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Stock returns for oil companies and their sensitivity to oil price fluctuations

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Preface

With this master thesis we finish our master's degree in business and administration with a specialization in finance at the Norwegian University of Life Sciences.

The study analyzes the stock returns of twenty-five publicly traded oil companies listed world-wide, and their sensitivity to oil price fluctuations. Throughout the degree, our interest and knowledge for financial markets have increased. The chosen subject was a natural selection as we find the topic highly relevant, and it gives us the opportunity to apply our knowledge from our financial subjects.

The work has been challenging, but also very rewarding and have given us more insight and knowledge about companies in the oil sector.

We would like to thank our advisors, associate professor Marie Steen and professor emeritus Ole Gjølberg for constructive feedback, guidance and support during the work period.

This thesis is a part of the MSc program at the Norwegian University of Life Sciences. The school takes no responsibility for the methods used, results found and conclusions drawn.

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Abstract

This master thesis is written to analyze the relationship between the stock returns for oil companies and their sensitivity to oil price fluctuation. The topic was chosen to better understand why the stock performance of oil companies differ, when all selected companies are being influenced by Brent crude oil prices. The results are intended to be of use for investors and stakeholders in oil companies.

Twenty-five publicly traded oil companies were selected and divided into three subsectors: integrated-, upstream-, and downstream companies. Brent crude was selected as our oil price benchmark and FTSE All World was selected as our market benchmark. Monthly data were retrieved for all companies, Brent crude and FTSE All World in the time period from Jan 2001 to Dec 2020.

The results from the analysis indicate that upstream companies have a higher oil beta value on average compared to integrated- and downstream oil companies. Previous oil prices have no effect on present stock returns. Negative oil price changes have a significantly greater effect on stock returns compared to positive changes. Extreme negative oil price changes give a significant addition or deduction to the oil beta. There exist significant values in the quantiles and a Wald-test showed significant differences between quantiles.

From the results we conclude that the relationship between the stock return of oil companies to Brent crude is time varying and differentiate under different market conditions.

Abstrakt

Formålet med denne masteroppgaven er å analysere forholdet mellom oljeselskapers avkastning og deres sensitivitet til oljeprisfluktuasjoner. Emnet ble valgt for å skape en større forståelse for hvorfor aksjeavkastningen mellom oljeselskaper differensierer da oljeselskapene er eksponert mot Nordsjøolje også kjent som Brent crude oil. Resultatene har som intensjon å kunne komme til nytte for investorer og andre interessenter i oljeselskaper.

Tjuefem børsnoterte selskaper ble utvalgt og inndelt i tre sektorer: integrerte-, oppstrøms- og nedstrømsselskaper. Brent crude ble valgt som referanseindeks for oljepris og FTSE All World ble valgt som referanseindeks for markedet. Månedlige data ble uthentet for samtlige selskaper, Brent crude og FTSE All World fra januar 2001 til desember 2020.

Resultatene fra analysene indikerer at oppstrømsselskaper har en gjennomsnittlig høyere oljebeta sammenliknet med integrerte- og nedstrømsselskaper. Tidligere oljepriser har ingen effekt på nåtidens aksjeavkastning for oljeselskaper. Negative oljeprisfluktuasjoner har en signifikant høyere effekt på aksjeavkastningen sammenliknet med positive oljeprisfluktuasjoner. Ekstremt negative oljeprisfluktuasjoner gir et signifikant tillegg eller fradrag i oljebetaen. Det eksisterer signifikante verdier i kvantilene, og en Wald-test viser signifikante forskjeller mellom kvantiler.

Ut ifra resultatene konkluderer vi med at forholdet mellom aksjeavkastningen til oljeselskaper og Brent crude varierer over tid og er forskjellig under ulike markedsforhold.

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1 Introduction

The purpose of this master thesis is to analyze the relationship between stock returns for oil companies and their sensitivity to oil price fluctuation. We have selected twenty-five publicly traded oil companies listed in various markets world-wide. All companies are exposed to oil price risk, and we have divided them into three subsectors: integrated-, upstream- and downstream companies. This approach is chosen to better analyze how the oil price exposure differs with various activities in the oil sector. We believe our master thesis will be relevant for all stakeholders in the oil and gas sector, but we write our thesis to work as a pointer for investors who wish to invest in oil companies.

The oil market has experienced sudden changes in supply and demand, rapid technology advancement, and an increased focus on decreasing world emissions, which forces oil companies to constantly adapt a more cost-efficient operation to stay profitable. This in addition to the recent oil price fluctuations the world has experienced, we find our topic to be highly relevant and wish to update previous research.

The analysis will be conducted using logarithmic returns for monthly observations in the time period from Jan 2001 to Dec 2020. To better understand the time varying and conditional relationship between stock returns and oil price fluctuations, we have divided our sample data into two periods: Jan 2001 to July 2008 and Jan 2011 to Dec 2020. The time periods are chosen because the first period experienced a steady oil price increase, named a bull oil market, and the second time period experienced a steady oil price decline, named a bear oil market. All analysis is conducted using Brent crude oil as our oil benchmark, because it is used as a benchmark to price two-thirds of the crude oil traded internationally. We use FTSE All World as our market benchmark because it is recognized as a global market benchmark and the Government Pension Fund Global have used it as their benchmark.

We conducted six different analyses to investigate the relationship between the stock returns of oil companies and oil price fluctuations. The first analysis we conducted is a linear regression analysis with FTSE All World and Brent crude as our independent variables and the company stock return as our dependent variable. Similar studies have been conducted by Sadorsky (2001). The study investigated the risk factors in the stock returns of Canadian oil and gas companies and concluded that there is a positive significant relationship between oil price increase and stock returns. Diaz & Gracia (2017) conducted a similar study to investigate the oil price effect on stock returns of oil and gas companies listed at the New

York stock exchange. This study found a significant positive relationship between oil price shocks and stock returns.

Linear regression analyses the conditional mean, which means that the tails of the stock return data are omitted. We conduct a quantile regression to analyze whether there are significant values in the quantiles. A similar study has been conducted by Zhu et al. (2016), which investigated the effect of oil price changes on the real industry stock market returns in China. The study concluded that there are significant values in the quantiles, and by using a Wald-test, they found that there are significant differences between the upper quantiles and the median.

One of our hypotheses is that we believe the market to be efficient, and therefore the stock returns are affected by oil price changes immediately. To investigate the lagged relationship, we conducted a regression where we add the logarithmic returns of Brent crude oil one month back and two months back as independent variables.

The next analysis is conducted to investigate whether there exists asymmetry in how positive and negative oil price changes affect the stock returns of the selected companies and between the subsectors. We use a similar approach as Sanusi & Ahmad (2016) and Lee & Zeng (2011). Sanusi & Ahmad (2016) concluded that oil price increases is more significant than oil price decreases and Lee & Zeng (2011) found opposite results, that negative oil price changes have a more significant effect on stock returns. Our hypothesis relates to the findings from Lee & Zeng (2011), as we believe negative oil prices changes to have a greater effect on the stock return. This is because we believe investors will restrain themselves as they know the possible returns are limited.

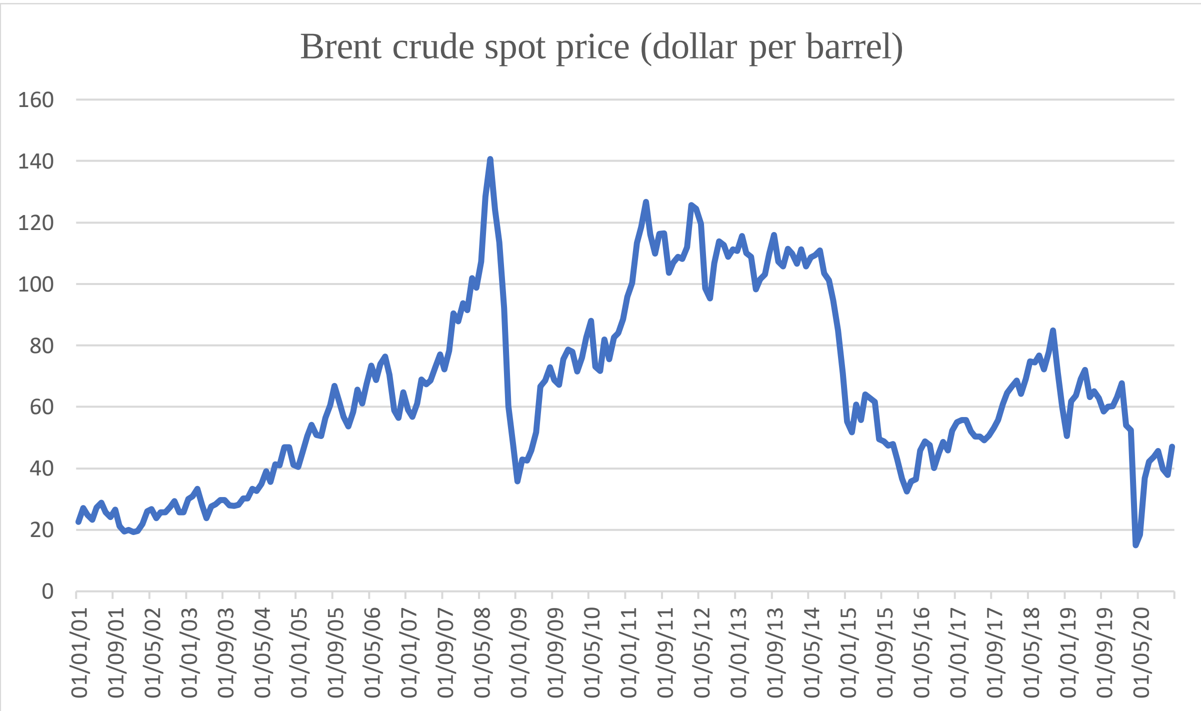
We also wanted to expand the asymmetry analysis. To do this, we conducted an analysis to investigate whether extreme oil price changes either give a significant addition or deduction in the oil price beta. From this analysis we expect the oil price beta to get a significant deduction because the companies are affected by other variables than the oil price. In extreme situations, the increase or decrease of stock returns will eventually slow down and not follow the oil price.

We start the master thesis with a presentation of Brent crude prices and global events that may have influenced the price fluctuations. In chapter three we review the theoretical framework and previous research on the relationship between stock returns and oil price fluctuations. After we decided upon a topic, we constructed some predefined hypotheses, which is presented in chapter four. Chapter five includes the selected data and descriptive analysis before we present the empirical framework in chapter six. In chapter seven we have presented the results from the analyses, and in chapter eight we conclude all findings.

2 Historic Brent crude prices and future predictions

Crude oil and its price fluctuations is closely linked to the world economy and about 45% of the world's energy consumption comes from oil products (IEA, 2020). Due to its importance and many stakeholders, it can be highly beneficial for investors and other stakeholders to understand its influencing factors and how the oil price is linked to global events.

The price of crude oil has experiences numerous periods with high fluctuations. The main component behind price fluctuations is the relationship behind supply and demand, but for crude oil, other variables may play an important role. Kilian (2009) points out that global events like wars, natural disasters, and cartels may affect the shifts in supply and demand. Baumeister & Kilian (2016) discovered that crude oil reserves influence the oil price. In this chapter we will review selected periods where oil price fluctuations coincide with global events that may have influenced the oil price.



Graph 1: Price of one-barrel Brent crude oil from Jan 2001 to Dec 2020.

In the beginning of 2001, the price of one-barrel of Brent crude were $23,43. In the years to follow we observe from graph 1 that a steep price increase began in 2003, and that the price increased steadily until 2008, except for a downward period during 2007 until mid-July 2008.

Between 2003 and 2008 the price increased from $23/bbl (barrel of oil) in May 2003 to $143/bbl in July 2008. Zhang et al. (2009) conducted a study to estimate the impact of extreme events on crude oil prices with a focus on the Iraqi war. In 2003 the United States invaded Iraq, which raised fear of supply shortage in the future. The study concluded that the invasion in addition to increased demand of oil from Asia and increased interest from speculators in the futures market, contributed to the increase in crude oil prices the following years.

