fundamental articles relating to volatility spillovers in international equity markets, after which we focus in more detail to studies linked to oil prices.

2.1 Volatility Spillover Research

Volatility transmission across markets was firstly formalized in a model by Bekaert and Harvey (1997), who apply it to emerging equity markets and distinguish between global and local shocks. Later on, Ng (2000), Bekaert *et al.* (2005) and Baele (2005) employ similar methodologies on other equity markets like Asia Pacific and EU respectively. Christiansen (2007) and Christiansen (2010) extend the study by also considering the bond markets. All the articles find evidence of significant spillover effects across markets, which revealed the high degree of integration and stimulated further research in this field.

Kaltenhäuser (2002) apply the general spillover model to ten European industry sectors. Again the total market innovations are decomposed into global US and regional EU shocks. Interestingly, the paper concludes that with the introduction of the euro currency, the studied sectors became more heterogeneous, which increases the importance of sector-specific research for the period comprising the last decade.

Since the volatility spillover across markets is an extensive area of research, we narrow the discussion by focusing on a more specific category of studies.

2.2 Oil Prices – Equity Markets Research

Next we consider the most relevant studies linking oil prices to equity returns. Some of these studies used macroeconomic models, which suppose low-frequency data.

Using quarterly data, Jones and Kaul (1996) examine whether the reaction of international stock markets to oil shocks can be justified by current and future changes in real cash flows or in expected returns. Authors show that oil price shocks have greater influence on real cash flows for the US and Canada, but being weaker for Japan and UK.[4]

Huang et al (1996) used daily US data and a VAR model for the same research question, concluding that oil futures returns influence *some* individual *oil* stocks, but they are not correlated with broad-market indices like S&P500. Therefore, information from the oil futures market may be useful to market makers in oil stocks, but is of much less use to public investors.[5]

In contrast, Sadorsky (1999) also use the VAR method, but come to the conclusion that oil prices and their conditional volatility have great impact on S&P500 and broad market stock returns. Especially after 1986 the explanatory power of oil prices is even higher than that of interest rates.[6]

Papapetrou (2001) also reach this result for Greek monthly data (1989-1999), using a VAR macroeconomic model. The model includes oil prices, real stock prices, interest rates, real economic activity and employment data. Thus, oil price changes affect real economic activity and employment and explain stock price movements.[7]

Lee and Ni (2002) considered how changes in oil prices influence demand and supply sides in different industries. Thus, industries where oil represents a large proportion of costs (petroleum

[4] Jones, C.M., Kaul, G. (1996), Oil and the Stock Markets, The Journal of Finance, Vol. LI, No. 2 , pp. 788–796
[5] Huang, R.D., Masulis, R.W., Stoll, H.R. (1996), Energy shocks and financial markets, The Journal of Futures Markets, Vol. 16, No. 1, pp. 1-27
[6] Sadorsky, P. (1999), Oil price shocks and stock market activity, Energy Economics, Vol. 21, pp. 449-469
[7] Papapetrou, E. (2001), Oil price shocks, stock market, economic, activity and employment in Greece, Energy Economics, Vol. 23, pp. 511-532

refinery, industrial chemicals), shocks in oil price reduce supply. On the other hand, for other industries (e.g. automobile industry), they diminish demand. In addition, oil price increases delay decisions to buy durable goods.

Hammoudeh et al (2004) analyze spillovers from oil spot/future prices on five US oil equity indices. Authors find that oil price series have common trends, allowing for few diversification opportunities. However, the five S&P oil indices are not co-integrated which permits diversification gains. None of the equity indices capture future movements in oil future prices.

Basher and Sadorsky (2006) explore the impact of oil price changes on equity returns from a set of emerging markets. Using an international multi-factor model, authors show that oil price risk impacts stock returns and that there is a non-linear conditional relationship between oil price risk and stock market returns.[8]

Chiou and Lee (2009) explore the asymmetry of oil price effects on equity returns over 1992-2006. Using an autoregressive conditional jump intensity model, authors conclude that high fluctuations in oil prices have asymmetric unexpected impacts on S&P 500 returns.[9]

Finally, as mentioned in the introduction chapter, there is little research analyzing the relationship between oil spot/futures prices and industry equity indices.

Hayo and Kutan (2004) study the impact of news, oil prices, and international financial market developments on daily returns on Russian bond and stock markets. The evidence suggests a significant effect of the growth in oil prices on Russian stock returns.[10]

Nandha and Faff (2008) analyzed the impact of oil prices on 35 global industry indices over 1983-2005. Thus, oil price rises have a negative impact on equity returns for all sectors except mining, and oil and gas industries. So, internationally diversified portfolios usually do not

[8] Basher S., Sadorsky, P. (2006), Oil price risk and emerging stock markets, Global Finance Journal 17, pp. 224–251
[9] Chiou, J., Lee, Y. (2009), Jump dynamics and volatility: Oil and the stock markets, Energy, vol. 34, pp. 788–796
[10] Bernd Hayo and Ali M. Kutan, Bernd Hayo & Ali M. Kutan, (2004), The Impact of News, Oil Prices, and Global Market Developments on Russian Financial Markets, William Davidson Institute Working Papers Series 2004-656, William Davidson Institute at the University of Michigan

achieve full diversification benefits unless they include some assets with positive sensitivity to oil price changes.[11]

Malik and Ewing (2009) study spillovers from oil prices on five US sector indexes (financial, industrial, consumer, health, and technology). Authors conclude on "significant transmission of shocks and volatility between oil prices and *some* of the examined market sectors"[12], which confirms the idea that investors indeed use information about energy prices when making investment/hedging decisions.

Al-Nahleh et al (2011) study the role of oil prices in explaining 'transport sector' equity returns in 38 countries across the world. The results suggest the strong role of oil prices in determining the transport sector returns for the countries falling within the 'Developed', 'Europe' and 'G7' categories. They also found the oil factor to be jointly significant along with the presence of negative oil risk premium in these groups.[13]

Table 1 below will summarize the most important research articles presented above, along with additional information on the data samples considered and the methods employed.

Article	**Year**	**Method**	**Data**	**Results**
Jones and Kaul	1996	Standard Dividend Valuation Model	Quarterly data (1947-1991) for US, Canada, Japan, UK; market equity indices, inflation, producer oil price indices, index of industrial production as proxy of aggregate cash flows, dividend yield, default spread etc	Oil price shocks have greater influence on real cash flows for the US and Canada, but being weaker for Japan and UK
Huang et al	1996	Vector autoregressive model (VAR)	Daily data (1979-1990) US oil futures prices, S&P500, 12 other equity indices and three individual oil company stocks.	Oil futures returns influence some individual oil stocks, but they are not correlated with broad-market indices. Oil futures prices are useful to market makers in oil stocks, but is less important to other investors.

[11] Nandha, M., Faff, R. (2008), Does oil move equity prices? A global view, Energy Economics 30, pp. 986–997

[12] Malik and Ewing (2009)

[13] Oil prices and transport sector returns: an international analysis ,Mohan Nandha and Robert Brooks, Review of Quantitative Finance and Accounting , Vol. 33, No. 4,pp. 393-409

Sadorsky	1999	VAR macroeconomic model	Monthly data (1947-1996) US industrial production index (output), interest rates, oil prices (measured by producer price index), S&P500, inflation	Oil prices and their conditional volatility have great impact on S&P500 After 1986 the explanatory power of oil prices is even higher than that of interest rates.
Papapetrou	2001	VAR macroeconomic model	Monthly data (1989-1999) for Greece: oil prices, real stock prices, interest rates, real economic activity and employment data.	Oil price changes affect real economic activity and employment and explain stock price movements.
Lee and Ni	2002	Macroeconomic VAR, AD-AS model	Monthly data (1959-1997) Oil prices, industry returns and macroeconomic variables	Industries where oil is a large share of costs, shocks in oil price reduce supply. For other industries they diminish demand.
Hammoudeh et al	2004	VAR, cointegration analysis, error correction model	Daily US data (1995-2001) Oil spot/futures prices, five oil equity indices	All oil price series are co-integrated, allowing for few diversification opportunities, but oil indices are not correlated and permit diversification gains. None of the equity indices capture future movements in oil future prices.
Basher and Sadorsky	2006	International multi-factor model	Daily data for 21 emerging markets (1992-2005) Oil prices, equity returns, exchange rate returns	Oil price risk impacts stock returns and there is a non-linear conditional relationship between oil price risk and stock returns.
Chiou and Lee	2009	Autoregressive Conditional Jump Intensity Model	Daily US data (1992-2006) for S&P500, oil prices	High fluctuations in oil prices have asymmetric unexpected impacts on S&P 500
Nandha and Faff	2008	International two-factor model (market and oil factors)	Monthly data (1983-2005) for 35 global industry indices, oil prices	oil price rises have a negative impact on equity returns for all sectors except mining, and oil and gas industries. So, internationally diversified portfolios usually do not achieve full diversification benefits unless they include some assets with positive sensitivity to oil price changes
Malik and Ewing	2009	Bivariate GARCH	Weekly returns (1992-2008) US industry indices, oil prices	"significant transmission of shocks and volatility between oil prices and *some* of the examined market sectors"

Table 1. Oil Prices – Equity Markets Research

Note: Table 1 summarizes the most relevant research about the relationship between oil prices and stock markets.

3. Methodology

In the current chapter, we start by briefly presenting the alternative spillover models, after which we consider in more detail the specification we apply to our data sample.

3.1 Volatility Spillover Models

The main model to describe volatility spillovers was introduced by Bekaert and Harvey (1997). This methodology consists of several steps, which can vary depending on the approach we undertake. Below we mention the two alternative approaches, based on the data we intend to use in our study.

- The first approach was applied by Ng (2000) and Baele (2005). It consists of only two steps, but estimates a trivariate GARCH in the first step including oil prices, US and EU returns. Before proceeding to the second step, residuals from the first model need to be orthogonalized. In the second step these orthogonal shocks are introduced into univariate GARCH specifications corresponding to each industry in order to analyze volatility spillovers.
- The second approach is used by Bekaert et al. (2005). It applies only univariate AR-GARCH models, but this simpler methodology requires two additional steps. In the first GARCH we estimate shocks for oil prices, then introduce them as explanatory variable in the second GARCH corresponding to US returns. Similarly, US shocks are used to explain EU returns. As can be noted, residuals are independent by construction and there is no need for orthogonalization. In the present essay we intend to apply this last approach and we describe it in more detail below.

It is also important to mention that the ordering of equations in the steps described above is cardinal. Thus, we estimate oil price shocks first, because, according to our posed research questions, they are believed to impact all equity returns. By this reasoning, news hitting the oil markets should transmit to equity markets: the global market (captured by the US broad-market index) and the regional EU market. Similarly, shocks from the global market should spill over

EU broad index and not the other way around; the direction of this relationship is supported by Granger causality tests (for more details see Christiansen, 2007)[14].

Our goal in this essay is to decompose the conditional volatility of the unexpected industry returns into proportions corresponding to oil prices, global US shocks, regional European news and industry-specific effects.

