Return and Volatility Spillover from Oil to Equity Market

An examination of the European market

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Abstract

In this essay a four stage GJR-GARCH(1,1) model is applied to test the presence of both return and volatility spillover to the European market from the oil market. The GJR-GARCH-model allow for asymmetric effects to be present in the country specific stock market. This four step model is applied to eight European countries and allow for spillover effects from oil market, US market and European market. The presence of oil spillover is found significant in all markets except for Ireland. A strong trend is that the shocks towards each country seem to have a more significant effect than the return spillover. Indicating that unexpected changes affect more than expected. To test the impact of shocks on the volatility a variance decomposition is performed and the variance ratios for the spillover are calculated. All average variance ratios from oil market are found to be smaller than 1% except for Denmark (1,315%) and Norway (7,846%).

A model that allow for asymmetric effects is also estimated, by separating the spillover effects into positive and negative values. Since oil prices increases would be expected to have a more significant effect on the economy. Some evidence of this asymmetry is found, although most countries seem to respond symmetric to oil price movements. Another extension is to allow for the oil spillovers to be time-varying in response to interest rates and industrial production. Although the effects from both are found significant in only a few markets.

Keywords: Return Spillover, Volatility Spillover, Oil Volatility, Oil Returns, GJR-GARCH, Asymmetric Oil Effects.

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1. Introduction

1.1 Background to Oil Price Effects Towards the Economy

The oil market have undergone large changes since the 1970s. From being a stable commodity until the crises during the 1970s to experience a constantly increased volatility. Following the 1980s there seem to have been a shift from the importance of oil price level towards oil price volatility that affect the economy output the most (Sauter & Awerbuch, 2003).

In theory an increase in oil price should lower the industrial production due to a more expensive production process (Apergis & Miller, 2009). Hence, leading to a lower gross domestic product (GDP) for a country dependent on industrial production. This was examined as early as Hamilton (1983) who found a significant negative effect from oil price on the US GDP. Oil exporting countries on the other hand would be expected to experience an increased GDP in response to a higher oil price. Since a permanent increase in oil price lead to a higher profit for the net exporter, this in turn increase the disposable income and lead to an increase in GDP.

The main area under investigation in this essay is the oil price movements effect on stock market, both return and volatility spillovers. Also asymmetric effects and a model with time-varying oil spillovers are examined. The early studies of oil effects towards stock market had a main focus on the oil price level and its changes. While many contemporary studies examine the effects of uncertainty caused by an increased oil volatility and what effect it have on markets. A higher uncertainty about future oil price tend to depress the investments made in a country (Elder & Serletis, 2010). A lower investment rate in turn tend to a lower economic growth rate. Another implication for oil price changes is the presence of asymmetric effects towards economic output. This asymmetry manifest in the form of a larger impact from oil price increases than for oil decreases. This seem to affect both GDP (Mork, 1989 and Ferderer, 1996) and the stock market (Sadorsky, 1999 and Ciner, 2001).

1.2 Why Study Spillover Effects?

The increasing globalization during the last 50 years has been rapid and important for the trade and development of counties. Especially the European countries that have joined the European Union (EU) have experienced an increase in mobility of capital, labor, goods and services. This in turn has increased the possibility for investors to easier invest in foreign countries to diversify the risk of a portfolio. Although at the same time an increased mobility of capital lead to spillover effects between the markets and hence reduce the effect of diversification. When the correlation between two markets is high the effects of international diversification is less effectual. Such is the case between the European and US markets where a higher correlation lowers the optimal weights for US in the minimum variance portfolio (MVP) as shown by Asgharian and Nossman (2011). Also the rapid technological development has lead to a higher degree of information transmission between markets, which in turn leads to more rapid spillover effects.

When hedging a portfolio spillover effects are also required to take under consideration. Hedging is usually done by taking a position in a derivative such as forwards, futures, swaps and options. For example both a long call and a long put option tend to increase in value when the volatility rises, ceteris paribus. This due to the limited downside risk for the owner of the long positions (Hull, 2008). A method for risk reduction towards volatility changes is to make a portfolio including one or more options Vega neutral. Vega defined as the rate of change of the value of the portfolio towards a change in the volatility of the underlying asset. This infers it will be harder to keep a Vega neutral portfolio in a market which is highly influenced by other markets (Hull, 2008).

When pricing securities the impact of a spillovers may affect the asset value. To consider the classic Black-Scholes pricing model that assumes a constant volatility over time when pricing an option. But when there is volatility spillover (e.g. from US or Oil) the assets volatility may change unexpectedly and is more risky than expected. By taking volatility and shock transmission under consideration more accurate predictions can be made when forecasting future equity and oil price movements (Malik & Hammoudeh, 2007).

1.3 Purpose

The purpose of this essay is to get an estimation of the spillover effects from oil movements towards the return and volatility of the European stock market. Also to give a description of the earlier work done with the transmission from oil market toward the economy. For eight European countries the variance ratios from oil price shocks are calculated four each country. Using a four stage estimation of a GJR-GARCH(1,1) process to orthogonalize the residuals and allow for asymmetric effects in each market. The model is also extended to allow for asymmetric effects from oil movements towards each country to see if there is a significant difference between increases and decreases of the oil price as suggested by theory.

1.4 Outline

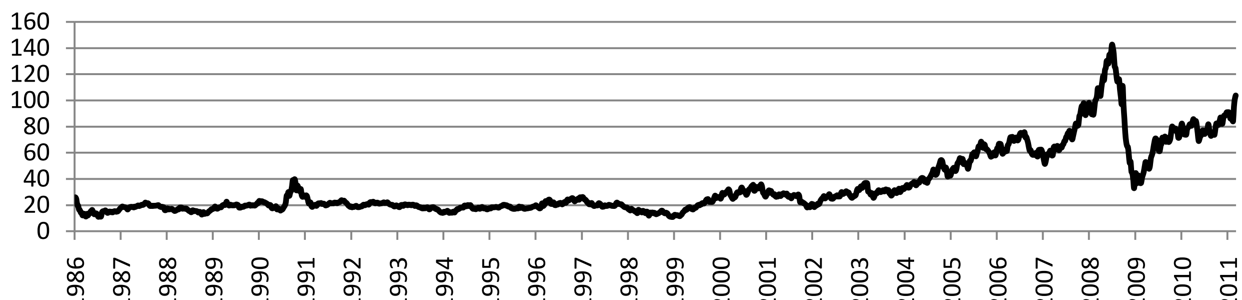
Chapter 2 describe the historical development of oil price movements and the effect on towards the macroeconomy. It also describe the effect oil price movements have towards stock markets and the asymmetric effects of oil price. Chapter 3 give a background on prior spillover models and the model used here. As well as extensions in form of a asymmetric model and a model where the oil spillovers are allowed to be time-varying in response to changes in interest rates and industrial production. Chapter 4 describe the data and methodology used. In chapter 5 the results from the spillover models are presented, while a conclusion is found in chapter 6.

2. Theoretical background

2.1 Historical Oil Price Development

West Texas Intermediate (WTI) and Brent crude oil are commonly used as benchmark for the oil price. WTI is refined in the US while Brent is sourced from the north sea. The WTI crude oil price level is presented in figure 1. It shows an increase during 1990 in response to the Persian Gulf crises followed by a sharp decrease. The price increased during most of the first decay of 2000 followed by a sharp decline in 2008 in connection with the most recent financial crisis.

Figure 1: Weekly Cushing WTI Spot Price (dollars per barrel)



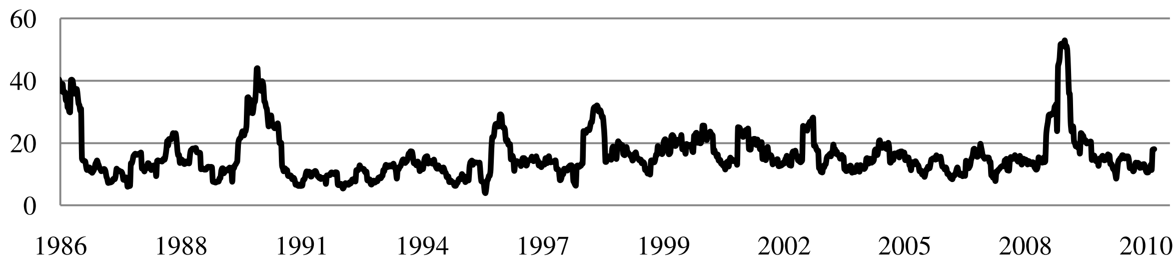
Note: Data compiled from EIA[1].

The oil price return volatility is presented in figure 2. Calculated as the quarterly standard deviation in a rolling window, that is annualized for each quarter. Notable is the high volatility following periods with rising oil price such as the 1990 and 2008. A common belief about oil price volatility is that following the oil crisis in the 1970s the volatility has increased and is an

[1] Data from: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_w.htm

especially volatile commodity. Regnier (2007) tested this by looking at the producer price index commodity series between 1945 and 2005. The volatility for oil and energy commodities did indeed rise following the 1973 crisis and the effect was reflected in the volatility of other commodities. Oil price volatility is also found to be highly volatile compared to products manufactured in USA, however compared to other commodities during the period it is found to be more volatile than 65% which does not make it any special exception. The reason why crude oil price is perceived as unusually high is because of this high relative volatility to manufactured products (Regnier, 2007).

Figure 2: Oil price return volatility



Note: Data compiled from EIA[2].

World consumption of oil in 2009 where roughly 84 million per day. The largest consumer of oil is the US with almost 19 million barrels per day reflecting 21,7% of world consumption. The second largest consumer of oil is China with 10,4%, whose consumption have increased with roughly 67,6% during the last decay. While the EU stand for 17,3% of the world consumption. In 2009 the total world capacity measured in thousands barrels daily was roughly 91000. USA is the largest producer with 19,5% of the total world capacity followed by China (9,5%). Europe (including Russia) have a production capacity ratio equal to 27,5% of the world while middle east have 8,7%. The production capacities have increased significantly for China (46,9%) and the middle east(18,5%) during the last decay. But Europe including Russia have decreased (-2,3%) while US (6,9%) have slightly increased its production[3].

2.2 Oil Price and the Macroeconomy

Oil price is an essential factor in the world economy; its effects have in studies been found to range from macro factors to the equity market. Oil price effects range from a positive effect on

[2] Data from: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_w.htm
[3] Data from BP:s statistical review of world energy 2010.

interest rates as well as a negative effect on industrial production mainly due to its vital contribution in the production process. The positive effect on interest rates can be explained by the inflationary pressure followed by an increase in oil price (Papapetrou, 2001).

Hamilton (1983) found evidence that oil price increases have been an underlying factor for all post World War II US recessions until 1973 with the exception for the one in the 1960s. He also showed that an increase in nominal oil price Granger-cause a negative effect on economic activity. Sauter and Awerbuch (2003) found evidence that the dynamics of oil volatility have changed over time. Prior to the 1970s oil where a stable commodity while the recessions during the decay resulted in a permanently increased volatility. Another change seem to have come after the 1980s where the oil price volatility seems to have a more significant effect on the economy than the oil price level.