Hamilton (2009) investigated the price shock in 2007-2008 and compared it to previous oil price shocks. The study concluded that the price run-up was caused by an increased demand and a stagnating world production.

After the oil price shock in 2007-2008 there was a steep price decline during the financial crisis of 2008. From the record high notation with crude oil prices of $143/bbl in July 2008, the price plummeted and in Dec 2008 the price was $33/bbl. In the following years, the priced stabilized before it would increase as the world again experienced a supply shortage due to a series of armed rebellions, uprisings and anti-government protests named the Arab Springs in 2011. In the time period the oil price increased to $126/bbl in April 2011.

In 2014 we observe that the crude oil price decreased rapidly, and prices fell from $115/bbl in June 2014 to $26/bbl in Jan 2016. Tokic (2015) conducted a study to analyze the causes and consequences of the 2014 oil bust. The study suggests that the oil price decline was a reaction to the increased shale production in the United States, decreased demand in China and the falling Euro versus US dollar exchange rate.

In the years following, the price stabilized before it decreased again in the beginning of 2020. In Jan 2020, the crude oil price hit $70/bbl and then decreased to $14/bbl in April 2020. There is still little research on the causes of the price drop, but as countries around the globe went into lockdown, closing businesses and prohibited traveling, global demand suddenly dropped drastically. In addition, the price war between Russia and Saudi Arabia could have resulted in the price decline.

Every year, British Petroleum (BP) releases a report where they give an energy outlook until 2050. The report is divided in three possible scenarios: Net Zero, Rapid and Business as usual. For the scenarios Net Zero and Rapid, the global demand for oil will never recover from the Covid-19 decrease, implying that oil demand peaked in 2019. In the Net Zero scenario, BP believes the demand will drop to approximately 30 million barrels per day by

2050, and to 50 million barrels per day in the Rapid scenario. The demand decrease will be focused in developed economies and China. For India, the other Asian countries and Africa, the outlook predicts a flat development throughout the time period for Rapid, and a decline in Net Zero after 2030.

For the Business as usual scenario, BP predicts the oil demand to recover from the impact of Covid-19 and that the consumption will be around a 100 million barrels per day for the next 20 years before it declines to around 95 million barrels per day by 2050. The outlook predicts an increase in India, other Asian countries and Africa, and a decrease in developed economies (BP Energy Outlook, 2020).

3 Theoretical Framework

We use the theoretical formula for stock pricing which build on Huang et al. (1996). The formula describes the stock price as the infinite stream of future cash flows discounted by a discount rate, and can be presented as:

$$P_i = \frac{E(CF)}{E(r)} \quad (1)$$

Where P_i is the present value of future cash flows; *E (·)* is the expectation operator; *CF* is the cash flow; and *r* is the discount rate.

3.1 Previous research on oil price effect on stock market return

To what extent oil price changes have a significant impact on stock market returns and the interconnection between the two markets have attracted attention for several years. Hamilton (1983) studied the relationship between oil price changes and its impact on the economic activity in the United States. Although price changes were found to have an impact on economic activity, the subject did not receive much attention prior to 1990 due to low oil price fluctuations. In later years, the oil price has experienced high volatility resulting in price surges and a sharp price decline, which have coincided with stock market fluctuations, attracting attention from various stakeholders.

Sanusi & Ahmad (2016) conducted a study to investigate which determinants that influence the stock returns of all oil and gas companies listed on the London stock exchange. The analysis is conducted using daily observations from Jan 2004 to Dec 2015. The chosen methodology was a multi factor asset pricing model and they made six discoveries. Firstly, oil price shocks influence stock returns of oil and gas companies. Secondly, they discovered the existence of asymmetry, with a price increase for Brent crude oil being more significant than a price decrease. A third discovery was the possible benefit of constructing a portfolio consisting of long positions in small firms and short positions in large firms. The fourth finding was that there is no evidence that using book to market value is beneficial in the oil and gas sector. Fifthly, constructing portfolios based on momentum is not beneficial, and lastly, the price shock of 2014 had a significant impact on stock returns unlike the price shock in 2007.

Diaz and Gracia (2016) investigated the impact of an oil price shock on the stock returns of four oil and gas companies listed on the New York stock exchange. They used monthly observations from Jan 1974 to Dec 2015 and all numbers are presented as natural logarithms. The chosen methodology was a VAR-model consisting of four linear and non-linear specifications for oil price, and the analysis contributed with four findings. The first finding was that the linear specification oil price changes have a positive significant effect on stock returns for oil and gas companies in the short run. The non-linear specification oil price increase has a positive effect on stock returns in the short run. Thirdly, oil price shocks were discovered to have a greater significance post 1986 on stock returns. Finally, the analysis indicated no evidence between stock returns and net oil price increase.

Broadstock et al. (2014) conducted a study with the purpose to research the direct and indirect effect of oil price shocks on energy related companies' stock returns for all markets in the Asia Pacific Region. The analysis is conducted using daily observations from Jan 1984 to Oct 2012 and is collected from the Bloomberg financial database. The methodology used in the research was an extended Capital Asset Pricing Model to test for both direct and indirect effects. The study concludes that oil price shocks do not always influence the stock returns directly, but the effect is always present indirectly. The effect is positive when the effect is significant.

Adekunle et al. (2020) used an oil price-augmented Capital Asset Pricing Model to analyse the role of crude oil prices in predicting the stock returns for oil and gas companies listed on the Nigerian stock exchange. In addition, they tested for asymmetry using restricted and unrestricted models of CAPM and oil-based stock returns. The analysis is conducted using monthly observations from Jan 2014 to Nov 2019 and the sample data is collected from Nigerian stock exchange, Central Bank of Nigeria, and the World bank. The main result from the study is that oil prices have a significant explanatory value when predicting stock returns for oil and gas companies in Nigeria. Additionally, the study finds evidence to suggest that asymmetry plays a role in predicting stock returns for most of the included companies.

Phan et al. (2015) conducted a study to analyse the effect of oil price changes related to the stock returns of crude oil consumers and producers. The selected dataset consisted of the top-20 firms in air transport, chemical manufacturing, petroleum sub-sectors, truck transport and

construction. The next phase was to create sub-sector specific indices using the top-60 firms based on market capitalization. All analysis is conducted using daily observations from Jan 1986 to Dec 2010.
The chosen methodology was a Generalised Autoregressive Conditional Heteroskedasticity regression model (GARCH 1,1). The study presents evidence suggesting that an increase in oil price positively affects stock prices of oil producers and negatively for oil consumers. From the analysis, they also find evidence of asymmetry, and that oil producers react faster to oil price changes compared to oil consumers. Lastly, they found that with increased firm size, the effect of oil price change is greater.

Bagirov & Mateus (2019) examined the relationship between oil price changes and stock returns in Europe. Because oil price changes affect differently across sector, they analysed the relationship between oil price changes related to stock returns of both listed and unlisted oil and gas companies in the Western Europe region. Stock market and indices data were collected from Datastream International, and Brent crude spot prices were collected from Energy Information Administration. They use weekly observations from Jan 2006 to Dec 2015 to conduct the analysis. They chose three empirical models in the paper. Vector autoregressive model, vector autoregressive – generalised autoregressive conditional heteroskedasticity model, and a generalised method of moments model. The results from the study were that the listed oil and gas companies have a positive and significant relation to crude oil prices, and unlisted oil and companies are not affected by crude oil prices.

Ding et al. (2016) conducted a study to investigate the relationship between West Texas Intermediate and Dubai crude oil with five stock indices within the quantiles. The empirical analysis is conducted using daily observations from Jan 1996 to Oct 2012. The main finding from the study is that the relationship between crude oil prices and stock returns are found in the lower and higher quantiles, indicating that in extreme market situation, the relationship is amplified.

Zhu et al. (2016) conducted a similar study to Ding et al (2016) but used a quantile regression approach to study the dependence between crude oil prices and the Chinese real industry stock market. They used monthly observations from March 1994 to June 2014. The results from the study suggest that there is a significantly positive effect between oil price and the Chinese real industry stock market, but only in the lower tail, or recessions.

Degiannakis et al. (2013) conducted a study to analyse the time-varying correlation between oil prices and various industry sectors in the European market. All estimations are completed using monthly observations from Jan 1992 to Dec 2010. The chosen methodology was a time-varying multivariate heteroskedastic framework. The main finding from the study is that the relationship between oil and stock returns are time-varying and mainly driven by economic or geopolitical developments resulting in periods with positive relationship and periods with negative relationship. For all selected industrial sectors, the correlation is time-varying, whether they are oil-users, oil-related oil-substitutes or non-oil-related.

From previous research we observe a consensus on that oil price fluctuations do have a significant impact on the stock returns of oil companies. However, as the analyses is conducted using different companies and time periods, the results indicate no consensus on how the relationship is during different market conditions.

4 Hypotheses on oil price effects on stock returns

After we discussed what the subject of our master thesis would be, we constructed hypotheses for what we thought would be the major findings from the analyses. As we mentioned earlier, we have divided the companies into three subsectors. We believe the stock returns for the selected companies in different subsectors will react differently to oil price fluctuations. This is because the value creation is different for integrated-, upstream- and downstream companies. We believe the analysis will suggest that integrated- and downstream companies are less sensitive to oil price fluctuations compared to upstream companies. The reason behind the hypothesis is that integrated companies have a value creation through the entire value chain, and therefore are more diversified against oil price changes. The oil price will be less relevant for downstream companies as they can adjust the price of their products accordingly. Upstream companies have high costs related to their activities, and in the event of an oil price decline, their revenue will decrease as well.

The next hypothesis states that the size of the selected companies measured as market capitalization plays a role in the stock returns, and in how much explanatory effect Brent crude oil prices have on the companies' stock return. Lee (2009) conducted a study to investigate whether firm size matters in firm performance for publicly traded companies in the United States. The findings from his study suggests that there is a positive relationship between market capitalization and performance. We expect to discover similar findings, and in addition we expect that with increased market capitalization Brent crude will have less explanatory effect. We believe this to be true because a large company have matured and constantly streamlined their operations.

Further we believe that oil price fluctuations will have an instant effect on the company's stock return. Our hypothesis builds on the findings done by Odusami (2009), who studied the effects of crude oil shocks on stock market returns in the United States. The study concludes that oil price shocks have no lagged effect on stock market returns. We believe we will find similar findings because the selected companies are publicly traded, and in an efficient market the changes shall be reflected in the stock prices immediately.

Our next hypothesis originated from the study conducted by Lee & Zeng (2011) and Sanusi & Ahmad (2016). Lee & Zeng (2011) found evidence for asymmetry and that negative oil price changes are more significant than positive oil price changes on stock returns, while Sanusi & Ahmad (2016) found opposite results, that positive oil price changes have a significant greater impact on stock returns. We believe the results from the analysis will give similar results as Lee & Zeng (2011). The reason behind our hypothesis is that we believe in the event of an oil price increase, the market will restrain themselves as the possible upside is limited.

Further we believe that the OLS-regression underestimates the influence of oil price changes to the stock return, as there might be significant values in the quantiles. This is because OLS-regression analyzes the unconditional mean which means that the tails of the stock return data are omitted. We believe that we will discover values of relevance with a quantile regression because time series data is usually left sided. Nusair & Al-Khasawneh (2017) conducted a study to investigate the effect of oil price shocks on the market return of the GCC countries (Bahrain, Kingdom of Saudi Arabia, Kuwait, Qatar, Sultanate of Oman, and United Arab Emirates (UAE)). The findings from their study suggests that there are significant values in the lower and upper quantiles, but it depends on the market is bearish or bullish.

Our last hypothesis is that we believe extreme oil price changes to give a significant deduction to the oil price beta. This is because the companies are affected by other variables than the oil price. In extreme situations, the increase or decrease of the stock return will eventually slow down and not follow the oil price.

5 Data and descriptive statistics

The dataset consists of twenty-five publicly traded oil companies listed world-wide, Brent crude and FTSE All World. All companies have been assorted to one of three subsectors: Integrated companies, upstream companies, and downstream companies. The list consists of fifteen companies that are integrated, five companies with activities limited to upstream activity, and five companies limited to downstream activity. The list of companies below is sorted from largest to smallest after market capitalization for the different subsectors. In addition, we have included the location of the company's headquarters.