3.2 Econometric Specification

Below we provide a detailed description of steps undertaken to measure volatility spillovers across the US and EU industries:

Step 1: The conditional mean equation for oil prices is assumed to take AR(1) form in order to avoid serial correlation:

$$r_{oil,t} = \varphi_{oil,0} + \varphi_{oil,1} r_{oil,t-1} + e_{oil,t}$$

$\varphi_{oil,0}$ and $\varphi_{oil,1}$ are coefficient estimates and $e_{oil,t}$ represent news entering oil markets at time *t*. For simplicity, we assume that innovations follow a conditional normal distribution, i.e. $e_t|\Omega_{t-1} \sim N(0; h_t)$, where Ω_{t-1} is the information available up to period *t-1* and h_t is the time-varying variance. As commonly documented in previous research, shocks are asymmetric. Therefore, decrease in returns due to negative news is larger than the increase due to positive innovations. Thus, we use the asymmetric GJR-GARCH(1,1) specification for conditional variance (proposed by Glosten et al. 1993):

$$h_{oil,t} = \omega_{oil} + \alpha_{oil} e_{oil,t-1}^2 + \beta_{oil} h_{oil,t-1} + \alpha_{oil}^* e_{oil,t-1}^2 I_{oil,t-1}$$

$I_{oil,t-1} = 1$ if $e_{oil,t-1} < 0$ and 0 otherwise. The other restrictions we set are:

$\omega_{oil} > 0$; $\alpha_{oil}, \beta_{oil}, \alpha_{oil} + \frac{1}{2}\alpha_{oil}^* \geq 0$ and $\alpha_{oil} + \beta_{oil} + \frac{1}{2}\alpha_{oil}^* \leq 1$

[14] Charlotte Christiansen, Volatility-Spillover Effects in European Bond Market (2007), European Financial Management, Vol. 13, No. 5, pp.923–948

If α^*_{oil} is positive, then negative shocks affect more oil returns than positive shocks (a commonly documented feature for equity markets).

Step 2: The model for US broad-market returns is specified as follows:

$$r_{US,t} = \varphi_{US,0} + \varphi_{US,1} r_{oil,t-1} + \varphi_{US,2} r_{US,t-1} + \gamma_{US,1} e_{oil,t} + e_{US,t}$$

The conditional variance equation is the same as in step 1.

So, mean spillover effect from the oil market on the US index is accounted through lagged oil prices, while volatility spillover comes from the penultimate term $e_{oil,t}$. Thus, the US return depends on idiosyncratic oil shocks.

Step 3: The model for the regional EU market takes a form similar to the previous specification, but with additional spillover terms representing information transmission from the US market on the EU broad equity index:

$$r_{EU,t} = \varphi_{EU,0} + \varphi_{EU,1} r_{oil,t-1} + \varphi_{EU,2} r_{US,t-1} + \varphi_{EU,3} r_{EU,t-1} + \gamma_{EU,1} e_{oil,t} + \gamma_{EU,2} e_{US,t} + e_{EU,t}$$

The conditional variance equation is the same as in step 1.

Step 4: As a final model we specify univariate GARCH models for each EU industry *i*:

$$r_{i,t} = \varphi_{i,0} + \varphi_{i,1} r_{i,t-1} + \varphi_{i,2} r_{oil,t-1} + \varphi_{i,3} r_{US,t-1} + \varphi_{i,4} r_{EU,t-1} + \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + \gamma_{i,3} e_{EU,t} + e_{i,t}$$

The conditional variance equation is the same as in step 1.

So, for each EU industry we allow for spillovers from oil prices, the global US equity market and the regional EU broad-market index. In contrast, for US industries we allow for only spillovers from oil prices and the broad-market US index, due to the direction of causality mentioned above:

$$r_{i,t} = \varphi_{i,0} + \varphi_{i,1} r_{i,t-1} + \varphi_{i,2} r_{oil,t-1} + \varphi_{i,3} r_{US,t-1} + \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + e_{i,t}$$

3.3 Volatility Spillover Effects

In the stepwise model presented above we decomposed the unexpected industry returns in the following way:

- *EU:* $\varepsilon_{EU,i,t} = \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + \gamma_{i,3} e_{EU,t} + e_{i,t}$
- *US:* $\varepsilon_{US,i,t} = \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + e_{i,t}$

All the terms in the equations above are independent by construction. The last shock in each equation captures the innovations unexplained by other factors (oil prices, US and EU stock markets. Consequently, the conditional variance of the total unexplained return can be simply written as the sum of variances of each individual term:

- *EU:* $h_{EU,i,t} = \gamma_{i,1}^2 \sigma_{oil,t}^2 + \gamma_{i,2}^2 \sigma_{US,t}^2 + \gamma_{i,3}^2 \sigma_{EU,t}^2 + \sigma_{i,t}^2$
- *US:* $h_{US,i,t} = \gamma_{i,1}^2 \sigma_{oil,t}^2 + \gamma_{i,2}^2 \sigma_{US,t}^2 + \sigma_{i,t}^2$

Thus, the total variance of each EU industry depends on idiosyncratic variances of oil, US and EU markets, along with its own idiosyncratic variance.

3.4 Variance Ratios

Next, we can quantify the proportion of each idiosyncratic shock in the total variance of unexpected industry returns:

- *EU:* $VR_{oil,i,t} = \frac{\gamma_{i,1}^2 \sigma_{oil,t}^2}{h_{EU,i,t}}$ $\quad VR_{US,i,t} = \frac{\gamma_{i,1}^2 \sigma_{US,t}^2}{h_{EU,i,t}}$ $\quad VR_{EU,i,t} = \frac{\gamma_{i,1}^2 \sigma_{EU,t}^2}{h_{EU,i,t}}$ $\quad VR_{i,t} = \frac{\sigma_{i,t}^2}{h_{EU,i,t}}$
- *US:* $VR_{oil,i,t} = \frac{\gamma_{i,1}^2 \sigma_{oil,t}^2}{h_{US,i,t}}$ $\quad VR_{US,i,t} = \frac{\gamma_{i,1}^2 \sigma_{US,t}^2}{h_{US,i,t}}$ $\quad VR_{i,t} = \frac{\sigma_{i,t}^2}{h_{US,i,t}}$

The variance ratios are similar to weights and can only take values between 0 and 1. Obviously, all variance ratios for US (and EU respectively) must sum to one. The last ratio for both US and

EU represent the share of industry-specific shocks, not attributable to global or regional innovations.

3.5 Ljung-Box Autocorrelation Test

In the methodology part we also describe briefly the Ljung-Box test employed for motivating the autoregressive process used in modeling returns.

To check whether some equity return is related to its past values, the *autocovariance* and *autocorrelation* measures are applied. Thus, the autocovariance between $r_{i,t}$ and $r_{i,t-s}$ shows how return at time *t* depends on its past value at time *(t-s)*. The autocovariance function is given by the formula:

$$\gamma_s = E\big(r_t - E(r_t)\big)\big(r_{t-s} - E(r_{t-s})\big) \qquad s = 0,1,2 \ldots$$

Usually we normalize autocovariances by dividing them by the variance γ_0:

$$\hat{\tau_s} = \frac{\gamma_s}{\gamma_0} \qquad s - lag\ length$$

That gives us the autocorrelation coefficient with values lying between [-1;+1].

Next, Ljung-Box measure is used to test the significance of this coefficient:

$$Q = \frac{T(T+2)}{T-k}\hat{\tau_s}^2 \quad \sim\chi^2(1)$$

The hypotheses we set are:

H_0: $\hat{\tau_s} = 0$ $\quad (no\ significant\ autocorrelation)$

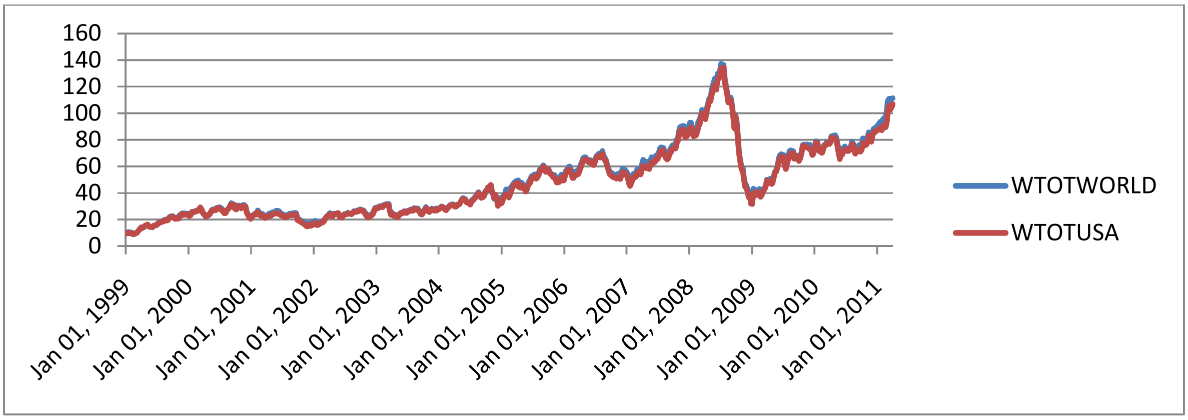
H_1: $\hat{\tau_s} \neq 0$

4. Data

In this section we describe the data employed in the essay, along with its basic statistical features.

4.1 Data Sample

In our essay we decided to employ both spot and futures oil prices, in order to analyze whether the share of oil spillovers on each industry varies in case when investors base their market expectations on one or another series. For spot crude oil prices we considered two series of relevance, and namely: the *US Spot Price FOB Weighted by Estimated Export Volume* (WTOTUSA) and the *All Countries Spot Price FOB Weighted by Estimated Export Volume* (WTOTWORLD). The data was collected with *weekly* frequency from the US Department of Energy (US Energy Information Administration) website[15]. In our study we consider the following period: 1 January 1999 – 15 April 2011, because all the EU indices below will be collected starting from the introduction of euro (1 January 1999), which according to Christiansen (2010) represents a structural break due to higher market integration after this date. However, the two spot oil price series are perfectly positively correlated due to the global reach of the US economy (please see graph 4.1.1 below). So, we included only *WTOTWORLD* in our analysis. All oil prices are reported in US dollars per barrel.



Graph 4.1.1 US and Global Spot Crude Oil Prices (USD per barrel)

[15]Spot oil prices: http://www.eia.doe.gov/dnav/pet/pet_pri_wco_k_w.htm

To denote futures crude oil price, we use the price of one-month and three-month crude oil futures contracts traded on the New York Mercantile Exchange (NYMEX). Data is provided by the same data source (the US Energy Information Administration website[16]), with weekly frequency over the period 1 January 1999 – 15 April 2011.

Weekly observations (compared to higher frequency) is more efficient at handling non-synchronous data, because close daily returns during stable periods underestimate correlations (see for ex. Martens and Poon (2001)) and determine spillover effects to be accepted too often.

We use *Thomson Reuters Datastream* source to collect all the other necessary equity indices. More specifically, we employ the *S&P 500* broad-market index to represent the US equity market and the regional *MSCI* index for the European Union. In what concerns industry equity indices, we use the classification of US and EU industries into 9 groups made by Datastream[17]: *Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Technology, Telecommunications and Utilities*. Table 1 in appendix offers more details for each index composition. All indices are total return indices (incl. dividends), so no additional adjustments for cash payouts are necessary.

For comparability reasons, all data series are collected in the same currency, and namely US dollars. Volatility spillover models usually employ common currency returns (see for ex. Bekaert *et al.* (2005)). Although this might imply some bias for EU investors who manage their wealth and returns in the euro currency, in this study we are more interested in oil prices spillovers rather than *absolute* measurement of investor returns. So, our analysis should be interpreted in *relative* terms from this prospective.

[16] Futures oil prices: http://www.eia.doe.gov/dnav/pet/pet_pri_fut_s1_w.htm

[17] In fact, Datastream classification comprises 10 industries, but we did not consider *Energy Industry*.

4.2 Data Analysis

As a first step, we transform each price series *i* into log-returns, by using the traditional formula:

$$r_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right)$$

The three tables below offer summary statistics for all the return series employed in our study. Table 4.2.1 presents the features of the spot and futures oil returns, along with the broad US and EU equity indices. Table 4.2.2 and table 4.2.3 highlight the characteristics of the US and the EU industries respectively.

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Oil Spot	0.0039	0.0058	0.0424	-0.47	4.92	122.2	0
1M Oil Futures	0.0035	0.0070	0.0435	-0.69	5.03	160.4	0
3M Oil Futures	0.0034	0.0067	0.0383	-0.70	4.64	123.8	0
S&P500	0.0001	0.0015	0.0272	-0.82	9.49	1197.7	0
MSCI EU	0.0003	0.0035	0.0310	-1.36	13.73	3273.1	0

Table 4.2.1 Summary statistics for oil returns and broad US and EU equity markets

Note: Table 4.2.1 presents the basic statistical features of the spot/futures oil returns and broad US/EU equity indices, and namely we offer: Mean, Median, Standard Deviation, Skewness, Kurtosis, Jarque-Berra statistics and its corresponding p-value.