Gisser and Goodwin (1986) examined the effects from crude oil price on the US economy. They examined lagged effect each quarter and the sum over the whole year. Finding that the crude oil price affected real GDP, general price level (GDP deflator), unemployment and real investment. This on both a quarterly and yearly basis. Rafiq et al. (2009) tested the effects of oil movements on the Thai economy. They found an impact from oil price volatility towards investment, unemployment rate, interest rate and trade balance. Elder and Serletis (2010) tested the effects of oil uncertainty on the economy, using the standard deviation of the forecast error for changes in real oil price. They found a negative and significant effect on real GDP, durables consumption, several components of fixed investments and industrial production ranging from 1975 to 2008.

A negative correlation between oil prices and economic activity has been found in many studies. Ferderer (1996) explain some of the channels that may be the reason for this negative correlation. Initially two channels connected with the role of money supply. First, an oil increase leads to an inflation which lowers the real balances, defined as the money supply divided by a price index. This in turn may be an underlying reason for recessions. Second, a counter inflationary monetary policy towards an oil shock can lead to real output losses, such as a lower industrial production. Third involves an income transfer from countries with net import of oil towards countries that are net exporters. Thus, the net importer is left with a lower domestic consumption and hence a lower aggregate demand. The fourth channel involves the effect on the supply side in response to an oil increase. If oil and capital are complements in a production process an increased price will in turn lower the amount spent on capital. This in turn leads to a lower productive capacity for a firm. Two more channels are described in Lardic and Mignon (2006). Oil increases may have a negative effect on consumption, investment and stock prices. Consumption is affected by the lower disposable income that is left for other goods in response to oil increases. While investments are affected by increasing firm costs. Finally, if oil price increases linger firms may change its production structure to decrease its oil dependence. This change can lead to a capital and labor reallocations, which in some cases cause unemployment.

Oil is a finite resource which is a factor that is not usually needed to take under consideration when pricing most commodities. An exhaustible resource will not equal its marginal cost, even in a market with complete competition (Fengdan & Yuxian, 2008). The concept of peak oil is well know and is defined as the maximum rate of oil extraction before a constant decrease over time. This would indicate that under a supply and demand relation the oil price will continue to rise and not just that which can be explained by inflation pressure. A prediction of the peak oil was examined by Cavallo (2002). Finding evidence that non-OPEC countries should begin to have a declining production somewhere between year 2015 and 2020. Thus, leading to a market strongly controlled by the OPEC countries.

2.3 Oil Effect on the Equity Market

The effect of oil shocks has been studied frequently and there is no unanimous consensus among which effect a shock have on the equity market. In theory oil price shocks affect equity market through expected earnings caused by a lower output in response to a more expensive production process (Apergis & Miller, 2009).

Jones and Kaul (1996) examined oil shocks on the Canadian, Japanese, UK and US stock markets. A significant negative relation between the stock market and oil price increases were found. Sadorsky (1999) tested the effect of oil shocks and found a negative and statistically significant effect on the stock returns. By using real stock return defined as the difference between continuously compounded return on the S&P 500 and the consumer price index to adjust for inflation. Finding a significant effect during the whole sample (1950:1-1996:4), but also that oil shocks have an increased explanation rate (11,22%) towards real stock return in a variance decomposition for a subsample between 1986:1-1996:4, than the earlier sample (1950:1-1985:12) that were found to be 5,41%. Papapetrou (2001) found evidence that oil prices have a negative effect on the Greece stock market. He explained this by the negative effect from oil increases on the industrial production and employment growth. In Apergis and Miller (2009) only a small effect on the international market from oil market shocks where found. Hong et al. (2002) tested the relation between 34 industry portfolios and a market index for cross-asset return. The results indicate that there is a lead effect from the petroleum industry towards the stock market. The effect on market returns in response to oil price movements where tested by Pollet (2002). Finding that market returns are predicted by expected oil price movements. He found evidence that a country that is highly based on oil production, like a Norwegian index, is leading the world stock market. Also that an anticipated oil movement is negatively related to the excess return in most industries. Malik and Hammoudeh (2007) examined the relation between oil price, US equity market and Gulf equity markets. They used a multivariate GARCH(1,1) model for a sample from February 1994 to December 2001 to estimate both mean and volatility spillovers between the markets. All Gulf economies (Bahrain, Kuwait and Saudi Arabia) receive a significant volatility transmission from the oil market. Although Saudi Arabia is found to be the only one that in turn affect the oil market, thus underlining what an important oil producing state Saudi Arabia is.

Miller and Ratti (2009) tested both the short-run and long-run relationship between real oil price (Brent) towards six OECD countries. Using a vector error correction (VECM) model for a sample between 1971 and 2008 to test the effect on the stock market. The model was used for the whole sample as well as for four subperiods defined by structural breaks in May 1980, January 1988 and September 1999. For the entire sample the long-run relationship is not statistically significant. Although the first period (January 1971 - May 1980) had all positive coefficient, thus a oil price decrease lead to a change in the opposite direction for the stock market. The results are significant for Germany, Italy, the UK and the US. For the sample June 1980 – January 1988 the long-run effect is insignificant for all countries while the February 1998 – September 1999 all long run relationships are significant with a positive sign. This change in the sample between September 1999 – May 2008 where most countries have insignificant effect and the US and Canada have a negative sign. The results can be interpreted as a presence of bubbles in the stock market and/or oil market that have had a large effect during the last decay.

Another distinction can be made between the oil price effect toward oil importing and oil exporting countries stock markets. An oil exporting country would be expected to receive a positive effect from an increase in oil price, while an importing the opposite. Filis et al. (2011)

tested the dynamic correlation between stock markets and oil price for six countries. Three oil exporters (Canada, Mexico and Brazil) and three oil importers (US, Germany and Netherland) where examined in a sample between 1987 and 2009. The finding is that the change in correlation between importing and exporting countries in response to a shock does not differ. Demand shocks are separated into aggregate demand-side shocks and precautionary demand shocks. The former is in response to changes in business cycles and the later is the uncertainty caused by a change in the future expectations of oil demand. Both importing and exporting countries experience an increased (decreased) correlation in response to significant aggregate demand-side (precautionary demand) oil shock. Although the supply-side shocks don't tend to affect the correlation between the stock and oil market. Hence, a supply side shock, like the several oil production cuts between 1998-1999, didn't affect the correlation between the two markets.

2.4 Asymmetric Effects from Oil Price Movements

The oil market has in many studies been found to exhibit signs of asymmetric effects towards several economic measurements. The asymmetric effect from the oil market manifest in form of a negative impact on economic growth for oil price increases, while oil decreases would tend to have smaller or no effect on the growth of the economy (Sauter & Awerbuch, 2003).

Mork (1989) where among the first to test for asymmetric effects of oil movements towards gross national product (GNP), by extending the study made by Hamilton (1983). He found evidence that both positive and negative changes affect GNP growth. Although the increases of real oil price where found to affect growth more. Ferderer (1996) allowed for both negative and positive changes in real oil price level to affect federal funds rate and industrial production growth. He found that the positive changes in real oil price explained almost twice as much of the variance compared to the negative changes towards industrial production. This support the presence of an asymmetric relation between output growth and real oil prices.

Ciner (2001) examined the oil price linkages to the US stock market by using both linear and a nonlinear Granger causality testing. When using linear Granger causality test the effect between the two markets are found insignificant for both the 1980s and 1990s. But evidence for nonlinear causality is found from crude oil toward the stock market for both sample periods. In accordance with Sadorsky (1999), who found a stronger oil price effect towards the stock market after 1986, Ciner found a stronger causality during the 1990s than for an earlier sample between 1983 to 1990. Lardic and Mignon (2006) tested the impact of oil prices on GDP in 12 European countries for asymmetric effects. By testing for both symmetric and asymmetric cointegration using quarterly data ranging from 1970 to 2003. Their findings support that there is an asymmetric cointegration relation between the two.

3. Spillover models

3.1 Modeling Oil Return Volatility

The most basic model when forecasting future volatility is the sample volatility with the underlying assumption of a constant true variance over time based on the historical observations. However when using the sample volatility for forecasting it has problem to describe changing volatility and seasonal effects. An exponentially weighted moving average model gives more recent observations a higher effect on the volatility. As well as allowing for the volatility to change from one period to another and can hence explain clustering effects. Volatility clustering means that a large price change is followed by a large price change and vice versa. But the sign of the change is of unpredictable sign. In many financial data, such as return data of stocks, this is visible in the form of high periods of volatility is followed by periods of low volatility.

Another way to estimate volatility is to use the implied volatility. By using the Black-Scholes formula for a traded security and the observed option price the volatility can be calculated. This method allow for a volatility that will respond rapidly to changes in the option market and could hence be applied to the oil price options.

When modeling financial return volatility the autoregressive conditional heteroskedasticity (ARCH) model developed by Engle (1982) and the generalized ARCH (GARCH) by Bollerslev (1986) are among the most frequently used. Both models have the ability to account for volatility clustering and to have strong empirical foundation; this was tested by Bollerslev et al. (1992). A market characterized by ARCH effects mean that the past values of volatility can be used to predict current volatility (Malik & Ewing, 2009). A GARCH(1,1) model have in many studies found to be sufficient when modeling financial returns and is the model applied in this essay.

3.2 Prior Spillover Models

There are two main theories that explain the presence of spillover effects between markets. First, they may be explained by hedging between markets and common information for investors.

When information about a market changes the investors reallocate their investments to a different market to adjust for the new information. The second involves financial contagion, meaning that a shock in one country can spread to another's financial market (Malik & Ewing, 2009).

Bekaert and Harvey (1997) developed a model for volatility spillover that allow for the impact of local and world (US) shocks to affect the volatility in emerging equity market. The presence of asymmetric effects in the emerging equity market are also tested for by using a GJR-GARCH(1,1). The asymmetric GJR-GARCH model seems to provide an improvement for most countries. The mean proportion that can be explained by world (US) factor were calculated for each county. The explanation rate is not found to be very high, with values of less than 10% for 16 of 19 countries.

A model for volatility spillover from the US and Japanese market to the Pacific-Basin where tested by Ng (2000). This model is an extension of the Bekaert and Harvey (1997) model, but this model is extended to allow for two types of spillovers. He allowed for three sources of shocks towards each country; local, regional (Japan) and world (US). Both a constant spillover model and a model with time-varying coefficients that allowed for liberalization where applied. Since there is a risk that common information is driving both the US and Japanese markets the residuals are orthogonalized using Cholesky decomposition. Empirically both the US and Japan are found to have a significant effect on market volatility. Although the world shocks seems to be of more importance in the variance decomposition. Another factor found to affect the spillover and correlation between markets is the degree of capital market liberalization, which increases the correlation between local and world market returns.