Table 1: Twenty-five selected oil and gas companies.

Integrated Companies	**Market capitalization in billions of dollars**	**Headquarters**
Exxon	235,25	USA
Chevron	198,07	USA
Royal Dutch Shell	145,58	Netherlands
Total	116,77	France
BP	83,86	England
Indian Oil	82,89	India
China Petroleum	76,06	China
Gazprom	71,3	Russia
Equinor	63,88	Norway
Lukoil	50,82	Russia
Eni	36,42	Italy
PTT	35,27	Thailand
Repsol YPF	18,48	Spain
Apache	6,48	USA
YPF	2,41	Argentina
Upstream companies		
ConocoPhillips	67,66	USA
CNOOC	53,21	China
TC Energy	46,39	Canada
Occidental Petroleum	22,82	USA
Hess	20,88	USA
Downstream companies		
Valero Energy	28,69	USA
Oil & Natural Gas	17,23	India
Blue Dolphin Energy	6,35	USA
Centrica	4,53	England
Hellenic Petroleum	1,79	Greece

All data is collected from Eikon (Thomson Reuters) Datastream, and we use monthly observations in the time period Jan 2001 to Dec 2020. The time period is chosen because it consists of the price shock in 2008, 2014 and 2020, and by using the chosen time periods we get an overview of the situation pre and post the oil price shocks. We extracted all time series as total return, which is the actual rate of return and includes capital gains, dividends, distributions, and interest realized over a period (Banton, 2020). All prices are presented in US Dollars.

The companies are selected due to them being listed world-wide, their different activities and various sizes. By including these companies in our analysis, we believe our study will expand previous research, as the studies we have found is commonly limited to few markets or few economies. By selecting companies with different activities, we get a detailed overview of how the stock returns are linked to the oil price sensitivity within the sector. In addition, the selected companies vary in size, which broadens the use of our findings.

5.1 Integrated-, upstream- and downstream companies

We divide the twenty-five selected companies from the oil sector into three different subsectors based on their field of operations: integrated- upstream- and downstream companies.

The first subsector is integrated oil companies which is defined as an oil company that is involved in the entire value chain. This includes exploration, production, refinement, and distribution. For integrated companies it is common to divide its activities in three categories: upstream activities include all activity related to exploration and production, midstream activities include storage and transportation of oil, and downstream activities which includes refinement and distribution. As integrated companies are involved in the entire value chain, they benefit from the possibility to streamline processes and reduce costs. In addition, their cash flow could be less sensitive to oil price fluctuations as they are naturally diversified through their activities (Chen, 2020).

Upstream companies are the second subsector. These companies are engaged in exploration and production of oil. This includes activities like exploration, drilling, and extraction (Chen, 2020). These companies differ from integrated companies as they are likely to be more sensitive to oil price fluctuations because they profit of the margin. Meaning that the cost of their activities is not related to the oil price, but their profit is.

The last subsector is downstream companies. These companies engage in the processes of converting oil into finished products, marketing, distribution and selling the finished oil product (Chen, 2020). In time periods where oil prices decrease substantially for a short time, downstream companies can benefit from the possibility to buy cheap oil and sell their finished products for a higher price to consumers.

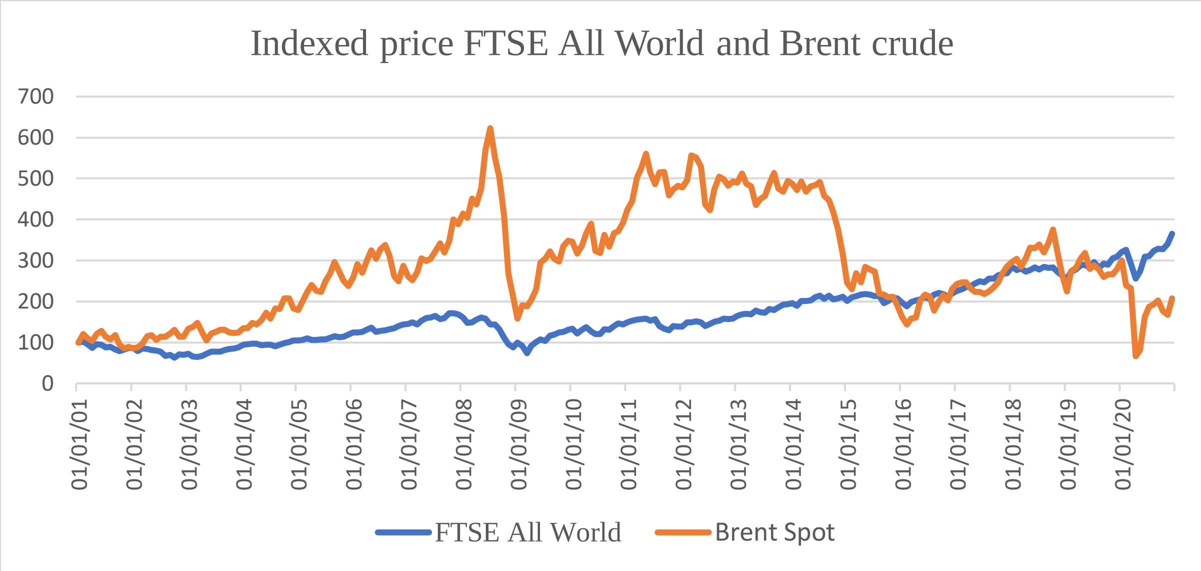
5.2 Brent Crude and FTSE All World

Brent crude oil, or Brent blend, is one out of three types of crude oil that serves as a benchmark for pricing various types of oil and oil-based securities. The two other benchmarks are West Texas Intermediate (WTI) and Dubai crude. WTI is produced in the United States and is the second most used benchmark. Dubai crude is commonly used as a benchmark due to its immediate availability and is frequently used as a benchmark for pricing exports to Asia (Downey, 2021).

Brent crude is considered a light, sweet crude oil, which indicates low density and low sulfur values. The Brent crude oil is extracted in the North Sea between the United Kingdom and Norway. We use Brent crude as oil benchmark. The reason behind our choice is that the analysis is conducted using oil companies from different markets, and Brent crude is used as a benchmark to price two-thirds of the crude oil traded internationally (Chen, 2020).

Financial Times Stock Exchange Group (FTSE) designed a stock index named FTSE All World with the purpose of tracking the performance of the global equity market. The index consists of stocks from approximately 3900 companies in almost 50 countries in both developed and emerging markets. FTSE All World is used by traders as a benchmark for the performance of global equity funds and as a guide to asset allocation. The main reason to why we chose FTSE All World as market benchmark, is because the index tracks the stock performance from various markets and the analysis is conducted using companies spread around the world. In addition, the FTSE All World is globally recognized as a benchmark for the global economy (Vanguard Asset Management, 2021).

5.3 Indexed benchmarks



Graph 2: Indexed price FTSE All World and Brent crude from Jan 2001 to Dec 2020.

The indexed price is calculated by setting the price in the first observation of both FTSE All World and Brent crude at a base of 100. Then we calculate the price change between the base and all observations. We observe from graph 2 that FTSE All World and Brent crude both experienced a price increase from Jan 2001 to July 2008, before they both decreased rapidly during what is categorized as the financial crisis of 2008. In the following years we observe that the price follows the same trend, until there is a shift around mid-2014, which is named the oil crisis of 2014. From 2015, FTSE All World maintain a small but steady increase while the price of Brent crude experienced higher fluctuations but decreased on average until the end of 2020.

Further we will complement the indexed price in graph 2 with calculated correlation values of FTSE All World and Brent crude from Jan 2001 to Dec 2020, Jan 2001 to July 2008, and Jan 2011 to Dec 2020. The correlation between two securities, which is a number between -1 (perfect negative) and +1 (perfect positive), is called the correlation coefficient and is a statistic measure that tells how the two securities move in relation to each other. Although the correlation coefficient gives an understanding of the relationship between the securities, it is important to remember that it does not imply causation.

From the calculations we get a correlation coefficient between the two securities of 0,17 in the time period from Jan 2001 to Dec 2020, 0,87 from Jan 2001 to July 2008, and -0,67 from Jan 2011 to Dec 2020.

5.4 Descriptive statistics for selected companies and FTSE All World

The calculated statistics is the annual average return and the annual standard deviation, which measures to what extent the data disperse from the average. In addition, we will comment the Jarque Bera values for all securities. Jarque Bera is a measure that indicates whether the sample data is normally distributed and is calculated from the kurtosis (symmetry measure) and skewness (heavy-tailed or light-tailed) values. All calculations are executed using logarithmic returns for monthly observations.

Table 2: Descriptive statistics from Jan 2001 to Dec 2020, Jan 2001 to July 2008 and Jan 2011 to Dec 2020 using monthly observations and logarithmic data. The bold numbers indicate that the company outperformed the market during the time period.

	Jan 2001 - Dec 2020		Jan 2001 - July 2008		Jan 2011 - Dec 2020	
Integrated companies	**Annual return**	**Annual std. deviation**	**Annual return**	**Annual std. deviation**	**Annual return**	**Annual std. deviation**
Exxon	2,40 %	21,30 %	**11,60 %**	17,80 %	-2,40 %	23,40 %
Chevron	**7,30 %**	23,80 %	**14,60 %**	20,10 %	4,50 %	25,30 %
Royal Dutch Shell	2,30 %	24,20 %	**7,50 %**	22,20 %	0,20 %	23,60 %
Total	5,90 %	23,30 %	**14,90 %**	19,20 %	4,50 %	23,70 %
BP	0,50 %	26,30 %	**8,10 %**	20,40 %	-0,90 %	25,00 %
Indian Oil	**11,50 %**	41,20 %	**21,60 %**	48,90 %	-2,20 %	34,00 %
China Petroleum	**6,50 %**	36,90 %	**14,30 %**	46,00 %	1,30 %	25,60 %
Gazprom	**14,50 %**	43,30 %	**54,20 %**	44,90 %	-3,10 %	37,10 %
Equinor	**8,70 %**	28,90 %	**14,90 %**	31,50 %	-0,30 %	27,20 %
Lukoil	**14,20 %**	35,40 %	**34,00 %**	34,50 %	7,30 %	30,10 %
Eni	4,50 %	24,40 %	**19,00 %**	19,20 %	-0,90 %	25,50 %
PTT	**19,30 %**	34,90 %	**33,70 %**	40,60 %	7,00 %	29,10 %
Repsol YPF	2,20 %	30,30 %	**13,80 %**	20,80 %	-2,90 %	31,90 %
Apache	-3,30 %	61,20 %	**21,20 %**	28,60 %	-20,30 %	79,30 %
YPF	-2,50 %	50,50 %	**10,90 %**	38,50 %	-12,60 %	59,50 %
Uptream companies						
ConocoPhillips	6,10 %	30,10 %	**18,50 %**	22,20 %	1,50 %	32,10 %
CNOOC	-2,60 %	66,30 %	**35,20 %**	33,90 %	-32,60 %	82,50 %
TC Energy	**11,00 %**	19,80 %	**20,40 %**	16,00 %	6,30 %	20,20 %
Occidental Petroleum	4,50 %	39,80 %	**29,30 %**	22,80 %	-13,30 %	48,70 %
Hess	4,70 %	40,10 %	**23,40 %**	32,90 %	-2,80 %	42,10 %
Downstream companies						
Valero Energy	**11,50 %**	42,80 %	**20,40 %**	39,50 %	**14,10 %**	42,50 %
Oil & Natural Gas	**10,70 %**	39,60 %	**35,70 %**	43,20 %	-10,60 %	33,70 %
Blue Dolphin Energy	-23,90 %	110,70 %	-4,80 %	102,10 %	-25,00 %	119,30 %
Centrica	-4,30 %	30,50 %	**8,90 %**	24,60 %	-15,40 %	33,30 %
Hellenic Petroleum	2,60 %	36,80 %	6,90 %	33,20 %	4,20 %	38,00 %
FTSE All World	6,50 %	17,80 %	4,80 %	16,20 %	9,30 %	13,50 %

For the integrated companies in the time period from Jan 2001 and Dec 2020, we observe that all companies except for Apache and YPF experienced an annual positive return on average. Further we observe that four companies yielded returns over 10% with PTT as the best performing company with an annual return on 19,3% on average. Seven out of fifteen integrated companies performed equally or better than the market, which experienced a return on 6,5%.