The last two columns in each table show the value of the Jarque-Berra normality test and its corresponding p-value:

$$JB = \frac{T}{6} * skew^2 + \frac{T}{24} * (kurt - 3)^2 \sim \chi^2(2) \qquad T - no. of\ observations$$

$$skew = \frac{\mu_3}{\sigma^3} = \frac{E[(x_i - E[x_i])^3]}{\sigma^3} \qquad kurt = \frac{\mu_4}{\sigma^4} = \frac{E[(x_i - E[x_i])^4]}{\sigma^4}$$

$H_0: skew \sim N\left(0; \frac{6}{T}\right)\ and\ kurt \sim N(0; \frac{24}{T})$ which implies **normality**

H_1: **non − normality**

We consider a 5% significance level, $\chi^2(2) = 5.991$, under which the null is strongly rejected. Thus, all the analyzed return series are non-normally distributed, being characterized by the common features of negative skewness and excess kurtosis (i.e. "fat tails").

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0013	0.0037	0.0389	-0.58	6.63	387.5	0
Consumer Goods	-0.00005	0.0010	0.0267	-1.22	11.47	2076.1	0
Consumer Services	0.0004	0.0015	0.0299	-0.59	7.61	604.0	0
Financials	-0.0002	0.0004	0.0386	-0.07	11.84	2089.6	0
Health Care	0.0003	0.0005	0.0241	-1.12	12.46	2526.3	0
Industrials	0.0008	0.0019	0.0325	-0.54	6.89	435.1	0
Technology	-0.00008	0.0015	0.0429	-0.67	7.23	525.4	0
Telecommunications	-0.0011	-0.0007	0.0329	-0.47	8.33	783.0	0
Utilities	0.0002	0.0010	0.0276	-1.33	11.87	2292.1	0

Table 4.2.2 Summary statistics for the US industries

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0020	0.0048	0.0403	-0.92	9.90	1362.4	0
Consumer Goods	0.0009	0.0035	0.0320	-0.94	10.29	1514.3	0
Consumer Services	0.0002	0.0032	0.0295	-1.11	9.78	1361.8	0
Financials	-0.0002	0.0026	0.0370	-1.46	13.19	2998.7	0
Health Care	0.0006	0.0028	0.0258	-1.68	17.19	5676.8	0
Industrials	0.0012	0.0047	0.0344	-0.92	7.21	563.6	0
Technology	-0.0003	0.0022	0.0472	-0.54	5.32	174.7	0
Telecom	-0.0002	0.0023	0.0371	-0.67	7.13	503.0	0
Utilities	0.0006	0.0028	0.0287	-2.22	24.62	13011.2	0

Table 4.2.3 Summary statistics for the EU industries

Notes: Table 4.2.2 presents the basic statistical features of the US equity returns by industries, and namely we offer: Mean, Median, Standard Deviation, Skewness, Kurtosis, Jarque-Berra statistics and its corresponding p-value. Table 4.2.3 shows the same measures for the EU industry returns. Both samples contain weekly returns from 08/01/1999 to 15/04/2011 with a total number of 641 observations.

As can be noted from table 4.2.1, oil mean returns are much higher than all US and EU equity returns (including broad indices and industry-specific indices). More specifically, oil *weekly* mean return range is 0.34-0.39%, being higher for spot prices, and somewhat lower when we consider one- and three-month expectations into the future. So, investors expect future oil returns to decline due to a rather high current level. On the other hand, broad US and EU equity indices had mean weekly returns of only 0.01% and 0.03% respectively over the studied period (January 1999 – April 2011). Of course such low returns might be attributed to the recent financial crisis, which will be examined below by splitting the total time interval into two sub-periods: pre-crisis (1999-2006) and the period afterwards respectively (2007-2011). However, now we only consider the summary statistics for the entire data sample.

Looking at returns across industries, we note that *Basic Materials* and *Industrials* showed the highest returns. On the other hand, three industries earned negative mean returns over the studied period for both US and EU: *Financials*, *Technology* and *Telecommunications*. In addition, the US industry *Consumer Goods* also had a negative return, although not far away from zero. Overall, dollar-denominated EU industry returns are higher than US returns except for *Consumer Services*. Thus, the weekly return range for US is [-0.11%; +0.13%], while for EU it is higher and namely [-0.03%; +0.2%].

As suggested by theory, higher return is associated with higher risk (measured by standard deviation). Indeed, oil does not only provide higher returns than the broad US and EU indices, but also imply higher volatility over the studied period (0.58-0.7% compared to 0.15% for S&P500 or 0.35% for EU index). However, comparing standard deviations across industries, we conclude that this risk-return positive relationship is not always respected. However, for both US and EU industries, volatility lies in a similar range: for US [2.41%; 4.29%] and for EU [2.58%;4.72%], the least volatile being *Health Care* and the most volatile – *Technology*. This result is consistent with the public's general impression of stock markets, because all economic downturns are shortly followed by declines in capital expenditures. On the other hand, healthcare profits are very little responsive to economic cycles.

Also we can note that for all the series standard deviations are much higher than the mean returns.

Further, as mentioned above, we split the whole time interval into two sub-periods: 8 January1999 – 29 December 2006 and 29 December 2006 – 15 April 2011. Thus, we want to examine how much different are the returns during the recent financial crisis from the previous more stable period[18]. In appendix (Tables 2-7) we present detailed summary statistics for the two sub-periods.

From tables 2 and 5 in appendix, we confirm the intuition that mean oil returns were higher for the first sub-period (0.39-0.42%) and lower during the recent financial crisis (0.23-0.33%). However, oil volatility increased only slightly during the crisis. On the other hand, for broad-market equity indices, standard deviations climbed up, and returns reversed their signs from positive to negative. Thus, both US and EU exhibited negative returns on equity indices during the recent economic turmoil.

Considering the effect of the crisis on different industries, we conclude that in EU the mean returns for *all* industries decreased (becoming negative in most cases), while in US the changes were not so unidirectional. Thus, *Basic Materials, Consumer Goods* and *Technology* earned higher mean returns during the last sub-period. So, these US industries were characterized by different business cycle than the whole American economy. From the volatility prospective, in EU standard deviations rose for most industries, while in US again the changes had different signs. So in conclusion, US industries seem to have different cycles from their European counterparts. That could lead to different conclusions when analyzing the effect of oil volatility spillovers on EU and US markets respectively.

[18] Although the financial crisis started only in the middle of 2007, we split the period at the beginning of 2007 in order to have more observations in the second sample and improve accuracy.

5. Empirical Results

In the present section we start by verifying autocorrelations within each equity index and the correlations between different series. After that we proceed to the stepwise methodology described in Chapter 3.

5.1 Ljung-Box Test Results

In order to determine the necessity for an autoregressive modeling methodology, we employ the Ljung-Box test, allowing us to verify whether some particular return r_i at time t depends on its past lags. For model simplicity, we first check autocorrelation at first lag, and in case it is insignificant, we report the lowest lag when it becomes significant. We compute autocorrelations for up to the twelfth lag (equivalent to three months, given that some macroeconomic indicators are reported only quarterly). Along with autocorrelation in each return series, we also compute the autocorrelation for each squared return series. The last measure helps to determine which return series exhibit features of conditional heteroskedasticity. Table 5.1.1 below summarizes results for oil spot/futures returns and the broad-market US/EU equity indices.

	Oil Spot	**1M Oil Futures**	**3M Oil Futures**	**S&P500**	**MSCI EU**
AC(1)	0.26	0.15	0.17	-0.08	-0.03
Q	43.1	14.8	18.0	3.9	0.6
$AC^2(1)$	0.16	0.12	0.14	0.28	0.18
Q	15.8	9.9	12.5	49.8	21.8

Table 5.1.1 Ljung-Box Test on oil returns and broad-market equity returns

Note: Table 5.1.1 presents the Ljung-Box autocorrelation test for returns and squared returns of the following series: oil spot and futures returns, S&P500 and MSCI EU broad indices.

Considering a 5% significance level, the value of Q measure is compared with $\chi^2(1) = 3.8$ (for 1% significance $\chi^2(1) = 6.6$; for 10% level $\chi^2(1) = 2.7$). Thus, all oil returns have significant first-order autocorrelations at both 5% and 1% levels. For *S&P500* AC(1) is only marginally significant at 5% level. For *MSCI EU* there is no sign of autoregressive structure in returns at first lag, but we found 10% significance at the sixth lag. But in order not to complicate the specifications with higher-order lags, we decided to use AR(1) processes for all the return series. In addition, we use Bollerslev-Wooldridge robust standard errors to eliminate the remaining autocorrelation in residuals. Another conclusion emerging from Table 5.1.1 is that for all five series we need to model conditional heteroskedasticity using GARCH methodology.

Tables 5.1.2 and 5.1.3 below summarize Ljung-Box test results for the US and EU industries respectively.

US	**Basic Materials**	**Consumer Goods**	**Consumer Services**	**Financials**	**Health Care**	**Industrials**	**Technology**	**Telecom**	**Utilities**
AC(1)	-0.03	-0.01	-0.07	-0.12	-0.12	-0.05	-0.05	-0.04	-0.01
Q	0.6[19]	0.04[20]	3.5	9.1	9.1	1.8[21]	1.7[22]	1.0[19]	0.04[19]
$AC^2(1)$	0.44	0.10	0.26	0.41	0.22	0.32	0.16	0.17	0.22
Q	127.2	5.8	41.8	108.2	31.8	65.9	16.1	18.0	29.8

Table 5.1.2 Ljung-Box Test on US industry returns

EU	**Basic Materials**	**Consumer Goods**	**Consumer Services**	**Financials**	**Health Care**	**Industrials**	**Technology**	**Telecom**	**Utilities**
AC(1)	0.00	0.00	0.04	0.04	-0.10	0.05	0.04	-0.00	-0.03
Q	0.0[19]	0.0[19]	0.8[19]	1.3[19]	6.0	1.3[19]	0.9[21]	0.0[23]	0.7[24]
$AC^2(1)$	0.37	0.44	0.17	0.21	0.22	0.26	0.12	0.20	0.22
Q	89.3	125.2	18.2	27.6	31.3	42.1	8.7	25.4	30.0

Table 5.1.3 Ljung-Box Test on EU industry returns

Note: Tables 5.1.2 and 5.1.3 present the Ljung-Box autocorrelation test for returns and squared returns of the following nine US and EU industry returns: Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Technology, Telecommunications and Utilities.

[19] 10% significance reached at lag 4
[20] No significance reached at 10% for 12 lags (≈3months of data)
[21] 5% significance reached at lag 3
[22] 10% significance reached at lag 7
[23] 10% significance reached at lag 9
[24] 5% significance reached at lag 8

For all industries (except four: *US Consumer Services, US Financials, US Healthcare* and *EU Healthcare*) the AC(1) measure is not significant even at 10%. Again we confirm the fact that *Healthcare* has its own business cycle, which is different from the whole economy (returns of pharma-companies depend more on patent life, product pipeline etc. and for that reason they might be more predictable based on financial results from previous years). By also checking autocorrelations at higher lags, we obtain significance for about half of the series. For these reasons, we decided to include explanatory autoregressive terms in industry equations, although in some cases they may turn insignificant.

Finally, all series have significant autocorrelations in squared returns (at 5% level), proving the necessity to model conditional heteroskedasticity. Furthermore, given that all returns are negatively skewed, we need to use asymmetric GARCH models in order to better capture the leverage effect.