Christiansen (2007) used an asymmetric GARCH model to decompose the variance for nine European countries toward spillover effects from the European and US market. Applied to both bond and stock market returns; significant spillover effects are found for both mean return and volatility. Asymmetric effects are only found significant for the stock market and not for the bond market. Each country variance for bonds (stocks) are decomposed into idiosyncratic US bond variance, European bond variance, US stock variance, European stock variance and own bond (stock) variance. The effects of local, regional and global are all found to be of importance for the European stock and bond market volatility. The introduction of euro is found to have had an impact on the degree of integration in the European market and is considered as a structural break. This integration effect is found stronger among EMS countries than for Denmark, Sweden and the UK.

Malik and Ewing (2009) tested volatility transmission between oil prices and five different US sector indices. By using a bivariate GARCH model for simultaneous estimation of the mean and conditional variance for each sector, both direct and indirect shocks where tested for. For technology, consumer service and health care sectors the oil price shocks directly affect the return volatility of each sector. While the effect on the financial and industrial sector is found to be insignificant. Thus the financial sector can be considered stable against oil volatility as tested by Ewing et al. (2003) is a sector where returns exhibit low volatility transmission from macroeconomic variable. More surprising is the finding that oil volatility does not affect the industrial sector since its firms are a mayor demander of oil in the economy. This could be explained by effective hedging through risk management in the firms.

Chang et al. (2010) tested the presence of volatility spillover and asymmetries between the different oil markets. By using the prices for WTI, Brent, Dubai/Oman and Tapis the effects between spot, forward and future markets where examined. Evidence is found of a volatility spillover effect from the Brent and WTI returns towards Dubai and Tapis markets. Implying that the Brent and WTI markets are the world references for crude oil prices.

A model with jump component and conditional parameters was tested by Asgharian and Nossman (2011). The jump component is defined as a discontinuity in equity returns, caused by information shocks or extreme events. By using a stochastic volatility model with time-varying coefficients and allowing for jumps in both return and volatility the spillover effects are examined. Three types of shocks are considered to affect the local (country) equity market, namely shocks from the global (US) market, regional (European) market and own idiosyncratic shocks. A spillover effect is found although different countries are influenced to a different degree by the shocks. A common trend found is that the regional shocks tend to have larger contribution to a countries variance than the US shock.

3.3 The Spillover Model

The model presented here is based on the Ng (2000) which in turn is an extension of the model used by Bekaert and Harvey (1997). An asymmetric spillover model was used by Bekaert and Harvey (1997), Sadorsky (1999) and Ng (2000). Asymmetric effect in stock market return would imply that a negative stock return of the same magnitude as a positive would have a greater effect on the market. In this essay a model with four types of shocks is applied to eight European countries. The shocks are oil shocks, world (US) shocks, regional (EU) shocks and own idiosyncratic shocks.

The model assumes that oil returns are driven solely by a constant and its own past returns. This imply that the oil market is assumed to be driven by factors other than what drives the US and European markets. Hence, the oil returns will follow an AR(1) process:

$$r_{oil,t} = \beta_0 + \beta_1 r_{oil,t-1} + \varepsilon_{oil,t} \tag{1}$$

$$\varepsilon_{oil,t} = e_{oil,t} \tag{2}$$

The asymmetric conditional variance is assumed to follow a GJR-GARCH(1,1) process developed by Glosten et al. (1993). The idiosyncratic shock, $e_{oil,t}$, are assumed normally distributed with mean zero and the conditional asymmetric variance $\sigma^2_{oil,t}$:

$$\sigma^2_{oil,t} = E\left[e^2_{oil,t} \middle| I_{t-1}\right] = \omega + \alpha_1 e^2_{oil,t-1} + \alpha_2 e^2_{oil,t-1}\zeta_{t-1} + b_1\sigma^2_{oil,t-1} \tag{3}$$

Where I_{t-1} is the information set available to investors at time t-1. To ensure a positive variance $\omega > 0$ as well as α_1, $b_1 > 0$. Also to ensure stationarity $\alpha_1 + b_1 < 1$ and ζ_{t-1} is an indicator function defined by:

$$\zeta_{t-1} = \begin{cases} 1 \text{ if } e_{oil,t} < 0 \\ 0 \text{ if } e_{oil,t} \geq 0 \end{cases} \tag{4}$$

In this asymmetric model the negative idiosyncratic shocks ($e_{oil,t} < 0$) are captured by α_1 and α_2 while positive shocks are captured by only α_1. If α_2 is not significantly different from zero the model is reduced to a symmetric GARCH(1,1) model. The sign of α_2 indicate which effect the asymmetry has, a positive α_2 mean that a negative shock increases the volatility more than a positive shock.

The US model allow for both mean and volatility spillover from the oil market. The model allow the own idiosyncratic shocks to be asymmetric which have been found in studies such as Horng and Wang (2008) to be significant for the US returns.

$$r_{US,t} = \beta_0 + \beta_1 r_{US,t-1} + \gamma_{US} r_{oil,t-1} + \varepsilon_{US,t} \tag{5}$$

$$\varepsilon_{US,t} = e_{US,t} + \Phi_{US} e_{oil,t} \tag{6}$$

Oil price shocks have in many studies found to have a significant and nonlinear negative effect on the US stock market returns which would indicate that the sign of β_1 should be negative (Odusami, 2009). The conditional mean return of the US is dependent on a constant, its own lagged return and the oil lagged return. The mean return spillover from oil is defined by lagged oil return, $r_{oil,t-1}$. As modeled by Bekaert and Harvey (1997) and Ng (2000) the US shocks are allowed to be affected by oil shocks and its own idiosyncratic shock. The volatility spillover effect from oil market to US market take the form of the shock from the oil market, $e_{oil,t}$. The idiosyncratic shock, $e_{US,t}$, have mean zero and the conditional asymmetric variance $\sigma^2_{US,t}$:

$$\sigma^2_{US,t} = E\left[e^2_{US,t} \middle| I_{t-1}\right] = \omega + \alpha_1 e^2_{US,t-1} + \alpha_2 e^2_{US,t-1} \zeta_{t-1} + b_1 \sigma^2_{US,t-1} \tag{7}$$

To ensure a positive variance $\omega > 0$ as well as α_1, $b_1 > 0$ and $\zeta_{t-1}$is the indicator function.

Next step involves the estimation of the European model where spillovers are from both the oil market and the US market.

$$r_{EU,t} = \beta_0 + \beta_1 r_{EU,t-1} + \gamma_{EU} r_{oil,t-1} + \delta_{EU} r_{US,t-1} + \varepsilon_{EU,t} \tag{8}$$

$$\varepsilon_{EU,t} = e_{EU,t} + \Phi_{EU} e_{oil,t} + \psi_{EU} e_{US,t} \tag{9}$$

The mean return of the European market is dependent on a constant, its own lagged return, the oil lagged return and the lagged US lagged return. The volatility spillover effect from oil market and US market towards European market take the form of the spillover shocks $e_{oil,t}$ and $e_{US,t}$. The own shocks, $e_{EU,t}$, have mean zero and the conditional asymmetric variance $\sigma^2_{EU,t}$:

$$\sigma^2_{EU,t} = E\left[e^2_{EU,t} \middle| I_{t-1}\right] = \omega + \alpha_1 e^2_{EU,t-1} + \alpha_2 e^2_{EU,t-1} \zeta_{t-1} + b_1 \sigma^2_{EU,t-1} \tag{10}$$

To ensure a positive variance $\omega > 0$ as well as α_1, $b_1 > 0$ and $\zeta_{t-1}$is the indicator function.

The first three steps are the same for all countries while the spillover model for country i is described by equations 11-13.

$$r_{i,t} = \beta_{0,i} + \beta_{1,i} r_{i,t-1} + \gamma_i r_{oil,t-1} + \delta_i r_{US,t-1} + \theta_i r_{EU,t-1} + \varepsilon_{i,t} \tag{11}$$

$$\varepsilon_{i,t} = e_{i,t} + \Phi_i e_{oil,t} + \psi_i e_{US,t} + \varphi_i e_{EU,t} \tag{12}$$

Each European country's mean return is now dependent on a constant, its own lagged return, the oil lagged return, the lagged US return and the lagged European return. The volatility spillover takes the form of the three shocks; from oil market, US market and European market. The idiosyncratic shock, $e_{i,t}$, have mean zero and the conditional asymmetric variance $\sigma_{i,t}^2$:

$$\sigma_{i,t}^2 = E\left[e_{i,t}^2 \middle| I_{t-1}\right] = \omega_i + \alpha_{1,i} e_{i,t-1}^2 + \alpha_{2,\mathrm{i}} e_{i,t-1}^2 \zeta_{\mathrm{t}-1} + b_{1,i} \sigma_{i,t-1}^2 \quad (13)$$

To ensure a positive variance $\omega_i > 0$ as well as $\alpha_{1,i}$, $b_{1,i} > 0$ and $\zeta_{t-1}$is the indicator function.

3.4 Variance Ratios

For each country a variance ratio is calculated for the different shocks. The variance ratios measure the proportion of the total conditional variance of country i that is explained by the different factors. Each variance ratio for each factor will be a number between zero and one. Spillover effect is assumed to be constant over time, hence the writing without a subscript t for the spillover coefficients. The conditional variance is based on that the different shocks are independent of each other.

$$\begin{aligned} E\left[\varepsilon_{i,t}^2 \middle| I_{t-1}\right] = h_{i,t} &= \sigma_{i,t}^2 + \Phi_i^2 \sigma_{oil,t}^2 + \psi_{\mathrm{i}}^2 \sigma_{US,t}^2 + \varphi_{\mathrm{i}}^2 \sigma_{EU,t}^2 \\ E\left[\varepsilon_{i,t} e_{oi,t} \middle| I_{t-1}\right] &= \Phi_i^2 \sigma_{oil,t}^2 \\ E\left[\varepsilon_{i,t} e_{US,t} \middle| I_{t-1}\right] &= \psi_{\mathrm{i}}^2 \sigma_{US,t}^2 \\ E\left[\varepsilon_{i,t} e_{EU,t} \middle| I_{t-1}\right] &= \varphi_{\mathrm{i}}^2 \sigma_{EU,t}^2 \end{aligned} \quad (14)$$

When there is no covariance between the shocks variance ratio for each country can be calculated as shown by equation 15.

$$\begin{aligned} VR_{i,t}^{own} &= \frac{\sigma_{i,t}^2}{h_{i,t}} \\ VR_{i,t}^{oil} &= \frac{\Phi_i^2 \sigma_{oil,t}^2}{h_{i,t}} \\ VR_{i,t}^{US} &= \frac{\psi_{\mathrm{i}}^2 \sigma_{US,t}^2}{h_{i,t}} \\ VR_{i,t}^{EU} &= \frac{\varphi_{\mathrm{i}}^2 \sigma_{EU,t}^2}{h_{i,t}} \end{aligned} \quad (15)$$