We observe a spread between the companies' standard deviation, but all companies have a higher standard deviation value compared to the market with 17,8%. As mentioned previously, the companies listed is sorted by subsectors and by their market capitalization. The calculated values in table 2 can give an indication that standard deviation decreases with higher market capitalization for the integrated companies. We observe that the five biggest companies in addition to Eni, have the lowest standard deviations. Further we observe that two companies stand out, Apache and YPF have the highest standard deviations with 61,2% and 50,5%, and they are the two companies with the lowest market capitalization.

For upstream companies we observe that CNOOC yields a negative annual return on average with -2,6%. Further we observe that TC Energy is the only upstream company that experienced a higher return in the time period compared to the market, with an annual return on 11,0% on average. From the calculated standard deviations, we observe that all companies have high values compared to the market with 17,8%, except for TC Energy which had a standard deviation of 19,8% during the time period.

For downstream companies we observe that two companies experienced a negative annual return on average, respectively Blue Dolphin Energy with -23,9% and Centrica with -4,3%. Further we observe that both Valero Energy and Oil & Natural Gas had a higher return in the time period compared to the market, with 11,5% and 10,7% respectively. From the calculated standard deviation, we observe that Blue Dolphin Energy stands out with a value of 110,7%, which is the highest standard deviation for all companies included in the time period from Jan 2001 to Dec 2020.

The Jarque Bera values are calculated from the Skewness and Kurtosis values which we obtain from descriptive statistics. From the calculations shown in appendix 10.1, we observe that BP and Chevron are normally distributed.

From Jan 2001 to July 2008 both the FTSE All World and Brent crude experienced a steady price increase, which is presented in graph 2. All selected integrated companies yielded a higher annual return on average compared to the market, which yielded an annual return of 4,8% on average. Only two companies had a return below 10% on average during the time period, respectively Royal Dutch Shell with 7,5% and BP with 8,1%. Gazprom is the company that experienced the highest return on average with 54,2%, followed by PTT with 33,7%.

For the companies´ calculated standard deviations, we observe that all companies have a higher standard deviation compared to the market. Similar to the time period from Jan 2001 to Dec 2020, we observe that the five biggest companies in addition to Eni, have the lowest standard deviation. A difference during this time period is that the smallest companies do not have the highest standard deviation, but Indian Oil do with a value of 48,9%.

During the time period from Jan 2001 to July 2008, all upstream companies yielded a higher return compared to the market. The lowest annual average return during the period is represented by ConocoPhillips with 18,5% and the highest return is yielded by CNOOC with an annual return of 35,2% on average. All upstream companies have a higher standard deviation compared to the market except from TC Energy, which have a standard deviation on 16,0%.

Further we observe that four out of five downstream companies yielded a positive annual return from Jan 2001 to July 2008 and that there is big difference in their performance. Oil & Natural Gas performed best in the period with an annual return on 35,7%, while Blue Dolphin Energy experienced a negative return on average with -4,8%. Blue Dolphin Energy is also the company with the highest standard deviation during the period with 103,1%, making it the company with the highest risk. The four other downstream companies are also riskier than the market, with higher standard deviations.

In the third time period Jan 2011 to Dec 2020, the oil price has decreased steadily while the market has experienced an annual increase of 9,3% on average. If we compare the third period to the second period, we observe that all companies performed worse in the third period and that most of the selected companies yielded a negative annual return.

For the integrated companies we observe that eight out of fifteen companies yielded a negative annual return. Apache is the company that performed the worst with an annual return of -20,3%. Lukoil yielded the highest annual return on average with 7,3%.

If we compare the standard deviations for the integrated companies between the second and third period, we observe that the risk of some companies is reduced even though the oil price decreased. For Indian Oil, China Petroleum, Gazprom, Equinor, Lukoil and PTT the standard deviation decreased. Apache on the opposite side experienced a standard deviation increase from 28,6% in the second period to 79,3% in the third.

For the selected upstream companies, three out of five yielded a negative annual return. The company that performed worst was CNOOC with an annual return of -32,6%. TC Energy performed best with an annual return of 6,3%. From the calculated standard deviations there is a major shift for CNOOC and Occidental Petroleum. CNOOC had a standard deviation of 82,5% in the third period compared to 33,9% in the second period. Occidental Petroleum had a standard deviation in the third period of 48,7% compared to 22,8% in the second.

Like upstream companies, three out of five downstream companies yielded a negative annual return in the third period. Valero Energy is the only company that experienced a higher annual return with 14,1% compared to the market return. Blue Dolphin Energy yielded a negative return in all time periods and in the third period they yielded a return of -25,0%. For the calculated standard deviations there are small differences, but Blue Dolphin Energy is still the riskiest company with a standard deviation of 119,3%. This is the highest calculated standard deviation in the sample data.

6 Empirical framework

Model one is constructed to analyze the relationship between FTSE All World and Brent crude. In addition, we decomposed the oil price changes is positive and negative changes to analyze whether there exists asymmetry.
We use the following models:

$$R_{m,t} = \beta_i^{Oil} \times ROil_t + \varepsilon_i \quad (2)$$

$$R_{m,t} = \alpha_i + \beta_i^{Oil} \times ROil_t^{+} + \beta_i^{Oil} \times ROil_t^{-} + \varepsilon_t \quad (3)$$

Where $R_{m,t}$ is the market return at time *t*; β_i^{Oil} is the oil beta; $ROil_t$ is the Brent crude log change at time *t* which is decomposed to both positive and negative changes; and ε_i is the error term at time *t*.

The second model is a regression analysis with the purpose to analyze to what extent the stock returns are affected by oil price fluctuations. We use a two-factor model where the dependent variable is the excess return for a selected company, and the two independent variables are the oil price changes and the market return.
We use the following model:

$$R_{i,t} = \alpha_1 + \beta_i^{Market} \times R_{m,t} + \beta_i^{Oil} \times ROil_t + \varepsilon_t \quad (4)$$

Where $R_{i,t}$ is the company return at time *t*; β_i^{Market} is the market beta; $R_{m,t}$ is the market return at time *t*; β_i^{Oil} is the oil beta; $ROil_t$ is the Brent crude log change at time *t*; and ε_t is the error term at time *t*.

The third model analyzes to what extent previous changes in the oil price affect the present stock return. We lagged the observations of oil price with one month and two months.
We use the following model:

$$R_{i,t} = \alpha_1 + \beta_i^{Market} \times R_{m,t} + \beta_i^{Oil} \times ROil_t$$
$$+ \beta_i^{Oil(t-1)} \times ROil_{t-1} + \beta_i^{Oil(t-2)} \times ROil_{t-2} + \varepsilon_t \quad (5)$$

Where $R_{i,t}$ is the company return at time *t*; β_i^{Market} is the market beta; $R_{m,t}$ is the market return at time *t*; β_i^{Oil} is the oil beta; $ROil_t$ is the Brent crude log change at time *t* decomposed into two lags; and ε_t is the error term at time *t*.

The fourth model is conducted to investigate whether the company's stock returns are affected asymmetric by positive or negative changes in the oil price.
We use the following model:

$$R_{i,t} = \alpha_1 + \beta_i^{Market} \times R_{m,t} + \beta_i^{Oil+} \times ROil_t^{+} + \beta_i^{Oil-} \times ROil_t^{-} + \varepsilon_t \quad (6)$$

Where $R_{i,t}$ is the company stock return at time *t*; β_i^{Market} is the market beta; $R_{m,t}$ is the market return at time *t*; β_i^{Oil} is the oil beta; $ROil_t$ is the Brent crude log change at time *t* which is decomposed to both positive and negative changes; and ε_i is the error term at time *t*.

The fifth model investigates whether extreme oil price changes have a significant effect on stock returns. We define an extreme oil price change to be an increase or decrease of 12%, 15% or 18% between two observations.
We use the following model:

$$R_{i,t} = \alpha_1 + \beta_i^{Market} \times R_{m,t} + \beta_i^{Oil} \times ROil_t + \beta_i^{Oilextreme+} \times ROil_t \times (Dummy1)$$
$$+ \beta_i^{Oilextreme-} \times ROil_t \times (Dummy2) + \varepsilon_t \quad (7)$$

Where $R_{i,t}$ is the company stock return at time *t*; β_i^{Market} is the market beta; $R_{m,t}$ is the market return at time *t*; β_i^{Oil} is the oil beta; $ROil_t$ is the Brent crude log change at time *t* which is decomposed to both positive and negative extreme oil price changes; *Dummy1* is a dummy variable for extreme positive oil price changes; *Dummy2* is a dummy variable for extreme negative oil price changes; and ε_i is the error term at time *t*.

Ordinary least square linear regression analyzes the unconditional mean, which means that the tails of the stock return data are omitted. The sixth model investigates whether there are significant values in the quantiles. By doing a quantile regression we get a full picture of how the relationship between stock returns and oil price fluctuations, meaning that we can analyze both the left-side and right-side tail of the sample data. We divide the sample data in seven quantiles. 0,05, 0,10 and 0,25 represents the lower quantiles, 0,50 represents the median, and 0,75, 0,90 and 0,95 represents the upper quantiles of the distribution.
We use the following model:

$$R_{i,t}^{\tau} = \alpha_i(\tau) + \beta_{i\,(\tau)}^{Market} \times R_{m,t} + \beta_{i\,(\tau)}^{Oil} \times ROil_t + \varepsilon_{i\,(\tau)} \qquad (8)$$

Where $R_{i,t}^{\tau}$ is the company stock return at time *t* in a given quantile; $\alpha_i(\tau)$ is the constant in a given quantile; $\beta_{i\,(\tau)}^{Market}$ is the market beta in a given quantile; $R_{m,t}$ is the market return at time *t*; $\beta_{i\,(\tau)}^{Oil}$ is the oil beta at time *t* in a given quantile; $ROil_t$ is the Brent crude log change at time *t*; and ε_i is the error term at time *t* in a given quantile.

The seventh analysis is conducted to investigate the Exponentially Weighted Moving Average (EWMA) beta values.
The values are calculated using the following models:

$$\sigma_t = \sqrt{(1-\lambda) \times R_{t-1}^2 + \lambda \times \sigma_{t-1}^2} \qquad (9)$$

Where σ_t is the standard deviation at time *t*; λ is the smoothing parameter; R_{t-1}^2 is the squared log return at time *t-1*; and σ_{t-1}^2 is the variance at time *t-1*.

$$Correlation_t = \frac{COVAR_{x,y}}{\sigma_x \times \sigma_y} \qquad 10)$$

Where $COVAR_{x,y}$ is the covariance between $company_i$ and Brent crude; σ_x is the variance of Brent crude; and σ_y is the variance of $company_i$.

$$Volatility_t = \frac{\sigma_y}{\sigma_x} \qquad (11)$$

Where σ_y is the variance of $company_i$; and σ_x is the variance of Brent crude.

$$Beta_t = Correlation_i \times Volatility_t \qquad (12)$$

Model (2), (3), (4), (5), (6) and (7) are conducted using Newey-West robust standard errors to adjust for heteroscedasticity and autocorrelation. Model (8) is conducted using Huber Sandwich standard errors.