5.2 Correlation Between Markets

As a final preparation before applying the stepwise methodology, we also need to check the correlation coefficients between some return series: oil returns, US and EU broad-market indices. If two highly correlated series are included together as explanatory variables in the same regression, that could produce spurious results and influence the value of residuals, which we further employ to measure the variance ratios. Thus, table 5.2.1 below presents the correlation coefficients mentioned above.

$corr(r_{oil_{spot}}, r_{US})$	$corr(r_{oil_{1M}}, r_{US})$	$corr(r_{oil_{3M}}, r_{US})$	$corr(r_{oil_{spot}}, r_{EU})$	$corr(r_{oil_{1M}}, r_{EU})$	$corr(r_{oil_{3M}}, r_{EU})$	$corr(r_{US}, r_{EU})$
0.05	0.10	0.13	0.11	0.18	0.23	0.79

Table 5.2.1 Correlation Coefficients Between Markets

Note: Table 5.2.1 shows the correlation coefficients between the main series we analyze: oil spot/futures oil returns and: 1) US broad index S&P500; 2) EU broad index MSCI EU. The last column offers the correlation between the US and EU market indices.

So, only two series are highly correlated and should have special treatment, and namely: the US and the EU broad-market indices. According to our methodology, these two series appear together in regressions explaining the EU industry returns. So, we decided to include only lagged EU returns in the corresponding regressions (because the European equity market is a better benchmark for these series).

5.3 Oil Volatility Spillovers on Broad-Market Stock Returns

In this section we present the estimation results from applying the first three methodology steps, which are common for all industries. We focus on both spot oil returns and futures contracts. Since all series exhibit negative skewness, we use the GJR asymmetric GARCH. Although return series are also leptokurtic, the *conditional* normal distribution assumption can accommodate excess kurtosis to some extent. All regressions are estimated using EViews software and at each step we verify that the residuals are not autocorrelated or heteroskedastic (Bollerslev-Wooldridge robust standard errors), because otherwise conclusions might be distorted.

Table 5.3.1 below summarizes the estimation results for the spot oil returns (the p-value for each coefficient estimate is offered in brackets).

We start by analyzing the mean equations. Due to the significant first-order autocorrelation in oil returns (documented in summary statistics), the AR(1) coefficient turns out significant in the first equation. So, about one fourth (27%) of oil return in week *t* is translated into the next period's return. However, one-period lagged oil returns have no significant impact on S&P500 or MSCI EU indices (even though parameter estimates are insignificant, they have the intuitive negative sign, i.e. the higher returns are earned in the oil industry, the more depressing it is to other sectors of the economy due to higher energy costs). In support to our findings in the summary statistics (i.e. weak serial correlation in the last two series), the AR(1) term in the US equation (φ_2) is significant at 10% level, but insignificant for EU (φ_3). Both coefficients are negative and small in value, implying weak negative serial correlation.

	φ_0	φ_1	φ_2	γ_1	φ_3	γ_2	ω	α	α^*	β	$\alpha+\beta+0.5\alpha^*\leq 1$
r_{oil}	0.0025 (0.11)	0.2664 (0)	-	-	-	-	0.0001 (0.02)	-0.0227 (0.54)	0.1325 (0)	0.8804 (0)	0.92
r_{US}	0.0006 (0.49)	-0.0012 (0.96)	-0.0833 (0.06)	0.0210 (0.42)	-	-	3.10^{-5} (0)	0.0153 (0.83)	0.2572 (0.01)	0.8044 (0)	0.95
r_{EU}	0.0011 (0.09)	-0.0127 (0.41)	-	0.0792 (0)	-0.0285 (0.32)	0.877 (0)	2.10^{-5} (0.01)	0.1029 (0.16)	0.0793 (0.40)	0.7883 (0)	0.93

Table 5.3.1 Modeling of Spot Oil, US and EU Returns

Note: Table 5.3.1 shows the maximum likelihood coefficient estimates from the following regressions (p-values are offered in brackets):

$$r_{oil,t} = \varphi_{oil,0} + \varphi_{oil,1} r_{oil,t-1} + e_{oil,t} \qquad e_t|\Omega_{t-1} \sim N(0; h_t) \quad (SPOT\ oil\ returns)$$

$$h_{oil,t} = \omega_{oil} + \alpha_{oil} e_{oil,t-1}^2 + \beta_{oil} h_{oil,t-1} + \alpha_{oil}^* e_{oil,t-1}^2 I_{oil,t-1}$$

$I_{oil,t-1} = 1$ if $e_{oil,t-1} < 0$ and 0 otherwise; $\omega_{oil} > 0;\ 0 \leq \alpha_{oil}, \beta_{oil}, \alpha_{oil} + \frac{1}{2}\alpha_{oil}^* \leq 1$

$$r_{US,t} = \varphi_{US,0} + \varphi_{US,1} r_{oil,t-1} + \varphi_{US,2} r_{US,t-1} + \gamma_{US,1} e_{oil,t} + e_{US,t}$$

$$r_{EU,t} = \varphi_{EU,0} + \varphi_{EU,1} r_{oil,t-1} + \varphi_{EU,3} r_{EU,t-1} + \gamma_{EU,1} e_{oil,t} + \gamma_{EU,2} e_{US,t} + e_{EU,t}$$

Next, we consider the gamma coefficients which reflect the volatility spillovers on returns. As can be noted, the US stock market is rather diversified and does not respond to oil shocks (insignificant γ_1). However, the European equity market is highly significantly responsive to both oil shocks and US shocks. The positive signs in both cases indicate that higher positive shocks occurring in the US stock market or oil prices, the more return compensation is required by the European investors. The magnitude of coefficients indicate that about 8% of oil shocks and 88% of the US stock market shocks are translated into the EU returns.

The last column of table 5.3.1 shows that the volatility equation coefficients satisfy the necessary restriction for the model not to be explosive. Analyzing the sign of the asymmetry coefficient α^*, we conclude that it is positive for all three regressions, although for EU equity returns it turns out insignificant. However, for oil returns and US broad equity index the estimates are highly statistically significant (1% significance level), which confirms the commonly documented leverage effect in stock markets. So, *negative* oil and US shocks have more impact on the corresponding returns than positive shocks of the same magnitude. As can be seen, the effect of *positive* shocks on all return series (represented by the coefficient α) is insignificant. Further, the beta coefficient is highly significant for all the series and its value close to unity shows high persistence in the conditional variance (i.e. shocks to the system disappear very slowly). All the intercepts are also significant at 5% level and their magnitude represents the long-run component of the time-varying volatility (it is rather small because we studied weekly returns without annualizing them).

Next, we split the whole sample into two sub-periods in order to analyze the effect of the recent financial crisis. For brevity, we report the corresponding estimation results in the appendix (Tables 8 and 9). So, the autoregressive structure in oil returns remained quite constant between the two periods (no influence from the crisis). However, the impact of oil prices on the US and EU stock markets does not have a clear sign. In the last sub-period, higher energy returns had the intuitive negative effect on the US equity market, but an insignificant positive impact on EU. For the first sub-period the signs and significance are reverse. Remembering that for the whole sample period we found these coefficients insignificant for both markets, we conclude that movements in broad stock markets due to changes in oil prices are ambiguous, allowing for two opposite interpretations: a recession or a booming economy.

Looking at the gamma parameter estimates, we confirm the same conclusion as for the whole period, i.e. that US investors do not require a higher return for increased oil price volatility, while the EU stock market compensates for both oil and US shocks. Additionally, in the second sub-period the values of these parameters increased, suggesting higher investor risk aversion.

Analyzing the volatility equation, we conclude that the above-documented leverage effect in the oil and US stock markets has intensified and became significant only during the financial crisis. Before the crisis the impact of any shocks (positive or negative) on the conditional volatility was insignificant. Both sub-periods are characterized by high persistence in the conditional variance.

Finally, we also consider the futures oil returns. Tables 5.3.2 and 5.3.3 below summarize our findings.

	φ_0	φ_1	φ_2	γ_1	φ_3	γ_2	ω	α	α^*	β	$\alpha+\beta+0.5\alpha^* \le 1$
r_{oil}	0.0028 (0.09)	0.1567 (0)	-	-	-	-	0.0001 (0.07)	-0.0033 (0.93)	0.0712 (0.11)	0.8902 (0)	0.92
r_{US}	0.0006 (0.50)	0.0009 (0.97)	-0.0839 (0.06)	0.0300 (0.26)	-	-	3.10^{-5} (0)	0.0182 (0.81)	0.2613 (0.01)	0.7984 (0)	0.95
r_{EU}	0.0010 (0.10)	-0.0019 (0.91)	-	0.1094 (0)	-0.0231 (0.41)	0.8753 (0)	2.10^{-5} (0.01)	0.1036 (0.15)	0.0954 (0.30)	0.7847 (0)	0.94

Table 5.3.2 Modeling of 1-Month Oil Futures, US and EU Returns

	φ_0	φ_1	φ_2	γ_1	φ_3	γ_2	ω	α	α^*	β	$\alpha+\beta+0.5\alpha^* \le 1$
r_{oil}	0.0030 (0.05)	0.1655 (0)	-	-	-	-	9.10^{-5} (0.08)	-0.0143 (0.70)	0.0713 (0.07)	0.9096 (0)	0.92
r_{US}	0.0006 (0.48)	-0.0041 (0.87)	-0.0858 (0.05)	0.0473 (0.11)	-	-	3.10^{-5} (0)	0.0157 (0.83)	0.2608 (0.01)	0.8006 (0)	0.95
r_{EU}	0.0011 (0.07)	-0.0174 (0.51)	-	0.1507 (0)	-0.0256 (0.35)	0.8664 (0)	2.10^{-5} (0.01)	0.0965 (0.16)	0.1165 (0.20)	0.7746 (0)	0.93

Table 5.3.3 Modeling of 3-Month Oil Futures, US and EU Returns

Note: Tables 5.3.2 and 5.3.3 provide a similar regression output to table 5.3.1, but performed on one-month and three-month oil futures instead of spot oil returns.

So, most coefficient estimates are close to the values found for the spot oil prices, but with two differences. First, there is less persistence in futures oil returns (due to higher uncertainty surrounding them), and namely 16% compared to previously computed 27%. Second, given the increased ambiguity, the European investors' risk aversion to oil volatility (γ_1) is also greater, the longer is the futures contract maturity.

5.4 US Industries Analysis

As a final step, we regress industry returns on their first lag, lagged oil and broad stock market returns, along with the contemporaneous shocks occurred in the respective markets. Table 5.4.1 below presents the estimation results for the nine aggregated US industries considered in our analysis.