3.5 Conditional Spillover Model

The unconditional spillover model can be extended to a conditional model with time-varying parameters. Each oil spillover parameter is extended to become time-varying in response to a constant, change in interest rate and change in industrial production. The use of interest rates and industrial production in the model is inspired by Miller and Ratti (2001), who used it to capture influences in the short-run. Interest rates are usually taken under consideration when pricing assets, such is the case of the capital asset pricing model (CAPM) that can use interest rates as an estimation of the risk-free asset. An increase in interest rates (such as federal funds rate) usually lead to a negative impact on the returns on the stock market. The linkage between the two markets can be explained by the discounted cash flow framework. Since a stock's value can be estimated by the future expected cash flows discounted to a present value, a higher interest rate lower the present value. Industrial production can be viewed as an indicator of the future expected economic situation. If a firm expects a boom year the company will increase its production to be able to supply the future increased demand.

$$
\begin{gathered}
\gamma_{US,t} = \gamma_{US,o} + \gamma_{US,1} IR_{US,t-1} + \gamma_{US,2} IP_{US,t-1} \\
\gamma_{EU,t} = \gamma_{EU,o} + \gamma_{EU,1} IR_{EU,t-1} + \gamma_{EU,2} IP_{EU,t-1} \\
\gamma_{i,t} = \gamma_{i,o} + \gamma_{i,1} IR_{i,t-1} + \gamma_{i,2} IP_{i,t-1} \\
\Phi_{US,t} = \Phi_{US,o} + \Phi_{US,1} IR_{US,t-1} + \Phi_{US,1} IP_{US,t-1} \\
\Phi_{EU,t} = \Phi_{EU,o} + \Phi_{EU,1} IR_{US,t-1} + \Phi_{EU,1} IP_{EU,t-1} \\
\Phi_{i,t} = \Phi_{i,o} + \Phi_{i,1} IR_{i,t-1} + \Phi_{i,1} IP_{i,t-1}
\end{gathered} \tag{16}
$$

Where $IR_{US,t-1}$is the change in 1 month interbank interest rate in US, $IR_{EU,t-1}$is the change in the European interest rate and $IR_{i,t-1}$ the change in a country specific interest rate. $IP_{US,t-1}$ is the monthly change in industrial production in US and $IP_{EU,t-1}$ is the change in industrial production in Europe. For each country $IP_{i,t-1}$ represent the change in industrial production.

3.4 Asymmetric Oil Effects on Stock Market Returns

An asymmetric effect in oil price would mean that increases tend to have a greater impact on the economy than decreases. Asymmetric effects by oil prices on the economy have been found by Mork (1989), Ferderer (1996), Sadorsky (1999) and Ciner (2001). Thus, an increase in oil price would be expected to have a more significant impact on the economy. By rewriting equations 11-13 to allow for both negative and positive spillovers from the oil market asymmetric effects can be tested for. This is based on the model presented by Ferderer (1996) where first difference of real oil price where decomposed into positive and negative values. Here both lagged oil return and oil shocks are allowed to have both positive and negative values as described by equations 17-19.

$$r_{i,t} = \beta_{0,i} + \beta_{1,i} r_{i,t-1} + \gamma_{1,i} r^{-}_{oil,t-1} + \gamma_{2,i} r^{+}_{oil,t-1} + \delta_i r_{US,t-1} + \theta_i r_{EU,t-1} + \varepsilon_{i,t} \qquad (17)$$

Where: $r^{-}_{oil,t-1} = r_{oil,t}$ if $r_{oil,t} < 0$ and 0 otherwise;

$r^{+}_{oil,t-1} = r_{oil,t}$ if $r_{oil,t} > 0$ and 0 otherwise.

The volatility spillover effects are allowed to affect through the error term once again as well as allowing for both positive and negative oil shocks towards each country.

$$\varepsilon_{i,t} = \mathrm{e}_{\mathrm{i,t}} + \Phi_{1,i} \mathrm{e}^{-}_{\mathrm{oil,t}} + \Phi_{2,i} \mathrm{e}^{+}_{\mathrm{oil,t}} + \psi_{\mathrm{i}} \mathrm{e}_{\mathrm{US,t}} + \varphi_{\mathrm{i}} \mathrm{e}_{\mathrm{EU,t}} \qquad (18)$$

Where $\mathrm{e}^{-}_{\mathrm{oil,t}} = \mathrm{e}_{\mathrm{oil,t}}$ if $\mathrm{e}_{\mathrm{oil,t}} < 0$;

$\mathrm{e}^{+}_{\mathrm{oil,t}} = \mathrm{e}_{\mathrm{oil,t}}$ if $\mathrm{e}_{\mathrm{oil,t}} > 0$.

The European idiosyncratic shocks, $e_{EU,t}$, have mean zero and the conditional asymmetric variance $\sigma^2_{EU,t}$ as before:

$$\sigma^2_{i,t} = E\left[e^2_{i,t} \middle| I_{t-1}\right] = \omega_i + \alpha_{1,i} e^2_{i,t-1} + \alpha_{2,\mathrm{i}} e^2_{i,t-1} \zeta_{\mathrm{t-1}} + b_{1,i} \sigma^2_{i,t-1} \qquad (19)$$

To ensure a positive variance once again $\omega_i > 0$ as well as $\alpha_{1,i}$, $b_{1,i} > 0$ and ζ_{t-1} is the indicator function. The null hypotheses of $\gamma_{1,i} = \gamma_{2,i}$ and $\Phi_{1,i} = \Phi_{2,i}$ can be tested by a Wald test to see if there is a significant asymmetric effect present in each country.

4. Methodology and Data

4.1 Methodology

Estimation of the spillover models are estimated in EViews. The residuals (shocks) are allowed to follow between each step and are hence orthogonalized. Another way to achieve this is the Cholesky decomposition, although it is not applied here. The variance ratios described by equation 14-15 are calculated in Excel.

4.2 Data

For each country an index composed by DataStream is used, this is intended to reflect the whole country specific stock market. The countries under observation are Denmark (Den), France (Fra), Germany (Ger), Ireland (Ire), Italy (Ita), Norway (Nor), Sweden (Swe) and the United Kingdom (UK). The sample period used is from 1988 to 2008 with starting date 1988-01-01 for all series. All indices are in US dollars. Weekly data is used to avoid the problems of non-synchronous trading and the day-of-the-week effects (Ng 2000). To represent oil price the WTI price per barrel in dollar is used. The oil price is not converted into real oil price since all indices are in US dollars the effect is assumed to be neutralized between the indices. For US the S&P500 composite index is used as a measure of the US stock market. For Europe an index composed by DataStream is used, this would indicate that the bigger and/or more influential countries can affect the index by itself. Thus, some of the effect of the local idiosyncratic shock will be reflected in the regional (European) shock. Since the interest in this essay is to find the effect from oil shocks this is not corrected for. A method applied by Asgharian and Nossman (2011) is to use a weighted average for the countries log returns except for the country under observation. This method prevents the problem of having the local shocks reflected in the regional shocks.

For the conditional model data for industrial production and interest rates are used. The industrial production data is collected from the OECD database[4] and is an index over the country specific industrial production. For Europe an index over 27 European states is used. Although since the data is monthly its converted into weekly data by assuming a linear growth between months. The weekly interest rates are gathered from the DataStream database. They are defined in appendix under definitions A1. Most are the one month interbank rate and the European interest rate is an average of the eight countries under observation.

[4] Data from: http://stats.oecd.org/

4.3 Descriptive Statistics

The return data is plotted in figure A2 in appendix; all seem to exhibit signs of ARCH-effects. The descriptive statistics for the country returns are presented in table 1 while the same stats are given in table 2 for Europe, US and WTI.

Table 1: Descriptive statistics for weekly return data

Descriptive statistics weekly return data for the eight countries under observation.

	Den	Fra	Ger	Ire	Ita	Nor	Swe	UK
No. of obs.	1092	1092	1092	1092	1092	1092	1092	1092
Mean	0,224	0,167	0,149	0,142	0,076	0,233	0,189	0,104
Std. Dev.	2,747	2,643	2,807	2,901	3,070	3,410	3,473	2,452
Skewness	-1,034	-0,743	-0,620	-1,175	-0,295	-0,634	-0,210	-0,585
Kurtosis	11,131	9,307	9,271	12,978	8,510	8,571	7,956	15,527
Jarque-Bera	3202,806	1910,274	1859,041	4781,488	1397,022	1485,227	1125,697	7202,149
Probability	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

All weekly percentage returns are in US dollars.

The mean return for all countries is positive ranging from 0,104% for the UK to 0,232% for Norway. The European, the US and the oil markets also exhibit positive mean return. Average weekly volatility for all indices are 3,016% ranging from low 2,248% for US to high 5,021% for the oil returns. The WTI return volatility is significantly higher than the other indices and hence the oil market seems to be the most volatile.

Table 2 Descriptive statistics for weekly return data

Descriptive statistics weekly return data for Europe, US and WTI.

	EU	US	WTI
No. of obs.	1092	1092	1092
Mean	0,126	0,142	0,238
Std. Dev.	2,407	2,248	5,021
Skewness	-0,896	-0,659	-0,248
Kurtosis	14,774	9,591	5,094
Jarque-Bera	6453,730	2055,875	210,732
Probability	0,000	0,000	0,000

All weekly percentage returns are in US dollars.

All indices exhibit a negative skewness and excess kurtosis, i.e. a kurtosis above three. A Jarque-Bera test is preformed to test for normality. The null hypothesis of normally distributed return series can be rejected for all indices. Somewhat notable is that the oil returns seem to be the most normally distributed of all the return data. All return series are also tested for stationarity by both an Augmented Dickey-Fuller (ADF) test and a Phillips-Perron (PP) test. The null hypothesis of individual unit root is highly rejected with p-values of 0,000 indicating that all series exhibit signs of stationary.

4.4 Correlations

The return correlation for each country with respect to Europe, US and oil returns are presented in table 3. One would expect that in an integrated capital markets a shock to the US market will spread to all countries that have nonzero covariance with the US market (Bekaert & Harvey, 1997). Not surprising is that the larger European countries are more correlated with the European market since they are influential enough to affect the total European index. The correlations with the US market range from 0,416 for Denmark to 0,625 for the UK. The oil returns are not strongly correlated with most countries, although Norway is the strongest correlated with 0,268 followed by Denmark with 0,121. Also notable is that the correlation between Europe and US is strong with a correlation of 0,684. When estimating the country specific model (eq 11-13) there may be a problem of finding one or both lagged returns for US and Euro insignificant for the country due to this correlation. When in reality one or both variables are exogenous and help predicting the endogenous variable (Ferderer 1996).