7 Results and discussion

7.1 Estimation results regression Brent crude and FTSE All World

The relationship between Brent crude and FTSE All World is investigated by equation (2) and (3) and we test the following hypothesis:

H_0: $\beta_i^{Oil} = 0$ and $\beta_i^{Oil+} = \beta_i^{Oil-}$

H_1: $\beta_i^{Oil} \neq 0$ and $\beta_i^{Oil+} \neq \beta_i^{Oil-}$

*Table 3: Estimation results from equation (2) and (3) from Jan 2001 to Dec 2020, Jan 2001 to July 2008 and Jan 2011 to Dec 2020. *** indicates significance at a 1%-level. Newey West robust standard errors are given in parentheses.*

	Jan 2001 - Dec 2020	**Jan 2001 - July 2008**	**Jan 2011 - Dec 2020**
β Oil	0,13*** (0,02)	0,01 (0,06)	0,13*** (0,02)
β Oil-	0,14*** (0,02)	-0,002 (0,25)	0,15*** (0,02)
β Oil+	0,14*** (0,02)	0,003 (0,25)	0,15*** (0,02)
R^2	0,12	0,03	0,28

We observe that during the entire time period from Jan 2001 to Dec 2020 that the oil price beta is significant, for both negative and positive changes, and that oil price changes explain 12% of the market changes. The oil price beta for both positive and negative changes are significant at a 10%-, 5%- and 1% level. We conducted a Wald-test to test whether there exists asymmetry for the entire time period from Jan 2001 to Dec 2020. From the test we get a t-value of 1,86 and that the difference between the two beta coefficients is 0,0015. These results indicate that there exists asymmetry, and that positive oil price changes have a greater influence on the market compared to negative oil price changes.

From Jan 2001 to July 2008, we observe that the oil price beta is not significantly different from 0 for both negative and positive oil price changes. Further we observe from the R^2 value that oil have a 3% explanatory effect on market changes.

The oil price beta is significant, both for positive and negative oil price changes in the period from Jan 2011 to Dec 2020. In this time period the market return is 28% explained by changes in the oil price.

7.2 Estimation results OLS-regression analysis

The relationship between the company stock return to FTSE All World and Brent crude from Jan 2001 to Dec 2020 is analyzed by using equation (4). We test the following hypothesis:

H_0: $\beta_i^{Market} = 1$ and $\beta_i^{Oil} = 0$

H_1: $\beta_i^{Market} \neq 1$ and $\beta_i^{Oil} \neq 0$

*Table 4: Estimation results from equation (4) from Jan 2001 to Dec 2020. N=239. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.*

Integrated companies	**β Oil**	**β Market**	**R²**
Exxon	0,18*** (0,02)	0,44*** (0,08)	0,40
Chevron	0,21*** (0,03)	0,52*** (0,09)	0,42
Royal Dutch Shell	0,15*** (0,05)	0,63*** (0,07)	0,39
Total	0,13*** (0,06)	0,67*** (0,06)	0,42
BP	0,20*** (0,04)	0,60*** (0,08)	0,39
Indian Oil	0,04 (0,07)	0,59*** (0,15)	0,07
China Petroleum	0,13 (0,08)	0,52*** (0,18)	0,12
Gazprom	0,27*** (0,08)	0,73** (0,11)	0,24
Equinor	0,26*** (0,10)	0,66*** (0,08)	0,46
Lukoil	0,29*** (0,07)	0,79* (0,12)	0,42
Eni	0,17*** (0,06)	0,60*** (0,08)	0,40
PTT	0,22*** (0,06)	0,70** (0,13)	0,29
Repsol YPF	0,19*** (0,06)	0,82* (0,11)	0,42
Apache	0,80*** (0,19)	0,71* (0,18)	0,51
YPF	0,38*** (0,06)	0,53*** (0,16)	0,20
Upstream companies			
ConocoPhillips	0,34*** (0,04)	0,60*** (0,11)	0,54
CNOOC	0,82*** (0,14)	0,78 (0,23)	0,48
TC Energy	0,12*** (0,03)	0,38*** (0,07)	0,26
Occidental Petroleum	0,44*** (0,11)	0,65*** (0,13)	0,46
Hess	0,46*** (0,07)	0,58*** (0,14)	0,46
Downstream companies			
Valero Energy	0,31*** (0,05)	0,91 (0,16)	0,35

Oil & Natural Gas	0,18*** (0,06)	0,79* (0,11)	0,22
Blue Dolphin Energy	0,21 (0,16)	0,53 (0,31)	0,02
Centrica	0,21*** (0,09)	0,59*** (0,15)	0,30
Hellenic Petroleum	0,16*** (0,06)	0,71** (0,12)	0,21

All oil beta- and market beta values are positive for all companies. The average oil beta value for all companies is 0,27. The integrated companies have an average oil beta value of 0,24, upstream companies 0,44 and downstream companies 0,21. Apache have the highest oil beta of the integrated companies with 0,80, and CNOOC have the highest beta of 0,82 of the upstream companies. The highest beta value for the downstream companies was Valero Energy with 0,31. We observe that it exists a high spread in beta values across all companies and sub-sectors. The oil beta fluctuates between 0,04 and 0,82 for all companies. We observe that Indian Oil, China Petroleum and Blue Dolphin Energy do not have significant oil betas.

The average market beta for all companies is 0,64. The integrated companies have an average market beta of 0,63, upstream companies 0,60, and downstream companies 0,71. For integrated companies, Repsol have the highest market beta value with 0,82. CNOOC have again the highest value of the upstream companies with 0,78. Valero Energy also have the highest market beta value with 0,91 of the downstream companies. The market beta values fluctuate between 0,38 and 0,91 for all companies. Blue Dolphin Energy, Valero Energy and CNOOC are the only companies who do not have a significant market beta.

The average R^2 for all companies is 0,34. This means that 34% of the return for the companies can be explained by fluctuations in the oil price and in the fluctuation in the return of the market. We observe that integrated companies have an average R^2 of 0,34, upstream companies 0,44 and downstream companies 0,22. We observe that larger companies have a higher R^2 compared to smaller companies.

We observe that upstream companies have a higher oil beta value compared to integrated- and downstream companies, which indicates that upstream companies are more exposed to oil price fluctuations. The findings of the regression analysis correlate well with our hypothesis, that "the stock returns for the selected companies in the different subsectors will react differently to oil price fluctuations".

We observe that the market beta values are more stable and fluctuate less over time compared to the oil beta values. This is an expected observation because the market is highly diversified and should be less volatile than the price of oil.

If an investor believes the oil price to increase in the future, our findings indicate that upstream companies might be a better investment compared to integrated- and upstream companies. This is because we observe a high oil price beta on average, which indicate that the stock return of upstream companies might increase with increased oil prices. If the investor believes the price to be declining in the future, but wants to include oil companies in the portfolio, integrated- and downstream companies might be a better investment. This is because the oil price beta is lower on average, making these companies less sensitive to oil price fluctuations.

The relationship between the company stock return to FTSE All World and Brent crude in a bear market from Jan 2001 to July 2008 is analyzed by using equation (4). We test the following hypothesis:

H_0: $\beta_i^{Market} = 1$ and $\beta_i^{Oil} = 0$

H_1: $\beta_i^{Market} \neq 1$ and $\beta_i^{Oil} \neq 0$

*Table 5: Estimation results from equation (4) from Jan 2001 to July 2008. N=90. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.*

Integrated companies	**β Oil**	**β Market**	**R^2**
Exxon	0,16*** (0,04)	0,55*** (0,11)	0,34
Chevron	0,23*** (0,06)	0,59*** (0,15)	0,37
Royal Dutch Shell	0,22*** (0,06)	0,77 (0,15)	0,42
Total	0,23*** (0,05)	0,62*** (0,10)	0,42
BP	0,30*** (0,04)	0,60*** (0,11)	0,45
Indian Oil	0,05 (0,20)	1,09 (0,28)	0,13
China Petroleum	0,25 (0,14)	0,73 (0,30)	0,09
Gazprom	0,08 (0,13)	0,70* (0,18)	0,07
Equinor	0,46*** (0,09)	0,97 (0,12)	0,54
Lukoil	0,37*** (0,08)	0,69 (0,23)	0,23
Eni	0,25*** (0,05)	0,51*** (0,13)	0,36

PTT	0,36*** (0,12)	0,72 (0,28)	0,17
Repsol YPF	0,16** (0,07)	0,56*** (0,14)	0,26
Apache	0,37*** (0,11)	0,52*** (0,17)	0,26
YPF	0,35*** (0,12)	0,50** (0,23)	0,13
Upstream companies			
ConocoPhillips	0,35*** (0,06)	0,52*** (0,14)	0,41
CNOOC	0,53*** (0,11)	0,37*** (0,23)	0,28
TC Energy	-0,03 (0,06)	0,13*** (0,12)	0,02
Occidental Petroleum	0,30*** (0,08)	0,52*** (0,13)	0,32
Hess	0,48*** (0,12)	0,36** (0,25)	0,25
Downstream companies			
Valero Energy	0,45*** (0,11)	0,89 (0,33)	0,27
Oil & Natural Gas	0,36*** (0,18)	1,01 (0,23)	0,22
Blue Dolphin Energy	0,81*** (0,30)	0,33 (0,60)	0,07
Centrica	-0,03 (0,06)	0,85 (0,20)	0,31
Hellenic Petroleum	0,10 (0,10)	0,77 (0,21)	0,15

For the time period from Jan 2001 to July 2008 the average oil beta for all companies is 0,26, the average market beta is 0,62, while the average R^2 is 0,26. When breaking these numbers down to the subsectors we get an average oil beta of 0,26 for integrated companies, 0,25 for upstream companies, and 0,29 for downstream companies. The average market beta was 0,67 for integrated companies, 0,34 for upstream companies, and 0,65 for downstream companies. The average R^2 was 0,26 for integrated companies, 0,25 for upstream companies, and 0,29 for downstream companies.

If an investor believes the oil price will be trending upwards in the years to come, one will want to invest in oil companies with a high oil beta. From the regression analysis we observe that downstream companies have the highest average beta values. If one were to select companies with high betas, one would choose upstream companies like CNOOC (β Oil 0,53), Hess (β Oil 0,48), downstream companies like Valero Energy (β Oil 0,45), Oil & Natural Gas (β Oil 0,36), and the integrated company Equinor (β Oil 0,46).

The relationship between the company stock return to FTSE All World and Brent crude in a bear market from Jan 2011 to Dec 2020 is analyzed by using equation (4). We test the following hypothesis:

H_0: $\beta_i^{Market} = 1$ and $\beta_i^{Oil} = 0$

H_1: $\beta_i^{Market} \neq 1$ and $\beta_i^{Oil} \neq 0$

Table 6: Estimation results from equation (4) from Jan 2011 to Dec 2020. N=120. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.