	φ_0	φ_1	φ_2	φ_3	γ_1	γ_2	ω	α	α^*	β
Basic Materials	0.0020 (0.01)	-0.1022 (0.02)	-0.0025 (0.89)	-0.0171 (0.80)	0.0529 (0)	1.2276 (80)	6.10^{-6} (0.16)	0.1067 (0.04)	-0.0097 (0.88)	0.8893 (0)
Consumer Goods	0.0008 (0.05)	-0.0143 (0.75)	0.0199 (0.06)	-0.0668 (0.07)	-0.0047 (0.70)	0.7597 (0)	8.10^{-7} (0.29)	0.0679 (0.03)	0.0731 (0.19)	0.8986 (0)
Consumer Services	0.0007 (0.07)	0.0090 (0.84)	-0.0022 (0.83)	-0.0835 (0.09)	-0.0284 (0.01)	0.9829 (0)	3.10^{-6} (0.07)	0.0539 (0.05)	0.0901 (0.03)	0.8796 (0)
Financials	0.0003 (0.44)	-0.0958 (0.02)	0.0020 (0.85)	-0.0056 (0.91)	0.0086 (0.43)	1.0252 (0)	2.10^{-6} (0.08)	0.0611 (0.04)	0.1388 (0.02)	0.8705 (0)
Health Care	0.0005 (0.31)	0.0069 (0.90)	0.0134 (0.27)	-0.0797 (0.06)	-0.0213 (0.11)	0.6980 (0)	5.10^{-6} (0.21)	0.1079 (0.08)	0.0455 (0.55)	0.8579 (0)
Industrials	0.0016 (0)	-0.0801 (0.12)	0.0036 (0.73)	-0.0202 (0.72)	0.0220 (0.06)	1.1269 (0)	6.10^{-6} (0.04)	0.1570 (0.01)	0.1196 (0.32)	0.7731 (0)
Technology	0.0012 (0.07)	-0.1051 (0.01)	-0.0172 (0.32)	0.0418 (0.46)	0.0115 (0.60)	1.1296 (0)	4.10^{-6} (0.26)	0.1355 (0)	-0.0458 (0.42)	0.8847 (0)
Telecom	3.10^{-5} (0.97)	-0.0241 (0.58)	-0.0178 (0.35)	0.0016 (0.98)	-0.0043 (0.83)	0.7931 (0)	6.10^{-6} (0.06)	0.0040 (0.83)	0.0928 (0.01)	0.9353 (0)
Utilities	0.0006 (0.41)	-0.0326 (0.50)	0.0125 (0.51)	0.0241 (0.62)	0.0403 (0.03)	0.6657 (0)	5.10^{-6} (0.25)	0.0796 (0.08)	-0.0021 (0.98)	0.9113 (0)

Table 5.4.1 US Industries Analysis (based on spot oil prices)

Note: Table 5.4.1 presents the parameters estimated using the following regression applied to nine US industry returns: $r_{i,t} = \varphi_{i,0} + \varphi_{i,1} r_{i,t-1} + \varphi_{i,2} r_{oil,t-1} + \varphi_{i,3} r_{US,t-1} + \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + e_{i,t}$ i=1..9

Consistent with our findings in the summary statistics regarding weak signs of serial correlation in the industry returns, we find significant coefficients φ_1 only in three series: *Basic Materials*, *Financials* and *Technology*. Although most of the respective estimates are insignificant, for seven out of nine industries there is negative correlation with the past returns.

Next we analyze coefficients φ_2 and φ_3 showing the effect of *mean* spillovers from oil and broad S&P500 returns respectively. In the case of oil returns, their impact is not statistically different from zero except for the industry *Consumer Goods* (whose estimate is significant at 10% level). So, higher returns in the oil sector do not depress or boost significantly other industries' returns, which is a quite intuitive result. For the S&P500 returns we find three significant estimates, but also only at 10% level, which highlights the diversity across industries and the necessity for modeling industry returns separately.

However, we are more interested in the *volatility* spillovers from oil and the broad US stock market (quantified through the coefficients gamma). Thus, oil shocks are significantly priced for four industry returns, and namely: *Basic Materials, Industrials, Utilities* and *Consumer Services*.

Since higher energy prices imply more risk for the entire economy, positive shocks would require a higher industry return compensation (i.e. a positive γ_1). However, in the case of *Consumer Services*, γ_1 is negative, implying that the corresponding investors get a lower return for the extra oil risk. We also identify a negative parameter for three other industries, but their impact on returns is not statistically different from zero. Further, we consider the coefficient γ_2, which is positive and highly significant for all series. This is the same result as we obtained previously for the broad US equity market. However, the responsiveness of different sectors to movements in the S&P500 index (sort of investor risk aversion) vary from 67-70% for *Utilities* and *Healthcare*, to 113-123% for *Basic Materials, Industrials* and *Technology*. This result seems intuitive given the fast decline in the last three industries when a recession begins (i.e. all companies' capital expenditures fall).

As can be noted, again all the conditional volatilities are highly persistent. Thus, the past week's variance accounts for 77-94% of the current volatility (the lowest beta coefficient is found for *Industrials* and, as will be shown below, it is due to its decrease during the financial crisis).

Another conclusion is that only three US industries exhibit significant leverage effect: *Consumer Services*, *Financials* and *Telecommunications*. Although for three other industries coefficient estimates have the intuitive positive sign, they turn out insignificant. Further, almost all α parameters (capturing the effect of return shocks on the time-varying volatility) are significantly priced and their magnitude implies that news to the market generally account for 7-16% of the current week's volatility. As expected, industries which are most responsive to shocks are those producing durables (i.e. *Industrials* and *Technology*), followed by *Financials* and *Basic Materials*. The least responsive to innovations are the *Consumer Goods*.

Next, we analyze how the industries above behaved during the recent financial crisis. The corresponding estimation results can be found in the appendix (Tables 10-11). Although, the main conclusions still hold, some additional comments could be made. Thus, during the recent economic turmoil the *negative* autocorrelations for all industries increased in magnitude (i.e. investors make greater forecast errors based on the last week's return, after which mean reversion occurs).

Second, the sign and significance of the parameter γ_1 (showing oil volatility spillovers) depends much on the chosen sample.

Finally, the beta coefficients in the conditional volatility equation are somewhat lower in the second sub-period, but the persistence in volatility still remains high[25]. The most substantial impact was typical of the *Industrials* sector, whose estimate became insignificant during the recent financial crisis (while the share of *negative* shocks on the current *Industrial*'s volatility increased up to very close to unity). By comparing the asymmetry parameters α^*, we conclude that both its significance and sign should be interpreted with caution since they depend much on the estimation sample. Across the two studied sub-samples, only one industry (*Telecommunications*) maintains the leverage effect, and two industries (*Basic Materials* and *Utilities*) treat shocks of both sign similarly.

In the last part of the section we consider the estimation results based on one-month oil futures returns (Table 5.4.2).

We conclude that using oil futures instead of spot oil returns do not impact the conclusions above, because the coefficient estimates in both cases are very close to each other. Similar results are also obtained for futures with a longer contract maturity (three months).

[25] Although for two of the estimated GJR GARCH models, the sum of volatility equation coefficients is slightly over unity, that does not impact further results (in many cases we have an IGARCH with coefficients' sum close to unity)

	φ_0	φ_1	φ_2	φ_3	γ_1	γ_2	ω	α	α^*	β
Basic Materials	0.0020 (0.01)	-0.1035 (0.02)	-0.0013 (0.95)	-0.0162 (0.81)	0.0847 (0)	1.2323 (0)	6.10^{-6} (0.16)	0.1029 (0.05)	0.0089 (0.89)	0.8924 (0)
Consumer Goods	0.0008 (0.06)	0.0022 (0.96)	0.0248 (0.01)	-0.0824 (0.02)	-0.0116 (0.31)	0.7650 (0)	9.10^{-7} (0.27)	0.0625 (0.05)	0.0715 (0.20)	0.9034 (0)
Consumer Services	0.0007 (0.05)	0.0138 (0.75)	-0.0083 (0.42)	-0.0935 (0.05)	-0.0255 (0.02)	0.9864 (0)	3.10^{-6} (0.07)	0.0520 (0.06)	0.0952 (0.03)	0.8784 (0)
Financials	0.0003 (0.44)	-0.0968 (0.02)	0.0037 (0.72)	-0.0045 (0.93)	0.0110 (0.29)	1.0244 (0)	2.10^{-6} (0.08)	0.0624 (0.04)	0.1362 (0.02)	0.8699 (0)
Health Care	0.0005 (0.27)	0.0152 (0.79)	0.0113 (0.38)	-0.0826 (0.06)	-0.0415 (0)	0.6985 (0)	5.10^{-6} (0.19)	0.1102 (0.09)	0.0524 (0.49)	0.8520 (0)
Industrials	0.0015 (0)	-0.0805 (0.11)	0.0082 (0.40)	-0.0201 (0.72)	0.0250 (0.04)	1.1287 (0)	6.10^{-6} (0.03)	0.1630 (0.01)	0.1199 (0.32)	0.7674 (0)
Technology	0.0012 (0.07)	-0.1035 (0.01)	-0.0175 (0.32)	0.0398 (0.48)	0.0232 (0.27)	1.1303 (0)	4.10^{-6} (0.25)	0.1352 (0)	-0.0462 (0.41)	0.8850 (0)
Telecom	1.10^{-5} (0.99)	-0.0220 (0.61)	-0.0190 (0.33)	-0.0031 (0.95)	0.0179 (0.36)	0.7921 (0)	6.10^{-6} (0.06)	0.0039 (0.83)	0.0940 (0.01)	0.9348 (0)
Utilities	0.0007 (0.36)	-0.0292 (0.55)	0.0076 (0.70)	0.0156 (0.74)	0.0939 (0)	0.6568 (0)	5.10^{-7} (0.26)	0.0760 (0.10)	0.0032 (0.96)	0.9120 (0)

Table 5.4.2 US Industries Analysis (based on one-month oil futures)

Note: Table 5.4.2 shows a similar regression output to table 5.4.1, but this time we use one-month oil futures instead of spot oil returns.

5.5 EU Industries Analysis

In this section we conduct a similar study for the European industries. We present the estimation output based on spot oil returns in table 5.5.1.

	φ_0	φ_1	φ_2	φ_4	γ_1	γ_2	γ_3	ω	α	α^*	β
Basic Materials	0.0033 (0)	-0.1075 (0.01)	0.0063 (0.61)	0.1180 (0.02)	0.1005 (0)	0.9062 (0)	1.1164 (0)	2.10^{-6} (0.13)	0.1132 (0)	-0.0408 (0.34)	0.9071 (0)
Consumer Goods	0.0021 (0)	0.0552 (0.22)	-0.0016 (0.89)	-0.0750 (0.06)	0.0491 (0)	0.7927 (0)	0.8834 (0)	4.10^{-6} (0.03)	0.1165 (0.02)	0.0998 (0.23)	0.8358 (0)
Consumer Services	0.0010 (0.01)	0.0554 (0.22)	-0.0172 (0.06)	-0.0332 (0.42)	0.0623 (0)	0.7484 (0)	0.9502 (0)	8.10^{-7} (0.17)	0.0125 (0.59)	0.0651 (0.06)	0.9476 (0)
Financials	0.0008 (0.01)	0.0603 (0.18)	-0.0184 (0.02)	-0.0367 (0.43)	0.0666 (0)	0.8970 (0)	1.0417 (0)	2.10^{-6} (0)	0.0356 (0.21)	0.1565 (0)	0.8790 (0)
Health Care	0.0011 (0.04)	-0.0712 (0.11)	0.0090 (0.49)	0.0173 (0.62)	0.0377 (0.01)	0.5415 (0)	0.7553 (0)	3.10^{-6} (0.08)	0.0943 (0.01)	0.0413 (0.48)	0.8774 (0)
Industrials	0.0022 (0)	0.0201 (0.67)	0.0007 (0.94)	-0.0075 (0.89)	0.0863 (0)	0.9615 (0)	1.0534 (0)	1.10^{-5} (0.02)	0.1692 (0.05)	0.0555 (0.59)	0.7440 (0)
Technology	0.0012 (0.14)	-0.0103 (0.80)	-0.0366 (0.07)	0.0064 (0.90)	0.0600 (0.01)	1.0036 (0)	0.8679 (0)	2.10^{-6} (0.19)	0.0698 (0)	-0.0123 (0.46)	0.9330 (0)
Telecom	0.0009 (0.17)	0.0291 (0.48)	-0.0199 (0.28)	-0.0283 (0.59)	0.0362 (0.06)	0.6854 (0)	0.9890 (0)	4.10^{-6} (0.13)	0.0717 (0.01)	0.0151 (0.70)	0.9142 (0)
Utilities	0.0016 (0.01)	-0.0130 (0.75)	-0.0035 (0.80)	0.0320 (0.37)	0.0614 (0)	0.5379 (0)	0.9175 (0)	2.10^{-5} (0.01)	0.0966 (0.01)	0.0493 (0.30)	0.8155 (0)

Table 5.5.1 EU Industries Analysis (based on spot oil prices)

Note: Table 5.5.1 presents the parameters estimated using the following regression applied to nine EU industry returns:

$$r_{i,t} = \varphi_{i,0} + \varphi_{i,1} r_{i,t-1} + \varphi_{i,2} r_{oil,t-1} + \varphi_{i,4} r_{EU,t-1} + \gamma_{i,1} e_{oil,t} + \gamma_{i,2} e_{US,t} + \gamma_{i,3} e_{EU,t} + e_{i,t} \qquad \text{i=1..9}$$

Considering the mean return spillovers from the oil and the broad EU stock markets respectively, we conclude that they do not follow the same pattern as for US and only few coefficients are significant at 10% level (this significance is probably occasional and depends on the sample selection). So, we reach the same conclusion that the magnitude of oil and lagged EU stock returns does not significantly affect a particular industry's returns.