Table 3: Correlation between return data

	EUROPE	US	WTI
Denmark	0,693	0,416	0,121
EU	1,000	0,684	0,083
France	0,895	0,619	0,078
Germany	0,888	0,592	0,042
Ireland	0,697	0,488	0,019
Italy	0,733	0,481	0,055
Norway	0,665	0,448	0,268
Sweden	0,784	0,565	0,062
UK	0,914	0,625	0,103
US	0,684	1,000	0,030
WTI	0,083	0,030	1,000

5. Empirical results

5.1 The Spillover Model

The first step is to get an estimate of the oil return market described by equations 1-3.

Table 4: Estimation of the oil returns
The oil returns are assumed to follow an AR(1) process as described by equation 1-3 and the error term follow a GJR-GARCH(1,1) process. The estimated coefficients are presented here.

	Coefficient	Std. Error
β_0	0,224 (0,100)	0,136
β_1	-0,068 (0,032)	0,032
ω	1,293 (0,004)	0,443
α_1	0,080 (0,004)	0,027
α_2	0,032 (0,251)	0,028
b_1	0,856 (0,000)	0,034

Note: P-values are given in brackets

The indicator function coefficient isn't statistically significant, thus implying that a symmetric GARCH-model would be sufficient when modeling oil returns. Although both the squared residuals and GARCH term is highly significant, implying that a GARCH-model is an appropriate form. A Wald test with the null $\alpha_1=b_1=0$ is rejected with a p-value of 0,000 indicating that ARCH effects are present in the oil market. More explanatory variables could have been added to the regression to increase the explanation rate, such as oil reserves, oil production, substitute products, mining activities and government policies (Fengdan & Yuxian, 2008). This would likely increase the R-square value and decrease the oil shocks ($e_{oil,t}$) that are put into the European model.

The second estimation step involves estimating the US model (eq 5-7) which allow for spillover effects from the oil market towards the US market. The results are presented in appendix under table A1.The US market doesn't seem to be affected by the oil market since the insignificant coefficients of lagged returns and oil shocks. A Wald test of $\gamma=\Phi=0$ is not rejected with a p-value of 0,898 following a chi-square distribution. This is a different finding than that of Horng and Wang (2008), who used a bivariate asymmetric-IGARCH(1,2) model for estimation. They found that lagged returns where insignificant but that both positive and negative effects from oil market affected the US market. Asymmetric effects seem to be present in the US market with a highly significant α_2 coefficient which is in accordance with findings by Horng and Wang (2008). A Wald test with the null of $\alpha_1=b_1=0$ is applied to test for ARCH-effects. The Wald test follows a chi-square distribution with two degrees of freedom. The null is highly rejected (p-value of 0,000) which indicate that ARCH-effects are present.

Third step involves estimation of the European model (eq 8-10).The estimated model is presented in appendix under table A2.The lagged oil returns are found insignificant for Europe while the lagged returns from US is found significant. As with the US returns an asymmetric model seems to be appropriate since the coefficient for the indicator function is highly significant (p-value of 0,000). The shocks from both the oil market and the US market are highly significant. Thus, indicating that shocks from both markets will affect the volatility. Wald tests for spillover effects from the oil market and US market are preformed with the null hypotheses of $\gamma=\Phi=0$ and $\delta=\psi=0$. The null of no oil spillover effect is rejected with a p-value of 0,005 while the null of no US spillover effect is rejected with a p-value of 0,000.

In the fourth estimation faze the country specific models are estimated, where each country is affected by spillovers from oil market, US market and European market. The estimation output for each country is presented in table 5.

Table 5: The spillover model for each country

The model described by equation 11-13 where each country is affected by both mean and volatility spillovers from oil market, US market and European market.

	Den	Fra	Ger	Ire	Ita	Nor	Swe	UK
β_0	0,256	0,183	0,176	0,186	0,100	0,230	0,200	0,108
	(0,000)	(0,000)	(0,000)	(0,001)	(0,013)	(0,001)	(0,000)	(0,000)
β_1	-0,096	-0,084	-0,078	0,001	-0,049	-0,030	-0,097	-0,137
	(0,003)	(0,009)	(0,016)	(0,972)	(0,114)	(0,345)	(0,003)	(0,000)
γ	0,013	0,005	-0,006	-0,016	-0,005	0,048	-0,006	0,004
	(0,191)	(0,312)	(0,344)	(0,179)	(0,464)	(0,001)	(0,566)	(0,415)
δ	0,210	0,069	0,111	0,134	0,068	0,164	0,204	0,083
	(0,000)	(0,000)	(0,000)	(0,000)	(0,009)	(0,000)	(0,000)	(0,000)
θ	-0,021	0,006	0,002	-0,037	0,013	-0,039	0,000	0,005
	(0,618)	(0,868)	(0,953)	(0,358)	(0,741)	(0,434)	(0,994)	(0,889)
Φ	0,056	0,035	0,018	0,012	0,040	0,172	0,040	0,042
	(0,000)	(0,000)	(0,008)	(0,310)	(0,000)	(0,000)	(0,000)	(0,000)
ψ	0,430	0,691	0,697	0,540	0,588	0,566	0,783	0,596
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
φ	0,833	1,016	1,048	0,831	0,961	0,912	1,086	0,917
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)
ω	0,199	0,008	0,010	0,080	0,014	0,332	0,045	0,003
	(0,001)	(0,050)	(0,033)	(0,000)	(0,026)	(0,001)	(0,005)	(0,196)
α_1	0,110	0,124	0,096	0,037	0,105	0,080	0,045	0,008
	(0,000)	(0,000)	(0,000)	(0,028)	(0,000)	(0,001)	(0,001)	(0,322)
α_2	0,052	-0,057	-0,042	0,071	0,009	0,064	0,051	0,069
	(0,128)	(0,011)	(0,040)	(0,004)	(0,690)	(0,039)	(0,001)	(0,000)
b_1	0,818	0,903	0,924	0,909	0,895	0,829	0,922	0,958
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)

Note: P-values are given in parenthesis.

The intercept coefficient is found significant for all countries on a 5% significance level. Although not all countries seem to be dependent on the past own return. For Ireland, Italy and Norway the null hypothesis of no lagged returns is not rejected.

Lagged oil returns are found insignificant in all countries except for Norway. According to theory an oil price increase would lower the industrial production and hence give a lower return for a market that have a production that's dependent on oil products. The finding here is that the coefficient vary in sign and have a low insignificant p-value value except for Norway. A net exporting country like Norway would be expected to have a positive coefficient since this increase the profits of export.

The lagged return from the US is found positive and highly significant for all countries. Thus, an increase in the US market seems to lead to a higher return in the European markets due to the positive coefficient for all countries.

The lagged return from Europe is found insignificant for all countries. This may be because of the high correlation between the US and European market. A redundant variable test is hence preformed for all countries. The coefficients for the lagged European return and European shocks are presented in table 6. When excluding both lagged US returns and US shocks towards each European country more are found to have a significant effect from lagged European returns. Denmark, Germany, Ireland, Norway, and UK now have a significant mean lagged return spillover from European market. Although the lagged return coefficients are still insignificant for France, Italy and Sweden. The shocks from the European market are still highly significant for all countries.

Table 6: Redundant variable test
The country specific model when excluding US spillover effects.

	θ	φ
Denmark	0,129	0,828
	(0,000)	(0,000)
France	-0,008	1,042
	(0,892)	(0,000)
Germany	0,116	1,037
	(0,028)	(0,000)
Ireland	0,086	0,820
	(0,019)	(0,000)
Italy	0,075	1,046
	(0,090)	(0,000)
Norway	0,152	0,931
	(0,000)	(0,000)
Sweden	0,099	1,041
	(0,063)	(0,000)
UK	0,111	0,958
	(0,018)	(0,000)

Note: P-values are given in parenthesis.

The shocks from the oil market are found significant for all countries except for Ireland. This indicates that it is the unexpected shocks that affect the stock market rather than the lagged returns that where found insignificant for all except Norway. This can to some extent be explained by the effects of oil uncertainty on the economy. As found by Elder and Serletis

(2010), uncertainty about oil movements tend to depress investment. This may be the reason for finding shocks significant but lagged returns insignificant. For all countries $|\Phi|<|\psi|<|\varphi|$ meaning that the oil shocks are less influential than US shocks that are in turn less influential than the European shocks. Shocks from both US and Europe are found highly significant for all countries.

When looking at the variance specification for the asymmetric GARCH(1,1)-model it seem to be appropriate for most countries. The squared lagged residuals are found significant for all countries except for the UK at a 5% significance level. The asymmetric effects seem to be present in France, Germany, Ireland, Norway, Sweden and UK when using a 5% significance level. But it is found to be insignificant for Denmark and Italy. The GARCH term is highly significant for all countries.

Wald test of spillover effect from oil market, US market and European market is tested in accordance with Ng (2000). The null hypotheses of no spillover effect from oil ($\gamma=\Phi=0$), from US ($\delta= \psi =0$) or from Europe ($\theta= \varphi =0$) are tested by Wald tests, following a chi-square distribution with 2 degrees of freedom. Finding evidence that spillover effects are highly significant (p-value < 0,001) for all markets except for oil market spillover effect towards Ireland where the p-value is found to be 0,222.

The average variance ratios for each country are presented in table 7. Variance ratios from oil are found low for most countries ranging from low 0,060% for Ireland to 7,846% for Norway. The three countries (Denmark, Norway and UK) with the highest correlation towards the oil market are also found to have the highest variance ratio from the oil market. The average variance ratios from the US market are ranging from 12,601% for Denmark to 32,056% for France. Here the larger economies of France, Germany and the UK have the highest variance ratios. The average variance ratios from Europe are found higher than the variance ratio from US for all countries, indicating that the regional European shocks have a larger impact than shocks from the US. The lower variance ratios from Europe towards Denmark, Norway and Sweden can to some extent be explained by the fact that they have not joined EMU. But on the other hand are these countries less influential towards the total European index than the larger countries.

The country specific variance ratios each week is presented in appendix under figure A2-A9. A notable trend among France, Germany, Italy, Sweden and the UK is a steady decrease in own idiosyncratic variance ratio after the merger of the EU. The variance ratios from the US seem to have an increasing trend over the sample. Perhaps this could be explained by the rapid technological development and faster information transmission between markets. Norway is the only country that has strong fluctuations in response to oil movements as expected when looking at the average variance ratios. The oil variance ratios for Norway were especially strong during the 1990-1991 period and 2003-2005.

Table 7: Spillover model: Average variance ratios

The average variance ratios over entire sample in percent.

	VR oil	VR US	VR EU	VR own
Denmark	1,315	12,601	30,975	55,110
France	0,529	32,056	46,653	20,762
Germany	0,133	30,064	45,831	23,972
Ireland	0,060	17,546	28,747	53,647
Italy	0,579	20,701	34,648	44,072
Norway	7,846	14,349	23,987	53,819
Sweden	0,428	25,589	32,950	41,033
UK	0,974	30,002	48,366	20,658

5.2 Conditional Spillover Model

The conditional model with time-varying coefficients was defined in equation 16. The coefficient in this estimation is now allowed to vary in response to a constant, interest rate and industrial production. Most countries still have 1092 observations except for Denmark (1063) and Sweden (1020), due to lack of data on interest rates in the early years. The results from the spillover coefficients are presented in table 8.