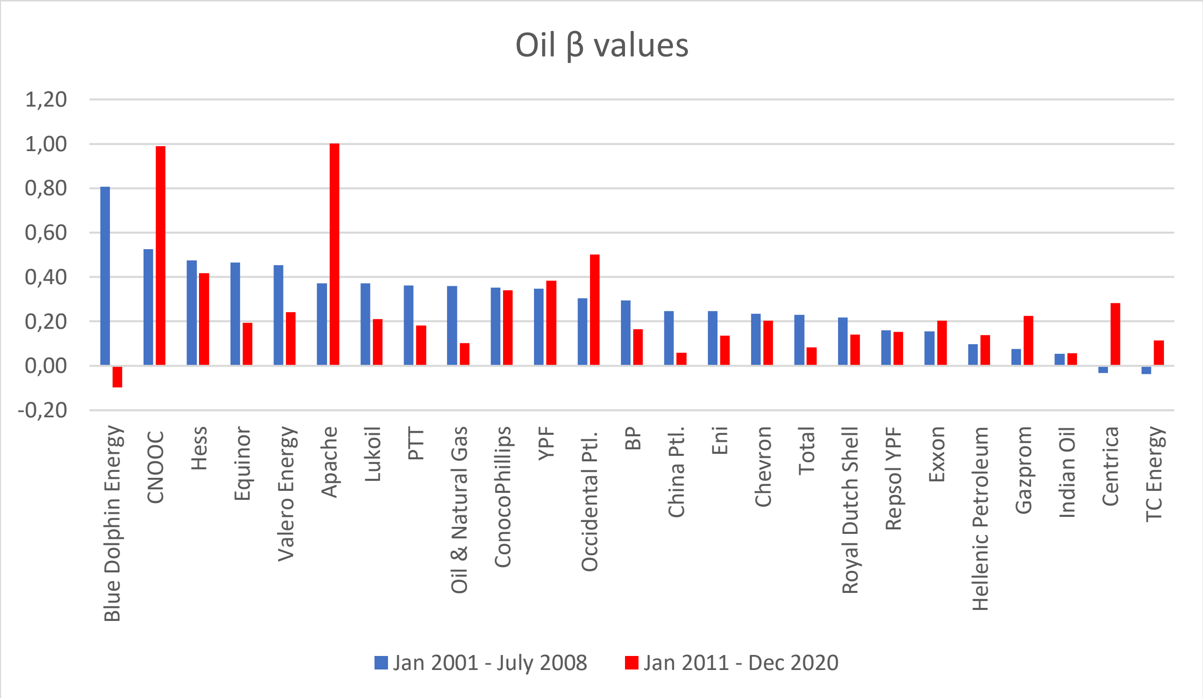
Integrated companies	**β Oil**	**β Market**	**R^2**
Exxon	0,20*** (0,04)	0,55*** (0,13)	0,50
Chevron	0,20*** (0,04)	0,58*** (0,12)	0,44
Royal Dutch Shell	0,14*** (0,06)	0,50*** (0,18)	0,30
Total	0,08** (0,07)	0,82 (0,15)	0,35
BP	0,17*** (0,06)	0,57** (0,17)	0,35
Indian Oil	0,06 (0,06)	0,55** (0,22)	0,08
China Petroleum	0,06 (0,06)	0,46** (0,20)	0,11
Gazprom	0,23*** (0,9)	0,71 (0,25)	0,27
Equinor	0,19*** (0,10)	0,65** (0,17)	0,40
Lukoil	0,21*** (0,06)	0,81 (0,20)	0,43
Eni	0,14*** (0,07)	0,73 (0,20)	0,36
PTT	0,18*** (0,06)	0,74 (0,21)	0,33
Repsol YPF	0,15*** (0,08)	1,01 (0,22)	0,37
Apache	1,00 (0,16)	0,64 (0,25)	0,58
YPF	0,38*** (0,03)	1,02 (0,30)	0,27
Upstream companies			
ConocoPhillips	0,34*** (0,05)	0,54** (0,18)	0,54
CNOOC	0,99 (0,12)	0,78 (0,38)	0,55
TC Energy	0,12*** (0,03)	0,47*** (0,15)	0,31
Occidental Petroleum	0,50*** (0,11)	0,80 (0,28)	0,51
Hess	0,42*** (0,07)	0,85 (0,26)	0,54
Downstream companies			
Valero Energy	0,24*** (0,06)	1,27 (0,24)	0,40
Oil & Natural Gas	0,10* (0,05)	0,89 (0,23)	0,22
Blue Dolphin Energy	-0,10 (0,13)	1,03 (0,81)	0,01

Centrica	0,28*** (0,09)	0,61** (0,15)	0,41
Hellenic Petroleum	0,14 (0,09)	0,84 (0,30)	0,19

For the last time period from Jan 2011 to Dec 2020 we observe an average oil beta of 0,26, an average market beta of 0,74, and an average R^2 of 0,35. The average oil beta was 0,23 for integrated companies, 0,47 for upstream companies, and 0,13 for downstream companies. The average market beta was 0,69 for integrated companies, 0,69 for upstream companies, and 0,93 for downstream companies. The average R^2 was 0,34 for integrated companies, 0,49 for upstream companies, and 0,25 for downstream companies.

If an investor believes the oil price will be declining in the years to come, one will want to invest in oil companies with a low or negative oil price beta. From the regression analysis we observe that downstream companies have the lowest average beta values. If one were to select companies with low betas, one would choose downstream companies like Blue Dolphin Energy (β Oil -0,10) although not significant and Oil & Natural Gas (β Oil 0,10), integrated companies like Royal Dutch Shell (β Oil 0,14) and Total (β Oil 0,08), and upstream companies like TC Energy (β Oil 0,12).

With the regression analysis for time period from Jan 2001 to July 2008 and Jan 2011 to Dec 2020 we graph the differences in oil beta-, market beta- and R² values for the companies in a bull- and bear market.

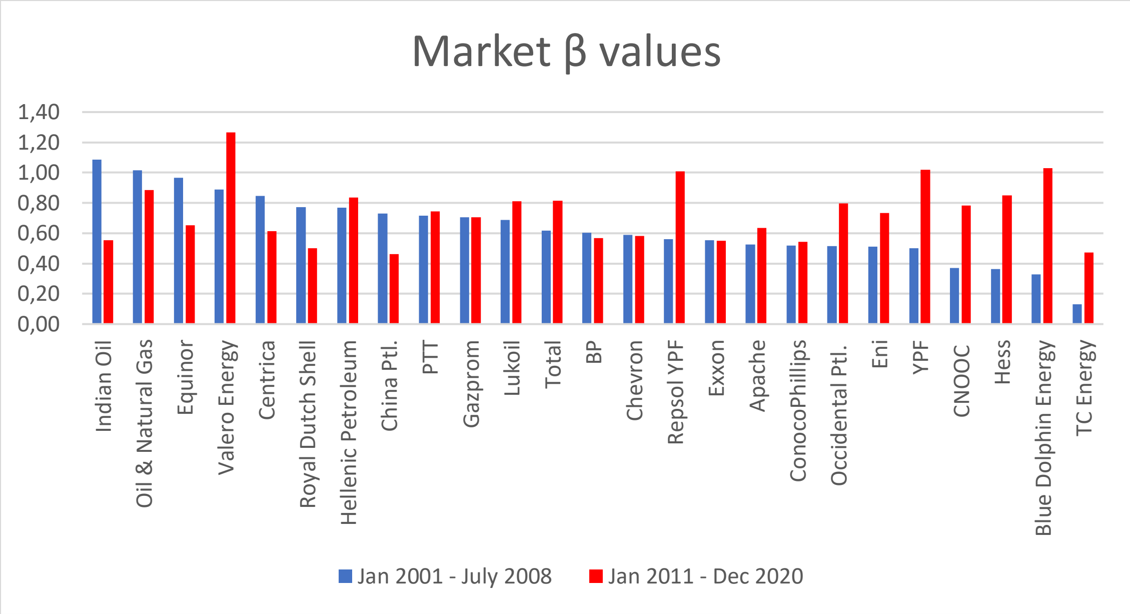


Graph 3: Oil beta values from table 5 and 6, sorted from largest to smallest value from time period from Jan 2001 to July 2008 and Jan 2011 to Dec 2020.

The pattern is that most of the companies have a higher oil beta from Jan 2001 to July 2008 compared to Jan 2011 to Dec 2020.

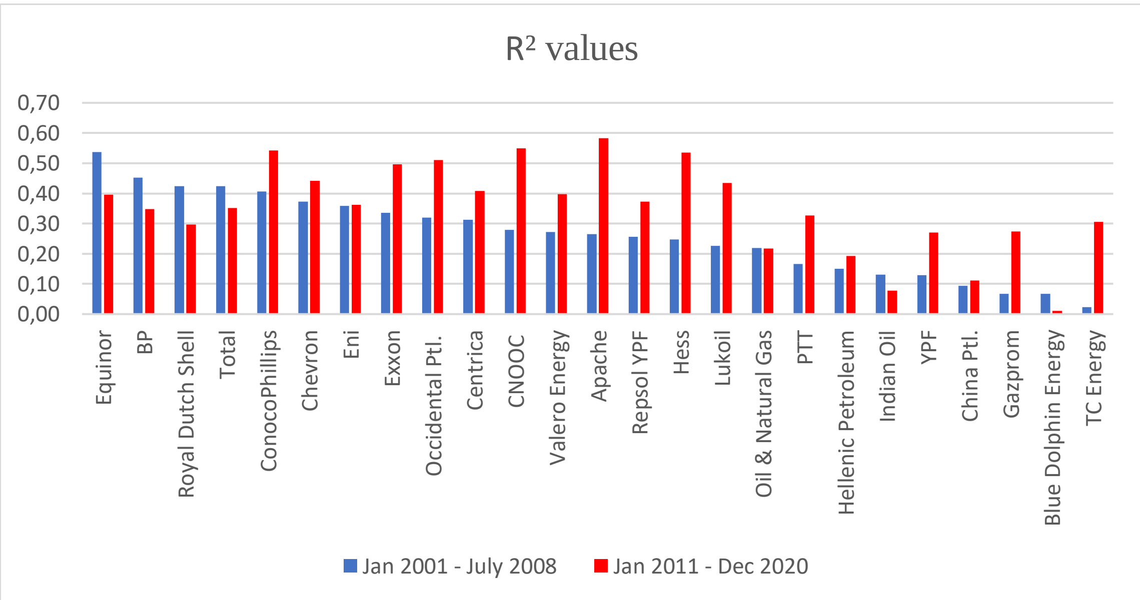
In the period from Jan 2001 to July 2008 the average oil beta is 0,26 and we observe low beta values for Gazprom, Indian Oil, and negative values for TC Energy and Centrica. In the period from Jan 2011 to Dec 2020 the average oil beta is 0,23 and we observe Indian Oil with another low beta value, and Blue Dolphin Energy with a negative value.

With these findings we observe that the change in return for most companies are more influenced by fluctuations in oil price in the period from Jan 2001 to July 2008 compared to Jan 2011 to Dec 2020. We need to remember that in time period from Jan 2001 to July 2008 the oil market experiences a bull market and in the time period from Jan 2011 to Dec 2020 the oil market experiences a bear market. The findings indicate that oil companies are more influenced by oil price fluctuations in a bull market compared to a bear market.



Graph 4: Market beta values from table 5 and 6, sorted from largest to smallest value from time period from Jan 2001 to July 2008 and Jan 2011 to Dec 2020.

We observe the market beta values for the time periods from Jan 2001 to July 2008 and Jan 2011 to Dec 2020. The average market beta for all companies was 0,62 in the first period, and 0,71 in the second period. As we can see from the graph there is no clear trend for the companies. The findings indicate that the companies are more influenced by the market in a bear market compared to a bull market.



Graph 5: R^2 values from table 5 and 6, sorted from largest to smallest value from time period from Jan 2001 to July 2008 and Jan 2011 to Dec 2020.

The average R^2 was 0,26 in time period from Jan 2001 to July 2008 compared to 0,34 in Jan 2011 to Dec 2020. As we can observe from the graph, there is a clear trend that the second period has a higher R^2 compared to the first. From the calculated R^2 values, we observe that there exist other factors that influence the companies' stock returns. The influence these unknown factors have on the companies' stock return is likely to be higher in a bull oil market compared to a bear oil market.

7.3 Estimation results regression analysis with lagged variables

To investigate whether previous oil price changes influence present stock return, we use equation (5) and test the following hypotheses:

$$H_0: \beta_i^{Oil(-1)} + \beta_i^{Oil(-2)} = 0$$

$$H_1: \beta_i^{Oil(-1)} + \beta_i^{Oil(-2)} \neq 0$$

*Table 7: Estimations results from equation (5) from Jan 2001 to Dec 2020. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.*