But a more interesting result are the volatility spillover coefficients gamma, which all turn out positive and highly significant. Even for the US industries these effects were not so strong and the sign of the parameter γ_1 varied between positive and negative. So, the European investors get an explicit return compensation for each oil, US (global) and EU (regional) positive shock. More specifically, 4-10% of current period's *oil* shocks are compensated through higher/lower returns. The industries most affected by energy prices are *Basic Materials* and *Industrials*. The least affected are *Telecommunications*, *Healthcare* and *Consumer Goods*. Comparing the values of γ_2 for the EU and US industries, we conclude that generally the European sectors incorporate slightly less of the US stock market shocks, but the difference is minor. Thus, about 54-100% of the S&P500 innovations are translated directly into the EU returns, even without having an economic motivation. Consistent with the conclusions made in the previous section, the most responsive industries are *Basic Materials*, *Industrials* and *Technology*. The least susceptible sectors are *Utilities* and *Healthcare*. Finally, the values of γ_3 which are close to unity show that the regional European stock market news are almost entirely incorporated into each industry's returns.

So in conclusion, the European industries are much more susceptible to oil and stock market shocks compared to their US counterparts, which should be considered by investors, analysts and corporate managers.

In the volatility equation we again document high persistence in the conditional variance and, similar to the US industries, the lowest coefficient is typical of *Industrials* after a substantial decrease in beta estimate during the recent financial crisis (see Tables 12-13 in the appendix). We identify *significant* leverage effect (at 10% level) for only two EU industries (*Consumer Services* and *Financials*), but unlike the US case, the positive shocks for these two sectors are not significantly quantified into the conditional volatility. For the remaining seven EU industries α estimates are significant at 5% level and their magnitude shows that news to the market account for 7-16% of the current volatility. The least responsive is *Technology*, while the most sensitive to shocks are *Industrials*.

By analogy to the US industries, we split the whole sample into two sub-periods and offer the regression output in the appendix (Tables 12-13). For most industries the oil volatility spillovers increased during the crisis, except *Consumer Services*, *Telecommunications* whose coefficients became insignificant (possibly due to a higher priority given to other equity shocks). By comparing all the three gammas across different economic sectors, we conclude that volatility spillovers increased for *Basic Materials* and *Financials*, but dropped for *Consumer Services*, *Technology* and *Telecommunications*.

Similar to our findings for the US industries, the European sectors were also characterized by lower beta coefficients during the recent financial turmoil. The greatest variations in volatility can be noticed for *Industrials* and *Technology*. The asymmetry parameters α^* depend much on the estimation sample and no general conclusion can be made.

Finally, we also present the results from substituting oil spot returns with one-month futures (Table 5.5.2). As can be noted the coefficients do not change much in value or significance, except for γ_1. Given the higher uncertainty surrounding the expected energy prices one month ahead, there is a wider range of variation for the amount of oil shocks incorporated into the EU industry returns (2-14% compared to spot oil returns – 4-10%).

	φ_0	φ_1	φ_2	φ_4	γ_1	γ_2	γ_3	ω	α	α^*	β
Basic Materials	0.0034 (0)	-0.1130 (0.01)	0.0071 (0.59)	0.1171 (0.02)	0.1442 (0)	0.9068 (0)	1.1061 (0)	2.10^{-6} (0.13)	0.1204 (0)	-0.0527 (0.25)	0.9057 (0)
Consumer Goods	0.0022 (0)	0.0707 (0.12)	0.0091 (0.44)	-0.0996 (0.01)	0.0611 (0)	0.7941 (0)	0.8932 (0)	4.10^{-6} (0.03)	0.1136 (0.02)	0.1204 (0.19)	0.8281 (0)
Consumer Services	0.0010 (0.01)	0.0355 (0.44)	-0.0090 (0.32)	-0.0226 (0.59)	0.0803 (0)	0.7484 (0)	0.9572 (0)	8.10^{-7} (0.10)	0.0151 (0.55)	0.0687 (0.06)	0.9429 (0)
Financials	0.0008 (0.01)	0.0486 (0.29)	-0.0080 (0.35)	-0.0289 (0.54)	0.0891 (0)	0.8973 (0)	1.0558 (0)	2.10^{-6} (0)	0.0302 (0.27)	0.1528 (0)	0.8832 (0)
Health Care	0.0011 (0.03)	-0.0834 (0.05)	0.0225 (0.13)	0.0178 (0.62)	0.0242 (0.07)	0.5387 (0)	0.7805 (0)	3.10^{-6} (0.08)	0.1119 (0.01)	0.0394 (0.52)	0.8635 (0)
Industrials	0.0023 (0)	0.0253 (0.60)	0.0066 (0.53)	-0.0165 (0.78)	0.1238 (0)	0.9421 (0)	1.0399 (0)	1.10^{-5} (0.02)	0.2048 (0.05)	0.0589 (0.62)	0.7010 (0)
Technology	0.0011 (0.16)	0.0024 (0.95)	-0.0211 (0.32)	-0.0103 (0.84)	0.0748 (0.01)	1.0024 (0)	0.8887 (0)	2.10^{-6} (0.41)	0.0689 (0.02)	-0.0106 (0.75)	0.9330 (0)
Telecom	0.0009 (0.16)	0.0202 (0.62)	0.0021 (0.92)	-0.0308 (0.55)	0.0462 (0.01)	0.6892 (0)	1.0175 (0)	3.10^{-6} (0.16)	0.0710 (0.01)	0.0121 (0.75)	0.9175 (0)
Utilities	0.0016 (0.01)	-0.0421 (0.34)	0.0072 (0.69)	0.0495 (0.21)	0.0987 (0)	0.5299 (0)	0.9232 (0)	2.10^{-5} (0.05)	0.1009 (0.04)	0.0552 (0.50)	0.8025 (0)

Table 5.5.2 EU Industries Analysis (based on one-month oil futures)

Note: Table 5.5.2 shows a similar regression output to table 5.5.1, but this time we use one-month oil futures instead of spot oil returns.

5.6 Variance Ratios

By analyzing the significance of gamma coefficients, we determined whether an industry's return is affected by oil, global US or regional EU shocks. But now we compute the share of each of these markets in an industry's total volatility. Tables 5.6.1 and 5.6.2 present the average variance ratio characteristic to the US and EU industries respectively.

	Basic Materials	Cons. Goods	Cons. Services	Financials	Health Care	Industrials	Technology	Telecom	Utilities
					Spot Oil Returns				
VR_{oil}	0.0039	0.0001	0.0022	0.0002	0.0018	0.0010	0.0002	0.0000	0.0046
VR_{US}	0.6268	0.6162	0.8063	0.7217	0.5749	0.8163	0.6042	0.4437	0.3977
VR_i	0.3693	0.3838	0.1915	0.2782	0.4233	0.1827	0.3956	0.5563	0.5978
					Sub-Sample 1 (1999-2006)				
VR_{oil}	0.0016	0.0016	0.0003	0.0001	0.0062	0.0007	0.0043	0.0004	0.0049
VR_{US}	0.5631	0.6499	0.7909	0.7443	0.5161	0.7690	0.6448	0.4064	0.2355
VR_i	0.4354	0.3485	0.2088	0.2556	0.4777	0.2303	0.3509	0.5931	0.7596
					Sub-Sample 2 (2006-2011)				
VR_{oil}	0.0087	0.0014	0.0057	0.0000	0.0000	0.0011	0.0015	0.0022	0.0026
VR_{US}	0.7091	0.8212	0.8598	0.7096	0.6546	0.8843	0.7378	0.5169	0.5703
VR_i	0.2823	0.1774	0.1345	0.2903	0.3453	0.1146	0.2607	0.4808	0.4271
					One-Month Oil Futures				
VR_{oil}	0.0110	0.0005	0.0020	0.0003	0.0074	0.0015	0.0009	0.0008	0.0273
VR_{US}	0.6251	0.6213	0.8094	0.7216	0.5771	0.8161	0.6039	0.4422	0.3840
VR_i	0.3640	0.3781	0.1886	0.2780	0.4155	0.1824	0.3952	0.5571	0.5886

Table 5.6.1 Average Variance Ratios for the US Industries

Note: Table 5.6.1 shows the average variance ratios for the US industry returns (both spot and futures oil returns, along with the whole data sample split into two sub-periods).

The first part of table 5.6.1 shows that oil volatility spillovers (based on spot oil returns) hold a very small share in an US industry's variance (0-0.46%), being highest for *Utilities* and *Basic Materials*, and lowest for *Telecommunications*, *Consumer Goods*, *Financials* and *Technology*. By splitting the whole data sample into two sub-periods, we conclude that during the recent turmoil oil spillovers increased for *Basic Materials*, *Consumer Services*, *Industrials* and *Telecommunications*, which represent sectors affected in first place during a crisis except for the last one (in fact the variance ratios for *Telecommunications* are less credible since for both sub-samples they increased compared to the zero value for the whole period; that could be attributed to small samples problem). As known, *Financials* were also much affected by the crisis, but oil has very little impact on this sector and that is why its oil variance ratios remained among the lowest. The oil ratios for *Consumer Goods* also remained mostly stable between the sub-periods, given that this industry is least affected by crises. We also note that substituting spot energy prices by one-month futures[26] leads to a higher range for oil ratios (0.03-2.73%), although the repartition among sectors follows the same pattern. A final remark is that the US *Healthcare* industry has a relatively high oil variance ratio among industries.

Next, we consider the EU variance ratios presented in Table 5.6.2. Firstly, we observe that the European oil ratios are higher, varying between 0.23-1.55% for spot returns and 0.21-4.66% for one-month futures. So, the European sectors are more susceptible to oil shocks. Again *Basic Materials* and *Utilities* are among the most responsive (along with *Industrials*), while *Telecommunications*, *Technology* and *Consumer Goods* are the least exposed. Unlike for US, the EU *Healthcare* is relatively little affected by oil news, while *Financials* are much more.

Considering the two sub-periods, we find out that during the crisis oil ratios rose for *Basic Materials*, *Consumer Goods*, *Industrials*, *Technology* and *Utilities*. That is partially different from the US results, since even for industries affected more slowly by recessions (*Consumer Goods*, *Technology* and *Utilities*) oil news' influence increased.

[26] We do not report results for three-month futures because they are very similar to one-month contracts.