Table 8: Coefficients for the conditional spillover model for each country
The conditional model where the oil spillover parameters are divided into a constant, interest rate and industrial production.

	Den	EU	Fra	Ger	Ire	Ita	Nor	Swe	UK	US
γ_0	0,014	0,002	0,006	-0,005	-0,015	-0,006	0,050	-0,008	0,007	-0,006
	(0,152)	(0,825)	(0,279)	(0,434)	(0,201)	(0,413)	(0,001)	(0,436)	(0,161)	(0,635)
γ_1	-0,003	-0,002	-0,006	-0,003	-0,001	0,001	-0,002	0,005	0,003	-0,003
	(0,297)	(0,665)	(0,000)	(0,406)	(0,713)	(0,669)	(0,614)	(0,100)	(0,069)	(0,435)
γ_2	-0,017	-0,202	-0,100	-0,068	0,005	-0,084	0,011	-0,105	-0,018	0,084
	(0,565)	(0,010)	(0,009)	(0,059)	(0,868)	(0,077)	(0,831)	(0,072)	(0,687)	(0,687)
δ	0,211	0,090	0,069	0,107	0,136	0,070	0,172	0,208	0,087	
	(0,000)	(0,004)	(0,000)	(0,000)	(0,000)	(0,007)	(0,000)	(0,000)	(0,000)	
θ	-0,009		0,009	0,001	-0,039	0,012	-0,039	0,022	0,006	
	(0,830)		(0,808)	(0,973)	(0,351)	(0,766)	(0,441)	(0,645)	(0,851)	
Φ_0	0,059	0,033	0,036	0,019	0,012	0,041	0,172	0,037	0,039	-0,002
	(0,000)	(0,001)	(0,000)	(0,008)	(0,329)	(0,000)	(0,000)	(0,001)	(0,000)	(0,889)
Φ_1	0,001	0,005	0,006	0,000	-0,003	0,009	0,009	0,001	-0,005	0,001
	(0,700)	(0,432)	(0,004)	(0,907)	(0,367)	(0,001)	(0,014)	(0,501)	(0,058)	(0,607)
Φ_2	-0,047	-0,014	0,049	-0,022	-0,012	0,001	0,045	0,108	-0,170	0,093
	(0,183)	(0,895)	(0,209)	(0,555)	(0,594)	(0,980)	(0,273)	(0,048)	(0,002)	(0,467)
ψ	0,423	0,668	0,690	0,701	0,540	0,590	0,557	0,797	0,594	
	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	
φ	0,848		1,019	1,053	0,828	0,964	0,905	1,095	0,917	
	(0,000)		(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	(0,000)	

Note: P-values are given in parenthesis.

The lagged time-varying return spillover coefficients are in most countries found insignificant at a 5% significance level. The intercept is found significant only for Norway and the change in interest rate is only significant for France. The change in industrial production is found significant for EU and France.

The oil shock intercept are found significant for all except Ireland and US. The interest rate are found significant for France, Italy and Norway while the industrial production is significant for Sweden and UK. The US and EU shocks are still highly significant for all countries. The variance ratios are calculated for the conditional model and are presented in table 9. The oil variance ratios are al found to be higher than for the unconditional model. Although the difference is not very large, the biggest difference is for Norway and it is only 0,347 % higher.

Table 9: Conditional model, Average variance ratios

The average variance ratios over entire sample in percent.

	VR oil	VR US	VR EU	VR own
Denmark	1,516	12,210	31,804	54,470
France	0,671	31,940	46,497	20,892
Germany	0,144	30,198	45,720	23,938
Ireland	0,094	17,589	28,307	54,010
Italy	0,782	20,811	34,479	43,928
Norway	8,192	14,122	23,687	53,999
Sweden	0,530	26,602	33,670	39,198
UK	1,039	30,012	48,392	20,558

5.3 Asymmetric Oil Effects on Stock Returns

A model that allow for testing the asymmetric effects of oil movements towards each country specific stock market are specified in equation 17-19. Asymmetric effects are examined by a Wald test with the null hypotheses of $\gamma_1 = \gamma_2$ for asymmetry in oil returns and $\Phi_1 = \Phi_2$ for asymmetry in the oil shocks. The results for the coefficients of γ_1, γ_2, Φ_1 and Φ_2 as well as the Wald tests are presented in table 10.

The lagged oil mean return is still found insignificant for both positive and negative returns for France, Germany, Ireland, Norway, Sweden and the UK. Somewhat surprising is the finding that both are insignificant for Norway, for which the combined shocks where significant. For Denmark only the positive returns have a significant and positive coefficient. Both positive and negative lagged oil returns have a significant effect on the Italian returns. For most countries the negative shocks have a coefficient greater than the positive shocks. This finding indicates that there is an asymmetric effect for oil shocks towards the stock markets. For Denmark, Italy and Sweden only the negative shocks have a significant effect on the returns. France, Norway and the UK are highly dependent on both types of shocks.

The Wald tests of no asymmetric returns are only rejected for Italy. The shocks are only significantly different for Denmark and Italy. Some evidence of asymmetric effects is hence found even though most countries do not seem to react asymmetric towards neither return nor shocks. Lardic and Mignon (2006) give four explanations to the presence of asymmetric oil price effects. First, the effect from monetary policy described by Bernanke et al. (1997). If the monetary authority does not maintain a constant nominal GDP through oil price increases, a country may suffer from GDP losses through the unexpected inflation. While in response to an oil price decline, the real wages must grow to clear the market. Hence, the idea is that monetary policy and not oil price changes cause asymmetry in the response to oil price movements. Second, cost adjustments in response to oil price movements can retard economic activity. Such could be the case when an oil price increase lingers and a firm in response change the production structure away from oil based methods. But an oil price decline does not create enough incitement for a change in the structure (Lardic & Mignon, 2006). Third, uncertainty about oil price can have an asymmetric effect on the economy as found by Elder and Serletis (2010). They found that real GDP does not respond symmetric to negative and positive oil price shocks. Investors tend to postpone investments in response to higher uncertainty (more volatile oil prices) about the return on investment. But they seem to react more strongly towards positive oil price shocks than negative, this causes an asymmetric effect. Finally, studies such as Bacon (1991) have found that there is an asymmetric speed of adjustment for petroleum product prices towards a change in crude oil prices. An example is that gasoline price tent to rise more in response to a crude oil increase than it fall toward a decrease of the same magnitude.

Table 10: Asymmetric oil model

The spillover coefficients when separating the spillover effects into positive and negative values. The model is specified in equation 17-19. The Wald test examine if the asymmetric effects are significant, the p-values are presented here.

	γ_1	γ_2	Φ_1	Φ_2	Wald (Return)	Wald (Shocks)
Denmark	-0,015	0,038	0,114	-0,002	0,103	0,000
	(0,458)	(0,035)	(0,000)	(0,922)		
France	0,015	-0,005	0,036	0,034	0,217	0,926
	(0,106)	(0,590)	(0,000)	(0,001)		
Germany	0,005	-0,017	0,017	0,019	0,315	0,920
	(0,718)	(0,185)	(0,149)	(0,172)		
Ireland	-0,018	-0,014	0,015	0,009	0,910	0,863
	(0,413)	(0,515)	(0,475)	(0,667)		
Italy	-0,049	0,037	0,066	0,013	0,000	0,030
	(0,000)	(0,011)	(0,000)	(0,407)		
Norway	0,054	0,043	0,201	0,144	0,805	0,164
	(0,066)	(0,081)	(0,000)	(0,000)		
Sweden	-0,024	0,011	0,055	0,025	0,276	0,370
	(0,223)	(0,553)	(0,002)	(0,249)		
UK	0,002	0,006	0,038	0,047	0,772	0,575
	(0,864)	(0,489)	(0,000)	(0,000)		

Note: P-values are within parenthesis. The Wald test follows a Chi-square distribution with 1 degree of freedom.

6. Conclusion

In this essay a four stage GJR-GARCH(1,1) model was applied to test the presence of both return and volatility spillover from oil market towards the European market. This model allowed each country to be affected by oil shocks, US shocks, European shocks and its own idiosyncratic shocks. Evidence for spillover effects are found from oil, US and Europe towards all countries, except for oil market spillover towards Ireland. Oil is found to have a significant although small effect on the stock market. To see the impact of the oil shocks variance decomposition was performed. All average variance ratios from oil market are found to be smaller than 1% except for Denmark (1,315%) and Norway (7,846%). A model that allow for asymmetric effects was also estimated by separating the spillover effects into positive and negative values. This since oil price increases would be expected to have a more significant effect on the economy than decreases. Only weak support is found for asymmetric effects from oil market towards the European market. Thus, the oil spillover effects seem to affect the European markets in a symmetric manner. In fact the only country with significant asymmetric mean and volatility spillovers are Italy.

My results can be interpreted in the line of the uncertainty a more volatile oil price contribute with. It is the unexpected oil changes (shocks) that are found significant (although small) and not the lagged oil returns. These oil shocks may cause the investors to act more carefully in the market and in turn lower the investment over time. This is supported by my findings of highly significant oil shocks towards the European market. An expected oil change can be hedged against using financial instruments such as derivatives and should not cause unforeseen losses to investors. But an unexpected shock can cause the investor to lose more than expected. So it seem that in response to a oil shock the investments made in the equity market is lowered. Perhaps until the investors expect a more stable economic climate. Although weekly data may have a problem of fully capture the oil effect on investments. A constant increase in volatility may take more than a week for investors to fully incorporate it in their financial analysis. Although most literature on oil effects towards the economy is monthly (Ferderer, 1996) or quarterly (Hamilton, 1983 and Gisser & Goodwin, 1986), my examination with weekly data give another perspective in a shorter time span.

For firms the uncertainty about future oil prices may create a cyclical investment climate. A more volatile oil price can cause firms to postpone the investments until the risk is lowered. In case of a constant increase in oil price (or volatility) firms may reallocate the resources away from oil based production into less oil dependent manufacturing, especially firms in the sector of industrial production. Although this effect is hard to measure due to the fact that the response time of firms differ. Not just firms but also private consumption seem to decrease in times of uncertainty, as found by Elder and Serletis (2010). Consumers may shift their consumption away from oil based heating and gas-powered cars in response to a lingering oil increase. This may cause the firms to change its supply to respond to this new demand.

References

Apergis, N., & Miller, S. M. (2009). Do structural oil-market shocks affect stock prices? *Energy Economics*, 31(4), 569-575.

Asgharian, H., & Nossman, M. (2011). Risk contagion among international stock markets. *Journal of International Money and Finance*, 30, 22-38.

Bacon, R. W. (1991). Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes. *Energy Economics,* 13(3) 211-218.