Integrated companies	**β Oil**	**β Oil t-1**	**β Oil t-2**	**R²**	**F**	**Wald test P-value**
Exxon	0,18*** (0.03)	0,01 (0.03)	0,00 (0.04)	0,40	38,68	0,82
Chevron	0,20*** (0.03)	0,03 (0.02)	0,00 (0.05)	0,42	42,56	0,49
Royal Dutch Shell	0,14*** (0.05)	**0,06***** (0.02)	-0,03 (0.03)	0,40	40,62	0,02**
Total	0,12 (0.05)	**0,07***** (0.02)	-0,01 (0.02)	0,44	47,94	**0,003*****
BP	0,19 (0.05)	0,03 (0.02)	-0,04 (0.03)	0,38	37,99	0,28
Indian Oil	0,04 (0.07)	0,04 (0.04)	-0,02 (0.0)	0,05	4,66	0,61
China Petroleum	0,14* (0.08)	-0,03 (0.04)	-0,08* (0.04)	0,11	7,95	0,18
Gazprom	0,27*** (0.07)	0,08 (0.06)	0,08* (0.04)	0,24	19,17	0,01**
Equinor	0,26*** (0.09)	0,00 (0.03)	0,06 (0.04)	0,45	47,52	0,26
Lukoil	0,28 (0.06)	0,03 (0.05)	0,07* (0.04)	0,41	33,46	0,08*
Eni	0,17*** (0.05)	0,05** (0.02)	0,01 (0.03)	0,41	41,46	0,06*
PTT	0,23*** (0.06)	-0,05 (0.03)	0,02 (0.05)	0,31	23,73	0,34
Repsol YPF	0,18*** (0.05)	**0,07***** (0.02)	0,03 (0.03)	0,43	45,70	**0,002*****
Apache	0,76*** (0.19)	-0,14 (0.09)	0,04 (0.10)	0,51	62,18	0,32
YPF	0,34*** (0.06)	-0,07 (0.05)	-0,01 (0.07)	0,18	14,21	0,42
Upstream companies						
ConocoPhillips	0,33*** (0.04)	0,00 (0.02)	0,03 (0.04)	0,52	67,10	0,71
CNOOC	0,78*** (0.15)	-0,06 (0.08)	**0,15***** (0.06)	0,48	54,27	0,02**
TC Energy	0,11*** (0.02)	0,01 (0.03)	-0,03* (0.02)	0,25	20,69	0,25
Occidental Petroleum	0,41*** (0.11)	-0,07 (0.05)	0,05* (0.03)	0,46	51,81	0,12
Hess	0,47*** (0.06)	0,07** (0.03)	0,04 (0.5)	0,45	49,60	**0,007*****
Downstream companies						
Valero Energy	0,29*** (0.05)	0,00 (0.04)	0,07* (0.04)	0,33	30,22	0,20
Oil & Natural Gas	0,18*** (0.06)	0,05 (0.05)	0,05 (0.04)	0,22	17,09	0,29

Blue Dolphin Energy	0,23 (0.16)	0,02 (0.12)	0,05 (0.12)	0,01	1,46	0,88
Centrica	0,18** (0.09)	-0,10* (0.05)	0,01 (0.03)	0,30	26,37	0,14
Hellenic Petroleum	0,15*** (0.05)	0,02 (0.04)	**0,11***** (0.03)	0,21	16,40	**0,002***

The results from the regression with lagged variables indicates a significant lagged effect for Royal Dutch Shell, Total and Repsol YPF in t-1, and for CNOOC and Hellenic Petroleum in t-2. As we are conducting the analysis with monthly observations, it is unlikely that a change in the oil price should influence stock return a month or two afterwards. From the conducted Wald-test we observe significance for Total, Repsol YPF, Hess and Hellenic Petroleum and reject the null hypothesis, which states that there might be a lagged effect for the stock return for these companies.

The companies' stock returns should on average not be delayed by oil price changes. As an investor it will not be likely that you will yield a return in a company a month or two after the oil price has increased.

7.4 Estimation results regression analysis asymmetry

The next analysis is conducted using equation (6) to analyze whether there exists asymmetry in how positive oil price changes affect the company stock return compared to negative oil price changes. Our approach builds on the study conducted by Sanusi & Ahmad (2016), they use a multifactor model with lagged variables for positive and negative oil price changes to analyze whether there exists asymmetry. We test the following hypotheses:

H_0: $\beta_i^{Oil+} = \beta_i^{Oil-}$

H_1: $\beta_i^{Oil+} \neq \beta_i^{Oil-}$

*Table 8: Estimation results from equation (6) from Jan 2001 to Dec 2020. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.*

Integrated companies	**β Oil+**	**β Oil-**	**R²**	**Wald-test (t-value)**
Exxon	0,192*** (-0,02)	0,194*** (-0,02)	0,43	-2,63***
Chevron	0,228*** (-0,03)	0,229*** (-0,03)	0,46	-1,51
Royal Dutch Shell	0,156*** (-0,03)	0,157*** (-0,03)	0,39	-1,24
Total	0,140*** (-0,03)	0,141*** (-0,03)	0,42	-1,61
BP	0,196*** (-0,06)	0,198*** (-0,06)	0,38	-1,38
Indian Oil	0,025 (-0,06)	0,028 (-0,06)	0,07	-0,14
China Petroleum	0,131 (-0,09)	0,133 (-0,09)	0,15	-1,05
Gazprom	0,250*** (-0,08)	0,260*** (-0,08)	0,25	-2,33**
Equinor	0,271*** (-0,10)	0,274*** (-0,10)	0,47	-2,28**
Lukoil	0,287*** (-0,07)	0,289*** (-0,07)	0,42	-1,92*
Eni	0,179*** (-0,07)	0,182*** (-0,06)	0,42	-2,68***
PTT	0,226*** (-0,06)	0,230*** (-0,06)	0,3	-2,02**
Repsol YPF	0,181*** (-0,06)	0,183*** (-0,06)	0,41	-1,26
Apache	0,889*** (-0,18)	0,895*** (-0,18)	0,66	-3,05***
YPF	0,374*** (-0,06)	0,376*** (-0,06)	0,19	-0,91
Upstream companies				
ConocoPhillips	0,351*** (-0,04)	0,353*** (-0,04)	0,55	-1,51
CNOOC	0,852*** (-0,13)	0,860*** (-0,13)	0,51	-2,45**
TC Energy	0,117*** (-0,02)	0,119*** (-0,02)	0,27	-2,20**
Occidental petroleum	0,482*** (-0,09)	0,488*** (-0,09)	0,54	-3,06***

Hess	0,498*** (-0,07)	0,500*** (-0,07)	0,49	-0,93
Downstream companies				
Valero Energy	0,333*** (-0,05)	0,335*** (-0,05)	0,35	-1,14
Oil & Natural Gas	0,162*** (-0,06)	0,168*** (-0,05)	0,25	-3,59***
Blue Dolphin Energy	0,184 (-0,16)	0,188 (-0,16)	0,01	-0,54
Centrica	0,206** (-0,09)	0,209** (-0,09)	0,31	-2,54**
Hellenic Petroleum	0,176*** (-0,07)	0,177*** (-0,07)	0,2	-0,19

We observe that all companies except for Indian Oil, China Petroleum and Blue Dolphin Energy are significantly influenced by both positive and negative oil price changes.

For the integrated companies we observe small differences in the beta coefficients, but there is an overall trend that negative oil price changes have a greater effect compared to positive changes. From the conducted Wald test, we observe that there exists significant asymmetry for Lukoil at a 10%-level, Gazprom, Equinor and PTT at 5%-level and Exxon, Eni and Apache at a 1%-level.

The selected upstream companies also have higher beta coefficients for negative oil price changes, and we observe that there exists significant asymmetry for three out of five companies, respectively CNOOC and TC Energy at a 5%-level and Occidental Petroleum at a 1%-level.

Like for integrated and upstream companies, the selected downstream companies also have higher beta coefficients for negative oil prices. We observe that two out of five companies have significant asymmetry, respectively Centrica at a 5%-level and Oil & Natural Gas at a 1%-level.

The findings correspond to the predefined hypothesis, as twelve out of twenty-five companies are significantly more affected by negative oil price changes compared to positive oil price changes. We also observe that there exists no asymmetry were positive oil price changes have a greater effect than negative oil price changes.

If an investor expects the oil price to be highly volatile in the future, but increase in the long run, the findings indicate that the investor should not invest in the companies that are significantly more affected by negative oil price changes. From table 6 we observe that the company with the least difference between the effect of positive and negative oil price changes is Hellenic Petroleum, followed by YPF, Hess, Valero Energy, Royal Dutch Shell, Repsol YPF, Chevron, ConocoPhillips and Total.

7.5 Estimation results regression analysis with extreme oil price changes

The next analysis is conducted using equation (7) to analyze whether extreme oil price changes have a significant effect on stock returns. We test the following hypothesis:

H_0: $\beta_i^{Oilextreme+} = 0$, $\beta_i^{Oilextreme-} = 0$

H_1: $\beta_i^{Oilextreme+} \neq 0$, $\beta_i^{Oilextreme-} \neq 0$

In table 9 below, we have presented the calculated values from the regression analysis where we added two dummy variables, one for extreme positive and one for extreme negative oil price changes. A significant OilExtreme beta indicates that extreme oil price changes either will add or deduct a significant value from the Oil beta. Table 9 is divided into three columns where we define an extreme oil price change as either 12%, 15% or 18%.

*Table 9: Estimations from OLS-regression with company return as the dependent variable and FTSE All World, Oil price changes and extreme oil price changes as the independent variables in the time period from Jan 2001 to Dec 2020. */**/*** indicates significance at a 10%/5%/1%-level. Newey West robust standard errors are given in parentheses.*

	12%		**15%**		**18%**	
Integrated companies	**β OilExtreme+**	**β OilExtreme-**	**β OilExtreme+**	**β OilExtreme-**	**β OilExtreme+**	**β OilExtreme-**
Exxon	-0,11 (-0,07)	-0,07 (-0,06)	-0,10* (-0,05)	-0,08 (-0,06)	-0,11** (-0,05)	-0,09 (-0,06)
Chevron	-0,09 (-0,09)	-0,06 (-0,06)	-0,16** (-0,08)	-0,12* (-0,06)	-0,13 (-0,08)	-0,09* (-0,05)
Royal Dutch Shell	-0,17 (-0,15)	-0,13* (-0,07)	-0,21 (-0,16)	-0,16** (-0,06)	-0,22 (-0,16)	-0,15*** (-0,05)
Total	-0,12 (-0,13)	-0,19*** (-0,07)	-0,15 (-0,13)	-0,21*** (-0,07)	-0,16 (-0,14)	-0,22*** (-0,05)
BP	-0,1 (-0,15)	-0,16** (-0,07)	-0,2 (-0,14)	-0,22*** (-0,07)	-0,23* (-0,14)	-0,22*** (-0,06)
Indian Oil	0,33* (-0,19)	0,33** (-0,15)	0,34* (-0,20)	0,32** (-0,14)	0,18 (-0,19)	0,23* (-0,12)
China Petroleum	-0,23 (-0,19)	-0,23* (-0,13)	-0,39** (-0,15)	-0,29** (-0,13)	-0,33** (-0,15)	-0,24** (-0,11)
Gazprom	0,11 (-0,19)	0,13 (-0,20)	0,00 (-0,16)	0,07 (-0,18)	0,04 (-0,17)	0,11 (-0,17)
Equinor	-0,27* (-0,16)	-0,33*** (-0,12)	-0,31** (-0,14)	-0,35*** (-0,09)	-0,32** (-0,14)	-0,34*** (-0,08)
Lukoil	0,03 (-0,15)	-0,02 (-0,12)	0,01 (-0,15)	-0,05 (-0,11)	0,01 (-0,14)	0,00 (-0,11)
Eni	-0,08 (-0,15)	-0,08 (-0,07)	-0,15 (-0,15)	-0,13** (-0,06)	-0,19 (-0,15)	-0,16*** (-0,05)
PTT	-0,21 (-0,16)	-0,16 (-0,13)	-0,31** (-0,14)	-0,22** (-0,10)	-0,22 (-0,15)	-0,13 (-0,08)
Repsol YPF	-0,02 (-0,15)	-0,02 (-0,08)	-0,10 (-0,15)	-0,07 (-0,08)	-0,07 (-0,18)	-0,05 (-0,07)
Apache	-0,12 (-0,17)	0,58** (-0,26)	-0,23 (-0,19)	0,44 (-0,28)	-0,22 (-0,20)	0,45* (-0,26)
YPF	0,07 (-0,16)	-0,02 (-0,18)	0,05 (-0,14)	-0,04 (-0,16)	0,15 (-0,16)	0,01 (-0,15)
Upstream companies						
ConocoPhillips	-0,14 (-0,11)	-0,03 (-0,07)	-0,18** (-0,09)	-0,07 (-0,05)	-0,16* (-0,09)	-0,06 (-0,05)
CNOOC	-0,08 (-0,28)	0,40* (-0,21)	-0,40 (-0,35)	0,15 (-0,21)	-0,45 (-0,37)	0,10 (-0,22)
TC Energy	0,06 (-0,10)	0,11* (-0,07)	-0,01 (-0,10)	0,08 (-0,06)	0,06 (-0,12)	0,12** (-0,05)
Occidental petroleum	-0,16 (-0,17)	0,30* (-0,16)	-0,25 (-0,21)	0,23 (-0,16)	-0,26 (-0,21)	0,24* (-0,14)
Hess	-0,11 (-0,15)	0,04 (-0,11)	-0,21 (-0,15)	-0,08 (-0,09)	-0,24 (-0,16)	-0,14* (-0,08)
Downstream companies						
Valero Energy	-0,13 (-0,17)	0,00 (-0,15)	-0,02 (-0,12)	0,04 (-0,12)	-0,15 (-0,12)	-0,05 (-0,09)
Oil & Natural Gas	0,01 (-0,18)	0,05 (-0,13)	-0,03 (-0,17)	0,06 (-0,13)	-0,11 (-0,17)	0,02 (-0,12)
Blue Dolphin Energy	-0,49 (-0,46)	-0,48 (-0,39)	-0,64* (-0,36)	-0,54* (-0,32)	-0,34 (-0,33)	-0,24 (-0,29)
Centrica	0,02 (-0,13)	0,35*** (-0,13)	-0,07 (-0,13)	0,29** (-0,12)	-0,04 (-0,13)	0,34*** (-0,10)
Hellenic Petroleum	0,07 (-0,14)	0,10 (-0,15)	0,02 (-0,13)	0,07 (-0,14)	0,02 (-0,12)	0,10 (-0,13)

When we define an extreme oil price change as a decrease or increase of 12%, we observe from table 9 that there are significant values. For extreme positive oil price changes, we observe that Indian Oil have a significant positive beta coefficient at a 10%-level, and Equinor a significant negative beta coefficient at a 10%-level. For extreme negative oil price changes, we observe that Royal Dutch Shell and China Petroleum have significantly negative beta coefficients at a 10%-level, BP at 5%-level and Total and Equinor at a 1%-level. Further we observe that CNOOC, TC Energy and Occidental Petroleum have significant positive beta coefficients at a 10%-level, Indian Oil and Apache at a 5%-level, and Centrica at a 1%-level.