	Basic Materials	Cons. Goods	Cons. Services	Financials	Health Care	Industrials	Technology	Telecom	Utilities
Spot Oil Returns									
VR_{oil}	0.0155	0.0053	0.0077	0.0088	0.0045	0.0130	0.0044	0.0023	0.0096
VR_{US}	0.3949	0.4309	0.4443	0.4930	0.2993	0.5133	0.3983	0.2630	0.2499
VR_{EU}	0.3224	0.2962	0.3911	0.3648	0.3136	0.3376	0.1680	0.2996	0.3801
VR_i	0.2672	0.2677	0.1570	0.1334	0.3825	0.1361	0.4293	0.4351	0.3604
Sub-Sample 1 (1999-2006)									
VR_{oil}	0.0081	0.0070	0.0207	0.0090	0.0033	0.0137	0.0073	0.0075	0.0061
VR_{US}	0.3776	0.4090	0.4384	0.4964	0.2650	0.5173	0.4964	0.2799	0.2108
VR_{EU}	0.3405	0.2846	0.3906	0.3842	0.3089	0.3269	0.1520	0.2742	0.3084
VR_i	0.2738	0.2995	0.1503	0.1105	0.4228	0.1422	0.3443	0.4385	0.4747
Sub-Sample 2 (2006-2011)									
VR_{oil}	0.0428	0.0085	0.0007	0.0074	0.0012	0.0144	0.0124	0.0002	0.0079
VR_{US}	0.5042	0.5114	0.4914	0.5491	0.3529	0.5138	0.4624	0.3050	0.2865
VR_{EU}	0.2388	0.3103	0.3608	0.3139	0.3095	0.3580	0.2632	0.4019	0.4283
VR_i	0.2143	0.1698	0.1471	0.1296	0.3363	0.1139	0.2620	0.2930	0.2774
One-Month Oil Futures									
VR_{oil}	0.0343	0.0466	0.0177	0.0171	0.0021	0.0299	0.0075	0.0041	0.0272
VR_{US}	0.3908	0.0054	0.4398	0.4868	0.2958	0.4985	0.3944	0.2632	0.2408
VR_{EU}	0.3063	0.4564	0.3835	0.3617	0.3271	0.3260	0.1711	0.3069	0.3748
VR_i	0.2686	0.4916	0.1589	0.1344	0.3751	0.1456	0.4269	0.4259	0.3572

Table 5.6.2 Average Variance Ratios for the EU Industries

Note: Table 5.6.2 shows the average variance ratios for the EU industry returns (both spot and futures oil returns, along with the whole data sample split into two sub-periods).

6. Conclusion

6.1 Concluding Remarks

The present essay examined the extent to which shocks and volatility are transmitted between oil prices and the major European and American industries: *Basic Materials, Consumer Goods, Consumer Services, Financials, Healthcare, Industrials, Technology, Telecommunications* and *Utilities*.
Our analysis used weekly data from 1 January 1999 to 15 April 2011. Additionally, we split the whole time interval into two sub-periods: pre-crisis (1999-2006) and the period afterwards (2007-2011) to capture the particularities of the recent economic turmoil.
We show that lagged oil returns have no significant impact on the broad indices: S&P500 and MSCI EU. Even for the US or EU industries we do not find important *mean spillovers* from the energy market.

Considering the *volatility spillovers*, the broad US stock market does not respond to oil shocks, but the EU market is significantly responsive to both oil shocks and US equity shocks. About 8% of oil shocks and 88% of US shocks are compensated for the EU equity investors (positive shocks increase returns). During the recent crisis, EU investors increased their risk aversion by requiring a higher share of shocks to be compensated. Risk aversion is also higher for futures oil returns, implying greater uncertainty about energy price movements.

For the *US industries* we conclude that oil news significantly affect *Basic Materials*, *Industrials*, *Utilities* and *Consumer Services* (the last industry having a negative coefficient). However, splitting the sample into two sub-periods we show that the sign and significance of oil spillover coefficients depend much on the estimation sample. All innovations to the S&P500 index are positively and significantly priced in the US industries (the same conclusion holds for sub-periods). Using oil futures instead of spot returns does not affect results.

The *EU industries* are much more sensitive to oil, US and regional EU shocks. All volatility spillover coefficients are positive and highly significant. About 4-10% of *oil* shocks, 54-100% of the S&P500 innovations and all the EU news are compensated through returns. The industries most affected by oil are *Basic Materials* and *Industrials*, while the least affected are *Telecommunications*, *Healthcare* and *Consumer Goods*. During the crisis oil volatility transmission rose for most industries. Substituting spot oil returns by futures, we conclude that a larger share of oil future shocks transmits to current industry returns.

Finally, computing variance ratios, we show that the share of oil shocks in an industry's total volatility remains very small (within the range 0-0.46% for US sectors and 0.23-1.55% for EU) compared to the innovations from the broad US and EU stock markets. For futures contracts these ratios are higher, and namely 0.03-2.73% and 0.21-4.66% respectively.

6.2 Possible Extensions

A possible extension of our essay would be to study the impact of oil volatility spillovers on emerging markets, where the variance ratios might be different. We also encourage studies of non-linear relationships between oil shocks and industry stock markets, because in our work we only employed a direct linear relationship.

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Appendix

Industry	Sub-Industries
Basic Materials	Chemicals, Forestry & Paper, Industrial Metals & Mining, Paper & Forest Products
Consumer Goods	Automobiles & Parts, Food & Beverage, Personal & Household Goods (Household & Home Construction, Leisure Goods, Clothing, Footwear, Tobacco)
Consumer Services	Retailers, Media, Travel & Leisure (Airlines, Gambling, Hotels, Restaurants, Travel)
Financials	Banks, Financial Services, Insurance, Real Estate, Equity Investment Instruments
Healthcare	Pharmaceuticals, Biotechnology, Healthcare Equipment
Industrials	Construction & Materials, Industrial Goods & Services (Aerospace, Containers & Packaging, Electronic & Electric Equipment, Industrial Engineering, Industrial Transportation, Support Services)
Technology	Software & Services, Hardware & Equipment, Semiconductors
Telecommunications	Fixed Line Telecommunications, Mobile Telecommunications
Utilities	Electricity, Gas, Water, Multi-Utilities

Table 1. Composition of US and EU Industry Indices

Tables 2-4 present summary statistics for the first sub-period (8 January 1999 – 29 December 2006, i.e. 417 observations) and tables 5-7 offer similar information for the second interval (29 December 2006 – 15 April 2011, i.e. 225 observations). More specifically, we summarize the following measures: mean, median, standard deviation, skewness, kurtosis, Jarque-Berra test and its corresponding p-value).

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Oil Spot	0.0042	0.0060	0.0409	-0.67	4.27	59.4	0
1M Oil Futures	0.0039	0.0069	0.0404	-0.81	5.08	121.0	0
3M Oil Futures	0.0039	0.0062	0.0353	-0.81	5.28	135.5	0
S&P500	0.0003	0.0016	0.0236	-0.57	6.27	208.1	0
MSCI EU	0.0009	0.0035	0.0235	-0.24	5.12	82.1	0

Table 2. Summary statistics for oil returns and broad US and EU equity markets (1999-2006)

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0011	0.0027	0.0319	-0.32	5.51	116.9	0
Consumer Goods	-0.0004	0.0007	0.0277	-1.02	9.78	871.2	0
Consumer Services	0.0004	0.0011	0.0280	-0.59	6.41	225.4	0
Financials	-0.0012	0.0007	0.0278	0.37	6.02	167.4	0
Health Care	0.0003	0.00005	0.0222	-0.29	5.95	157.4	0
Industrials	0.0011	0.0022	0.0296	-0.74	8.64	589.6	0
Technology	-0.0006	-0.0009	0.0468	-0.63	6.93	296.4	0
Telecom	-0.0012	-0.0010	0.0325	-0.22	5.21	88.4	0
Utilities	0.0006	0.0010	0.0253	-0.65	6.08	194.9	0

Table 3. Summary statistics for the US industries (1999-2006)

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0025	0.0040	0.0264	-0.70	6.27	220.2	0
Consumer Goods	0.0011	0.0025	0.0285	-1.04	9.16	734.7	0
Consumer Services	0.0008	0.0025	0.0246	-0.63	6.27	213.6	0
Financials	0.0013	0.0026	0.0256	-0.41	7.60	378.9	0
Health Care	0.0009	0.0017	0.0206	-0.13	4.42	36.1	0
Industrials	0.0019	0.0045	0.0280	-0.66	4.61	75.2	0
Technology	-0.00008	0.0024	0.0500	-0.33	4.31	37.4	0
Telecom	-0.0002	0.0024	0.0374	-0.15	4.44	37.3	0
Utilities	0.0016	0.0016	0.0196	-0.08	3.62	7.0	0.03

Table 4. Summary statistics for the EU industries (1999-2006)

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Oil Spot	0.0033	0.0057	0.0450	-0.17	5.67	68.0	0
1M Oil Futures	0.0024	0.0070	0.0489	-0.51	4.64	35.1	0
3M Oil Futures	0.0023	0.0069	0.0434	-0.54	3.76	16.2	0
S&P500	-0.0003	0.0014	0.0327	-0.93	9.72	455.6	0
MSCI EU	-0.0008	0.0044	0.0414	-1.49	11.15	706.0	0

Table 5. Summary statistics for oil returns and broad US and EU equity markets (2006-2011)

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0016	0.0073	0.0493	-0.66	5.57	78.3	0
Consumer Goods	0.0006	0.0014	0.0249	-1.70	15.98	1688.1	0
Consumer Services	0.0003	0.0032	0.0331	-0.59	8.39	285.2	0
Financials	-0.0028	0.0001	0.0530	-0.07	8.65	299.0	0
Health Care	0.0003	0.0013	0.0273	-1.92	16.86	1939.7	0
Industrials	0.0003	0.0012	0.0373	-0.33	5.01	42.0	0
Technology	0.0009	0.0039	0.0344	-0.68	5.68	85.0	0
Telecom	-0.0007	-0.0004	0.0337	-0.90	13.36	1036.7	0
Utilities	-0.0005	0.0012	0.0314	-1.94	15.44	1591.2	0

Table 6. Summary statistics for the US industries (2006-2011)

	Mean	*Median*	*Std. Dev*	*Skewness*	*Kurtosis*	*JB*	*p-value*
Basic Materials	0.0011	0.0083	0.0579	-0.73	6.13	111.7	0
Consumer Goods	0.0006	0.0059	0.0377	-0.81	9.76	452.7	0
Consumer Services	-0.0009	0.0046	0.0369	-1.24	9.03	397.7	0
Financials	-0.0029	0.0026	0.0519	-1.31	8.68	366.2	0
Health Care	-0.00002	0.0039	0.0333	-2.13	16.25	1815.0	0
Industrials	-0.0001	0.0052	0.0439	-0.90	6.29	132.2	0
Technology	-0.0007	0.0022	0.0414	-1.22	8.57	346.7	0
Telecom	-0.0004	0.0014	0.0365	-1.71	12.66	984.4	0
Utilities	-0.0012	0.0044	0.0405	-2.14	17.05	2024.0	0

Table 7. Summary statistics for the EU industries (2006-2011)

Tables 8 and 9 show the estimation results for the first three methodology steps when the whole data sample is split into two sub-periods: 8 January 1999 – 29 December 2006 and 29 December 2006 – 15 April 2011.

	φ_0	φ_1	φ_2	γ_1	φ_3	γ_2	ω	α	α^*	β	$\alpha+\beta + 0.5\alpha^* \leq 1$
r_{oil}	0.0022 (0.25)	0.2802 (0)	-	-	-	-	0.0002 (0.20)	-0.0077 (0.89)	0.0796 (0.11)	0.8495 (0)	0.88
r_{US}	0.0007 (0.44)	0.0180 (0.43)	-0.1282 (0.01)	-0.0151 (0.55)	-	-	6.10^{-6} (0.22)	0.0050 (0.95)	0.1260 (0.11)	0.9160 (0)	0.98
r_{EU}	0.0014 (0.07)	-0.0283 (0.10)	-	0.0519 (0)	-0.0175 (0.66)	0.7298 (0)	5.10^{-5} (0.08)	0.0861 (0.32)	0.1000 (0.46)	0.6795 (0)	0.82

Table 8. Modeling of Spot Oil, US and EU Returns (1999-2006)

	φ_0	φ_1	φ_2	γ_1	φ_3	γ_2	ω	α	α^*	β	$\alpha+\beta$ $+0.5\alpha^*$ ≤ 1
r_{oil}	0.0037 (0.13)	0.2480 (0)	-	-	-	-	8.10^{-5} (0.13)	-0.0326 (0.60)	0.1867 (0.02)	0.8815 (0)	0.94
r_{US}	0.0014 (0.40)	-0.0782 (0.09)	-0.0753 (0.33)	0.0800 (0.12)	-	-	8.10^{-5} (0.02)	-0.0123 (0.87)	0.3758 (0.06)	0.7041 (0)	0.88
r_{EU}	-0.0002 (0.87)	0.0141 (0.66)	-	0.1180 (0.001)	-0.0764 (0.08)	1.0372 (0)	2.10^{-5} (0.02)	0.0103 (0.93)	0.1774 (0.23)	0.8629 (0)	0.96

Table 9. Modeling of Spot Oil, US and EU Returns (2006-2011)

Tables 10 and 11 show the estimation results for the US industries when the whole data sample is divided into two parts: 1999-2006 and 2006-2011. Tables 12 and 13 offer similar information for the EU industries.