Bekaert, G., & Harvey, C.R. (1997). Emerging equity market volatility. *Journal of Financial Economics,* 43(1), 29–77.

Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*, 31(3), 307-327.

Bollerslev, T., Chou R. T., & Kroner, K. F. (1992). ARCH modeling in finance: A review of the theory and empirical evidence. *Journal of Econometrics,* 52(1-2), 5-59.

Cavallo, A. J. (2002). Predicting the Peak in World Oil production. *Natural Resources Research*, 11(3), 187-195.

Chang, C. L., McAleer, M., & Tansuchat, R. (2010). Analyzing and forecasting volatility spillovers, asymmetries and hedging in major oil markets. *Energy Economics*, 32(6), 1445-1455.

Ciner, C. (2001). Energy Shocks and Financial Markets: Nonlinear Linkages. *Studies in Nonlinear Dynamics and Econometrics,* 5(3), 203-212.

Elder, J., & Serletis, A. (2010). Oil Price Uncertainty. *Journal of Money, Credit and Banking, 42(6), 1137-1159*

Engle, R. F. (1982). Autoregressive Conditional Heteroskedasticity with Estimates of Variance of United Kingdom Inflation. *Econometrica,* 50(4), 987-1008.

Ewing, B. T., Forbes, S. M., & Payne, J. E. (2003). The effects of macroeconomic shocks on sector-specific returns. *Applied Economics*, 35(2), 201−207.

Fengdan, S., & Yuxian H. (2008). Empirical study on international oil price and oil consumption. *International Conference on Bioinformatics and Biomedical Engineering*, 2, 4641-4644.

Ferderer, J. P. (1996). Oil Price Volatility and the Macroeconomy. *Journal of Macroeconomics*, 18(1), 1-12.

Filis, G., Degianakis, S., & Floros, C. (2011). Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. *International Review of Financial Analysis*, 20(3) 152-164.

Gisser, M., & Goodwin, T. H. (1986). Crude Oil and the Macroeconomy: Tests of Some Popular Notions: Note. *Journal of Money, Credit and Banking,* 18(1), 95-103.

Glosten, L. R., Jagannathan, R., & Runkle, D. (1993). On the relation between the expected value and the volatility of the nominal excess return on stocks. *Journal of Finance,* 48(5), 1779–1801.

Hamilton, J. D. (1983). Oil and the Macroeconomy since World War II. J. *The Journal of Political Economy*, 91(2), 228-248.

Hong, H., Torous, W., & Valkanov, R. (2002). Do industries lead the stock market? Gradual diffusion of information and cross-asset return predictability. *Working Paper, Stanford University and UCLA*.

Horng, W. J., & Wang Y.Y. (2008). An Impact of the Oil Prices' Volatility Rate for the U.S. and the Japan's Stock Market Return: A DCC and Bivariate Asymmetric-GARCH Model. *The 3rd Intetnational Conference on Innovative Computing Information and Control*, 269-269.

Hull, J. C. (2008). Options, Futures and Other derivatives, 7th edition, Pearson Education, Prentice Hall. ISBN: 978-0-13-601586-4.

Jones, C. M., & Kaul, G. (1996). Oil and the stock markets. *The Journal of Finance*, 51(2), 463-491.

Lardic, S., & Mignon, V. (2006). The impact of oil prices on GDP in European countries: An empirical investigation based on asymmetric cointegration. *Energy Policy,* 34(18), 3910-3915.

Malik, F., & Hammoudeh, S. (2007). Shock and volatility transmission in the oil, US and Gulf equity markets. *International Review of Economics and Finance*, 16(3), 357-368.

Malik, F., & Ewing, B. T. (2009). Volatility transmission between oil prices and equity sector returns. *International Review of Financial Analysis,* 18(3), 95–100.

Miller, J. I., & Ratti, R. A. (2001). Crude oil and stock markets: Stability, instability and bubbles. *Energy Economics,* 31(4), 559-568.

Mork, K. A. (1989). Oil and the Macroeconomy When Prices Go Up and Down: An Extension of Hamilton's Results. *Journal of Political Economy,* 97(3), 740-744.

Ng, A. (2000). Volatility spillover effects from Japan and the US to the Pacific basin. *Journal of International Money and Finance*, 19(2), 207–233.

Odusami, O. B. (2009). Crude oil shocks and stock market returns. *Applied financial economics*, 19(4), 291-303.

Pollet, J. (2002). Predicting asset returns with expected oil price changes. *Harvard University Working Paper*.

Rafiq, S., Salim, R. & Bloch, H. (2009). Impact of crude oil price volatility on economic activities: An empirical investigation in the Thai economy. Resources Policy, 34(3), 121-132.

Regnier, E. (2007). Oil and energy price volatility. *Energy Economics*, 29(3), 405-427.

Sadorsky, P. (1999). Oil price shocks and stock market activity. *Energy Economics,* 21(5), 449-469.

Webb sources

Interest rates and Industrial production. Collected 4th June from OECD: http://stats.oecd.org/

PET_PRI_SPT_S1_W.xls. (n.d.). Collected 4th May 2011 from EIA: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_w.htm

Statistical Review of World Energy 2010. (n.d.). Collected 4th May 2011 from BP oil: http://www.bp.com/subsection.do?categoryId=9023761&contentId=7044545

Appendix

Definitions

A1: Interest rates used

Denmark, INTERBANK 1 MONTH - OFFERED RATE

France, INTERBANK 1 MONTH - OFFERED RATE

Germany, INTERBANK 1 MTH (LDN:BBA) - OFFERED RATE

Ireland, INTERBANK 1 MONTH - OFFERED RATE

Italy, EURO-LIRE 1M (FT/ICAP/TR) - MIDDLE RATE

Norway, INTERBANK 1 MONTH - MIDDLE RATE

Sweden, TREASURY BILL 30 DAY - MIDDLE RATE

UK, INTERBANK 1 MONTH - MIDDLE RATE

US, INTERBANK 1 MTH (LDN:BBA) - OFFERED RATE

Tables

Table A1: Estimation of the US model
The coefficients for the US GJR-GARCH(1,1) regression described by equations 5-7.

	Coefficient	Std. Error
β_0	0,188	0,056
	(0,001)	
β_1	-0,145	0,031
	(0,000)	
γ	-0,005	0,011
	(0,644)	
Φ	0,000	0,011
	(0,995)	
ω	0,112	0,029
	(0,000)	
α_1	0,029	0,017
	(0,088)	
α_2	0,145	0,022
	(0,000)	
b_1	0,877	0,019
	(0,000)	

Note: P-values are given in parenthesis.

Table A2: Estimation of the European model
The coefficients for the European GJR-GARCH(1,1) regression described by equations 8-10.

	Coefficient	Std. Error
β_0	0,145	0,050
	(0,004)	
β_1	-0,111	0,033
	(0,001)	
γ	0,000	0,010
	(0,960)	
δ	0,090	0,031
	(0,004)	
Φ	0,033	0,010
	(0,001)	
ψ	0,670	0,020
	(0,000)	
ω	0,314	0,079
	(0,000)	
α_1	0,046	0,025
	(0,073)	
α_2	0,139	0,038
	(0,000)	
b_1	0,777	0,042
	(0,000)	

Note: P-values are given in parenthesis.

Figures

Figure A1: Plot of the return data.

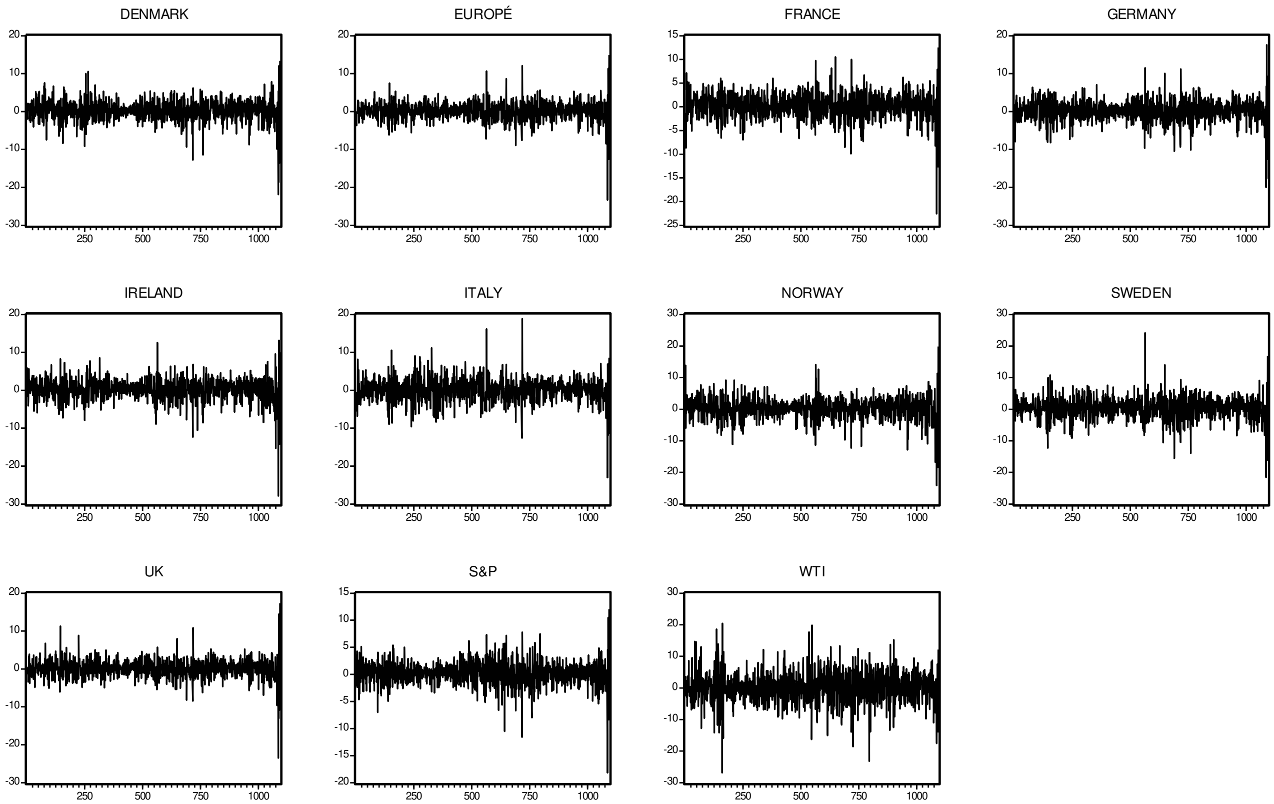


Figure A2-A9: Variance decomposition over time.