	φ_0	φ_1	φ_2	φ_3	γ_1	γ_2	ω	α	α^*	β
Basic Materials	0.0016 (0.08)	-0.0181 (0.72)	5.10^{-5} (1.0)	-0.1092 (0.14)	0.0283 (0.21)	1.1017 (0)	3.10^{-6} (0.35)	0.0477 (0.13)	-0.0018 (0.96)	0.9408 (0)
Consumer Goods	-0.0012 (0.09)	-5.10^{-5} (1.0)	0.0007 (0.97)	-0.0133 (0.80)	0.0249 (0.23)	1.0209 (0)	-2.10^{-6} (0)	-0.0307 (0.01)	0.0583 (0.02)	1.0077 (0)
Consumer Services	0.0002 (0.73)	0.0141 (0.79)	0.0089 (0.44)	-0.0763 (0.20)	-0.0095 (0.43)	1.0459 (0)	1.10^{-6} (0.30)	0.0268 (0.27)	0.0524 (0.17)	0.9368 (0)
Financials	0.0010 (0.04)	-0.0577 (0.26)	0.0084 (0.45)	-0.0412 (0.49)	0.0051 (0.70)	0.9741 (0)	1.10^{-6} (0.39)	0.0509 (0.15)	0.0512 (0.33)	0.9147 (0)
Health Care	0.0002 (0.74)	0.0117 (0.84)	-0.0065 (0.64)	-0.1252 (0.01)	-0.0355 (0.05)	0.6638 (0)	2.10^{-6} (0.18)	0.0324 (0.43)	0.1416 (0.08)	0.8927 (0)
Industrials	0.0014 (0.01)	-0.0475 (0.35)	-0.0105 (0.41)	-0.0748 (0.21)	0.0164 (0.24)	1.1098 (0)	3.10^{-6} (0.28)	0.1335 (0.03)	0.0257 (0.76)	0.8499 (0)
Technology	-9.10^{-5} (0.92)	-0.0948 (0.06)	-0.0111 (0.60)	0.0972 (0.32)	0.0580 (0.01)	1.4737 (0)	4.10^{-6} (0.34)	0.1180 (0.04)	0.0001 (1.0)	0.8773 (0)
Telecom	-0.0002 (0.87)	-0.0032 (0.95)	-0.0041 (0.86)	0.0038 (0.96)	0.0137 (0.59)	0.8557 (0)	5.10^{-6} (0.16)	0.0042 (0.85)	0.0861 (0.07)	0.9422 (0)
Utilities	0.0016 (0.06)	0.0026 (0.97)	0.0221 (0.39)	0.0623 (0.28)	0.0365 (0.09)	0.5063 (0)	3.10^{-6} (0.60)	0.1162 (0.11)	-0.0327 (0.73)	0.8984 (0)

Table 10. US Industries Analysis (1999-2006)

	φ_0	φ_1	φ_2	φ_3	γ_1	γ_2	ω	α	α^*	β
Basic Materials	0.0036 (0.01)	-0.2680 (0)	-0.0155 (0.69)	0.1637 (0.19)	0.0979 (0.01)	1.3729 (0)	1.10^{-5} (0.33)	0.1619 (0.28)	-0.0751 (0.68)	0.8690 (0)
Consumer Goods	0.0014 (0)	-0.0698 (0.35)	0.0195 (0.12)	-0.0340 (0.55)	-0.0188 (0.11)	0.7108 (0)	2.10^{-6} (0.06)	0.1267 (0.14)	-0.0257 (0.76)	0.8644 (0)
Consumer Services	0.0014 (0.02)	-0.0177 (0.80)	-0.0251 (0.11)	-0.0439 (0.55)	-0.0500 (0)	0.9602 (0)	4.10^{-6} (0.18)	0.0967 (0.14)	0.1169 (0.27)	0.8126 (0)
Financials	-0.0018 (0.01)	-0.2068 (0)	-0.0437 (0.02)	0.1192 (0.11)	0.0056 (0.80)	1.1583 (0)	4.10^{-6} (0.02)	-0.0432 (0.20)	0.4235 (0)	0.8823 (0)
Health Care	0.0008 (0.31)	0.0096 (0.91)	0.0447 (0.03)	-0.0626 (0.39)	-0.0033 (0.90)	0.7231 (0)	6.10^{-6} (0.40)	0.1561 (0.13)	-0.1207 (0.30)	0.8827 (0)
Industrials	0.0015 (0.03)	-0.0542 (0.56)	0.0146 (0.41)	-0.0061 (0.96)	0.0253 (0.10)	1.1323 (0)	4.10^{-5} (0)	0.2322 (0.06)	0.9707 (0.02)	0.0873 (0.35)
Technology	0.0023 (0.01)	-0.1175 (0.07)	0.0009 (0.97)	0.0320 (0.64)	0.0289 (0.27)	0.9921 (0)	8.10^{-6} (0.59)	0.2179 (0.03)	-0.1984 (0.08)	0.8611 (0)
Telecom	0.0003 (0.82)	-0.0545 (0.43)	-0.0410 (0.19)	0.0441 (0.54)	-0.0323 (0.32)	0.7354 (0)	1.10^{-5} (0.11)	-0.0433 (0.21)	0.1705 (0.01)	0.9202 (0)
Utilities	-0.0005 (0.64)	-0.0232 (0.79)	0.0129 (0.66)	-0.0242 (0.75)	0.0344 (0.23)	0.7733 (0)	3.10^{-5} (0.15)	0.1221 (0.26)	0.0472 (0.75)	0.7540 (0)

Table 11. US Industries Analysis (2006-2011)

	φ_0	φ_1	φ_2	φ_4	γ_1	γ_2	γ_3	ω	α	α^*	β
Basic Materials	0.0032 (0)	-0.0497 (0.36)	0.0049 (0.72)	0.0968 (0.09)	0.0597 (0)	0.7731 (0)	1.0128 (0)	3.10^{-6} (0.17)	0.1538 (0.01)	-0.1109 (0.15)	0.8975 (0)
Consumer Goods	0.0012 (0.07)	0.1056 (0.05)	-0.0011 (0.93)	-0.0670 (0.28)	0.0557 (0)	0.8400 (0)	0.9230 (0)	6.10^{-7} (0)	0.0181 (0.65)	0.0382 (0.59)	0.9633 (0)
Consumer Services	0.0009 (0.04)	0.0854 (0.10)	-0.0166 (0.10)	-0.0090 (0.86)	0.0880 (0)	0.7734 (0)	0.9962 (0)	4.10^{-7} (0.32)	0.0142 (0.69)	0.0301 (0.54)	0.9626 (0)
Financials	0.0014 (0)	0.0488 (0.34)	-0.0180 (0.04)	-0.0299 (0.58)	0.0593 (0)	0.8570 (0)	1.0157 (0)	1.10^{-6} (0.08)	0.0795 (0.02)	0.1237 (0.15)	0.8456 (0)
Health Care	0.0010 (0.07)	-0.0235 (0.63)	-0.0076 (0.57)	-0.0559 (0.20)	0.0294 (0.07)	0.5088 (0)	0.7408 (0)	2.10^{-6} (0.17)	0.0310 (0.28)	0.0959 (0.08)	0.9151 (0)
Industrials	0.0022 (0)	0.0695 (0.16)	0.0010 (0.93)	0.0083 (0.88)	0.0843 (0)	0.9910 (0)	1.0683 (0)	8.10^{-7} (0.42)	0.0901 (0.07)	-0.0826 (0.17)	0.9481 (0)
Technology	0.0004 (0.72)	0.0546 (0.29)	-0.0334 (0.24)	-0.1634 (0.07)	0.0909 (0)	1.5000 (0)	1.0747 (0)	3.10^{-7} (0.89)	0.0646 (0)	-0.0291 (0.05)	0.9497 (0)
Telecom	2.10^{-6} (1.0)	0.0478 (0.33)	-0.0166 (0.37)	-0.0435 (0.50)	0.0684 (0)	0.8386 (0)	1.0871 (0)	2.10^{-6} (0.34)	0.0538 (0.09)	0.0586 (0.19)	0.9149 (0)
Utilities	0.0022 (0)	-0.0348 (0,50)	-0.0153 (0.36)	0.0254 (0.54)	0.0406 (0.04)	0.4303 (0)	0.7407 (0)	6.10^{-6} (0.18)	4.10^{-5} (1.0)	0.0466 (0.15)	0.9458 (0)

Table 12. EU Industries Analysis (1999-2006)

	φ_0	φ_1	φ_2	φ_4	γ_1	γ_2	γ_3	ω	α	α^*	β
Basic Materials	0.0043 (0)	-0.2366 (0.001)	0.0125 (0.71)	0.1899 (0.07)	0.2349 (0)	1.2153 (0)	1.1330 (0)	8.10^{-6} (0.40)	0.1314 (0.09)	-0.0450 (0.58)	0.8779 (0)
Consumer Goods	0.0030 (0)	-0.1035 (0.18)	0.0095 (0.62)	0.0343 (0.64)	0.0658 (0)	0.7815 (0)	0.8240 (0)	2.10^{-5} (0.04)	0.3368 (0.02)	0.0276 (0.88)	0.5706 (0)
Consumer Services	0.0008 (0.19)	-0.0323 (0.65)	-0.0169 (0.36)	0.0121 (0.85)	0.0190 (0.21)	0.7484 (0)	0.8755 (0)	1.10^{-5} (0.04)	0.0287 (0.59)	0.2534 (0.12)	0.7228 (0)
Financials	-0.0009 (0.24)	-0.0023 (0.98)	-0.0135 (0.54)	0.0358 (0.71)	0.0815 (0)	1.0764 (0)	1.1071 (0)	7.10^{-6} (0.09)	0.1150 (0.28)	0.0442 (0.69)	0.8342 (0)
Health Care	0.0012 (0.18)	-0.1872 (0.02)	0.0540 (0.07)	0.1292 (0.02)	0.0222 (0.41)	0.5655 (0)	0.7282 (0)	1.10^{-5} (0.08)	0.2249 (0.03)	-0.0963 (0.47)	0.7860 (0)
Industrials	0.0023 (0)	-0.0357 (0.62)	-0.0109 (0.52)	0.0040 (0.96)	0.1021 (0)	0.9370 (0)	1.0646 (0)	4.10^{-5} (0)	0.0947 (0.31)	0.3827 (0.05)	0.4536 (0)
Technology	0.0010 (0.36)	0.0869 (0.34)	-0.0258 (0.22)	-0.0665 (0.44)	0.0926 (0)	0.8528 (0)	0.8721 (0)	0.0002 (0.01)	0.1874 (0.21)	0.3053 (0.20)	0.0940 (0.67)
Telecom	0.0023 (0.06)	-0.0485 (0.49)	-0.0265 (0.39)	0.0617 (0.34)	-0.0115 (0.68)	0.6519 (0)	1.0401 (0)	2.10^{-7} (0.71)	0.0884 (0.01)	-0.1574 (0.01)	0.9862 (0)
Utilities	0.0003 (0.79)	0.0209 (0.73)	0.0140 (0.59)	0.0425 (0.47)	0.0675 (0.02)	0.6027 (0)	1.0237 (0)	2.10^{-5} (0.05)	0.3082 (0.04)	-0.1315 (0.45)	0.6948 (0)

Table 13. EU Industries Analysis (2006-2011)