Figure A2: Variance ratios Denmark

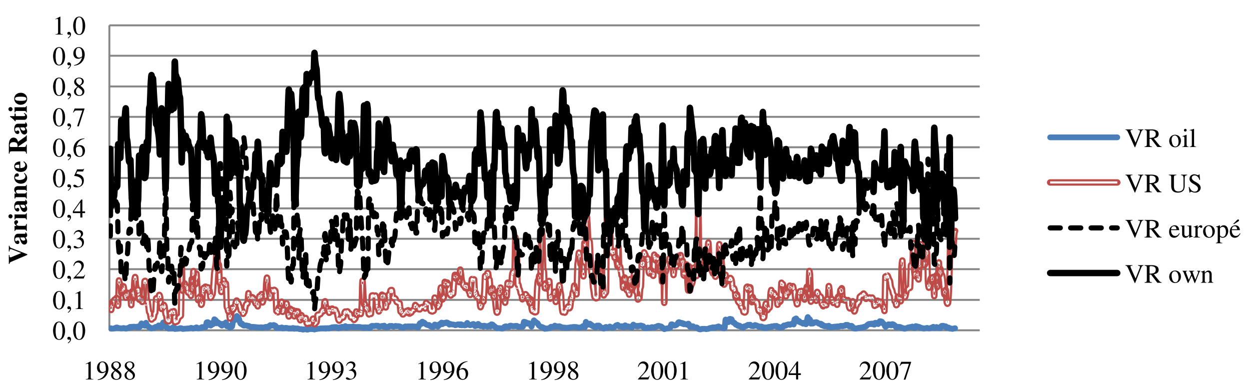


Figure A3: Variance ratios France

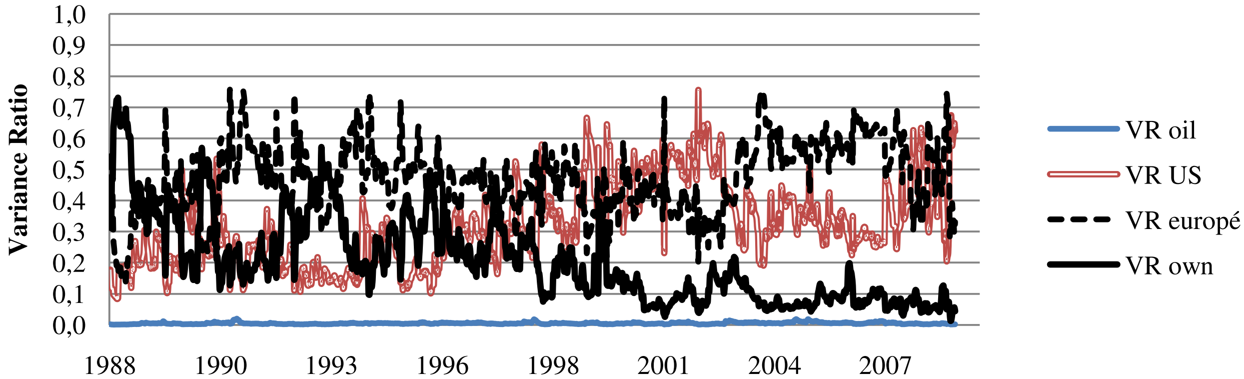


Figure A4: Variance ratios Germany

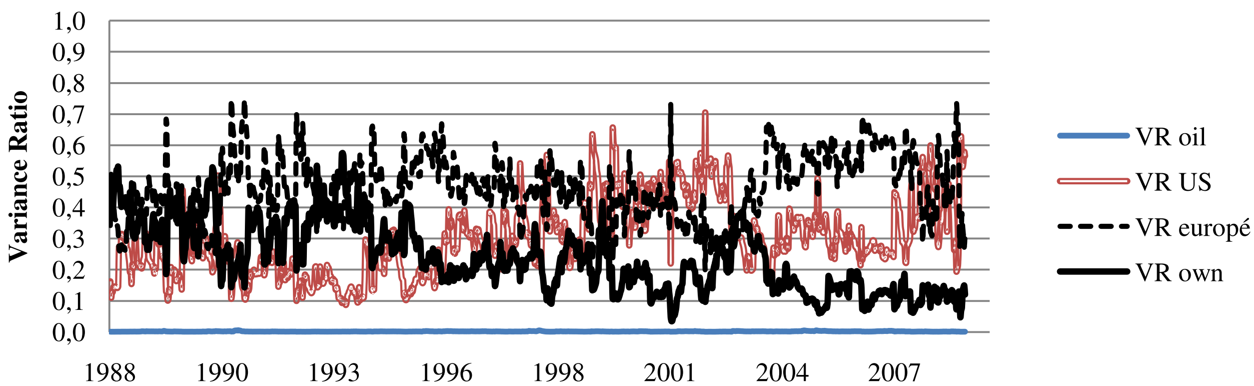


Figure A5: Variance ratios Ireland

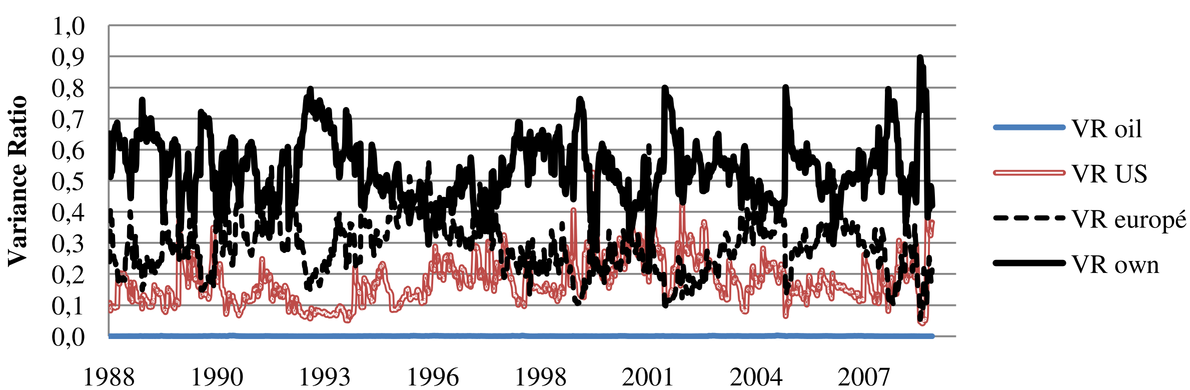


Figure A6: Variance ratios Italy

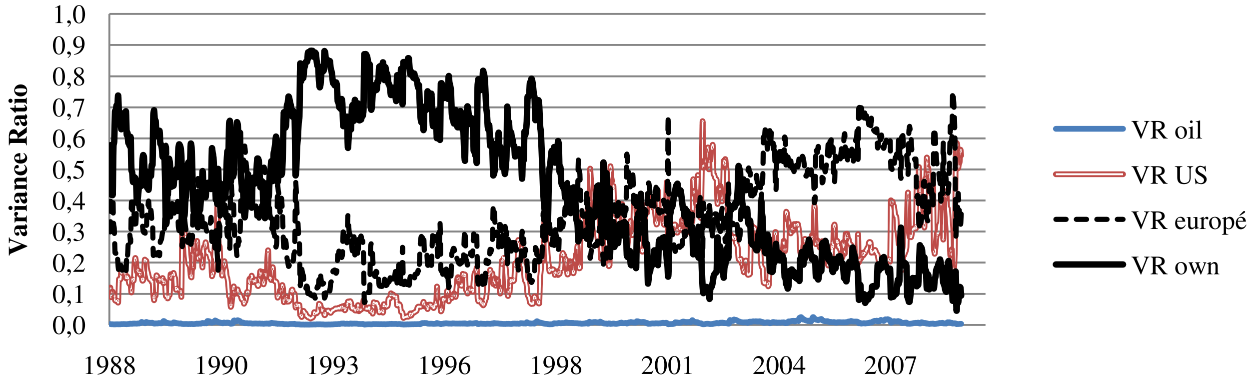


Figure A7: Variance ratios Norway

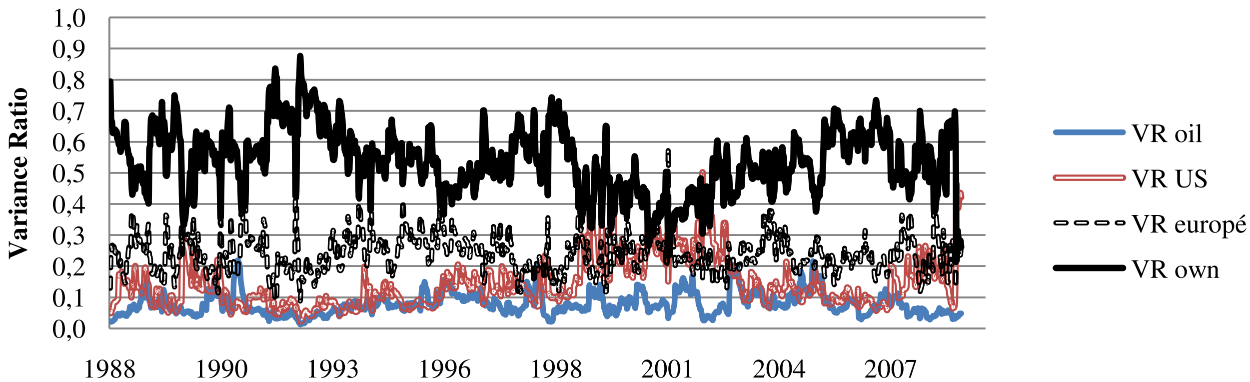


Figure A8: Variance ratios Sweden

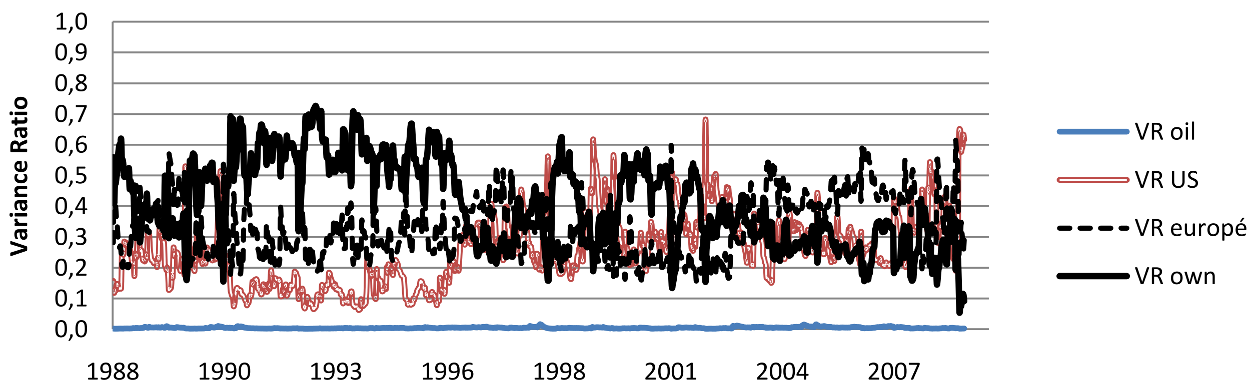


Figure A9: Variance ratios UK