If we change the definition of an extreme oil price change from 12% to 15%, we observe that there are small differences. For extreme positive changes we observe that the beta coefficient for Equinor is significant at a 5%-level. In addition, we get significant negative beta coefficients for Exxon and Blue Dolphin Energy at a 10%-level, Chevron and China Petroleum, PTT and ConocoPhillips at a 5%-level. For extreme negative oil price changes, we observe that the significance level changes for Royal Dutch Shell, BP, China Petroleum and Centrica, where all beta coefficients are significant at a higher level except for Centrica. We observe new significant values for Chevron, PTT and Blue Dolphin Energy with negative beta coefficients at a 10%-level, and Eni at a 5%-level. For TC Energy and Occidental Petroleum, the beta coefficients for extreme negative oil price changes are no longer significant.

The last definition of an extreme oil price change we selected, is a price change of 18% or higher. We do observe some differences in this situation as well, Exxon is more significant, ConocoPhillips is less significant, and PTT is no longer significant. In addition, we observe a new significant negative beta coefficient for BP. For extreme positive changes, we observe new significant positive beta values for Apache, Occidental Petroleum at a 10%-level and TC Energy at a 5%-level. For Hess we observe a significant negative beta value at a 10%-level. We also observe that Royal Dutch shell, Eni and Centrica are significant at a higher level.

If an investor has conducted an analysis that indicates an extreme oil price increase, one should not invest in Exxon, Chevron, BP, China Petroleum, Equinor and ConocoPhillips. This is because these companies have a positive oil beta and a negative OilExtreme beta, which indicate that the return of these companies will be less affected by the positive increase compared to the other selected companies with a positive oil beta.

If the analysis indicates an extreme negative oil price change in the future, an investor should not invest in China Petroleum, Apache, TC Energy, Occidental Petroleum and Hess. These companies have a positive oil price beta, which indicate that in the event of an extreme oil price decrease, the return will decrease accordingly. If an investor will invest in oil companies even though the oil price is expected to decrease, one should select Chevron, Royal Dutch Shell, Total, BP, Equinor, Eni. The return of these companies will be less volatile in relation to the oil price decrease and therefore the return will be less affected.

7.6 Estimation results quantile regression

The next analysis is conducted using equation (8) to analyze whether there exist significant values in the quantiles. We test the following hypothesis:

H_0: $\beta_{i\,(\tau)}^{Oil} = 0$
H_1: $\beta_{i\,(\tau)}^{Oil} \neq 0$

*Table 10: Estimations from quantile-regression with the companies' monthly return as the dependent variable and FTSE All World, Oil price in the time period from Jan 2001 to Dec 2020. */**/*** indicates significance at a 10%/5%/1%-level. Huber-Sandwich robust standard errors are given in parentheses.*

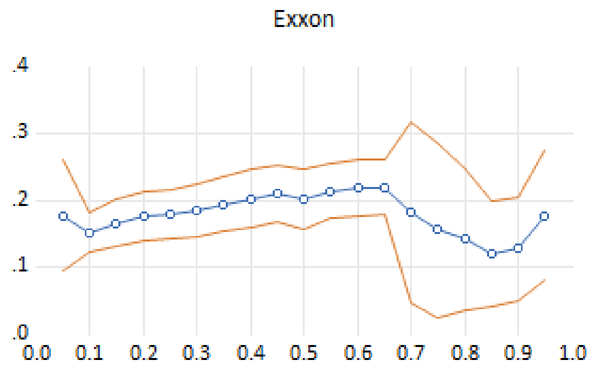
Integrated companies	**Q 0,05**	**Q 0,10**	**Q 0,25**	**Q 0,50**	**Q 0,75**	**Q 0,90**	**Q 0,95**
Exxon	0,18*** (0.04)	0,15*** (0.02)	0,18*** (0.02)	0,20*** (0.02)	0,15** (0.07)	0,13*** (0.04)	0,18*** (0.05)
Chevron	0,16* (0.08)	0,16* (0.09)	0,17*** (0.03)	0,21*** (0.02)	0,23*** (0.02)	0,25*** (0.02)	0,23*** (0.05)
Royal Dutch Shell	0,15 (0.10)	0,25*** (0.07)	0,18** (0.07)	0,17** (0.08)	0,14*** (0.02)	0,16*** (0.02)	0,16*** (0.02)
Total	0,12*** (0.04)	0,16** (0.07)	0,18*** (0.07)	0,20*** (0.07)	0,15* (0.08)	0,08 (0.06)	0,05*** (0.01)
BP	0,13*** (0.03)	0,10*** (0.04)	0,25*** (0.08)	0,26*** (0.06)	0,22*** (0.06)	0,16*** (0.02)	0,17*** (0.02)
Indian Oil	0,01 (0.06)	0,10*** (0.04)	0,03 (0.09)	-0,03 (0.09)	-0,01 (0.11)	0,05 (0.19)	0,27*** (0.04)
China Petroleum	0,28** (0.14)	0,29*** (0.09)	0,27** (0.11)	0,11* (0.10)	0,10*** (0.03)	0,09 (0.21)	0,06 (0.23)
Gazprom	0,30*** (0.07)	0,36*** (0.08)	0,38*** (0.09)	0,32*** (0.11)	0,20*** (0.05)	0,22*** (0.03)	0,30*** (0.04)
Equinor	0,39*** (0.09)	0,45*** (0.08)	0,33*** (0.08)	0,39*** (0.09)	0,38*** (0.07)	0,24*** (0.06)	0,16*** (0.02)
Lukoil	0,27*** (0.08)	0,43*** (0.09)	0,36** (0.14)	0,34*** (0.10)	0,23*** (0.03)	0,28*** (0.02)	0,33*** (0.03)
Eni	0,10*** (0.03)	0,17*** (0.06)	0,21*** (0.07)	0,20** (0.08)	0,21*** (0.08)	0,16*** (0.02)	0,18*** (0.02)
PTT	0,10** (0.05)	0,20** (0.09)	0,28*** (0.09)	0,26** (0.11)	0,20*** (0.03)	0,23*** (0.02)	0,24*** (0.01)
Repsol YPF	0,26** (0.10)	0,28*** (0.10)	0,24*** (0.08)	0,16* (0.09)	0,14*** (0.03)	0,19*** (0.03)	0,18*** (0.06)
Apache	0,90*** (0.26)	0,75*** (0.16)	0,59*** (0.11)	0,56*** (0.12)	0,43*** (0.09)	0,39*** (0.11)	0,46*** (0.13)
YPF	0,64*** (0.16)	0,50*** (0.10)	0,42*** (0.05)	0,35*** (0.09)	0,23** (0.11)	0,10 (0.15)	0,14 (0.25)
Upstream companies							
ConocoPhillips	0,25*** (0.02)	0,26*** (0.02)	0,40*** (0.07)	0,37*** (0.03)	0,38*** (0.03)	0,36*** (0.06)	0,32*** (0.08)
CNOOC	1,07*** (0.06)	1,08*** (0.06)	0,84*** (0.16)	0,62*** (0.14)	0,69*** (0.14)	0,77*** (0.17)	0,94*** (0.18)
TC Energy	0,10*** (0.02)	0,11*** (0.02)	0,12*** (0.02)	0,12 (0.8)	0,13** (0.06)	0,11** (0.05)	0,16*** (0.06)
Occidental Petroleum	0,60* (0.33)	0,52*** (0.18)	0,40*** (0.09)	0,43*** (0.06)	0,35*** (0.10)	0,37*** (0.14)	0,32* (0.17)
Hess	0,35** (0.15)	0,52*** (0.14)	0,58*** (0.09)	0,58*** (0.10)	0,44*** (0.04)	0,45*** (0.06)	0,50*** (0.03)
Downstream companies							
Valero Energy	0,29*** (0.05)	0,27*** (0.06)	0,30** (0.14)	0,32*** (0.06)	0,35*** (0.05)	0,38*** (0.04)	0,33*** (0.05)

Oil & Natural Gas	0,10 (0.09)	0,06 (0.05)	0,13 (0.13)	0,13*** (0.04)	0,20*** (0.04)	0,24*** (0.03)	0,26*** (0.03)
Blue Dolphin Energy	-0,15 (0.39)	0,16 (0.16)	0,12 (0.16)	0,32 (0.21)	0,16 (0.14)	0,18** (0.08)	0,15* (0.09)
Centrica	0,40*** (0.04)	0,25 (0.31)	0,13* (0.08)	0,10 (0.07)	0,11 (0.08)	0,08 (0.08)	0,06 (0.08)
Hellenic Petroleum	0,24* (0.14)	0,15** (0.06)	0,28*** (0.09)	0,18** (0.09)	0,10 (0.19)	0,06 (0.19)	0,16* (0.09)

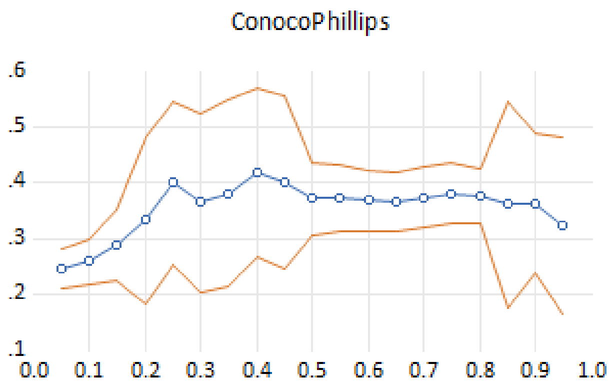
From the quantile regression we observe a large number of significant quantiles for all companies which are higher than we expected. For integrated companies we observe significant values in the quantiles with some exceptions. Chevron is not significant in its lowest quantiles, 0,05 and 0,10 respectively. Total is not significant in its 0,10, 0,75 and 0,90 quantiles. Indian oil is the only integrated company with significant values in the quantiles 0,10 and 0,95. Eni and Repsol YPF is not significant in their median quantile 0,50. PTT is not significant in its median quantile 0,5 and 0,10. YPF is not significant in its qunatiles 0,75, 0,90 and 0,95.

For the upstream companies we observe significant quantiles for all companies. ConocoPhilips and CNOOC have significant values in all quantiles. TC energy is not significance in its 0,50, 0,75 and 0,90 quantiles. Occidental Petroleum is not significant in its quantiles 0,05 and 0,95. And Hess is not significant in its 0,05 quantile.

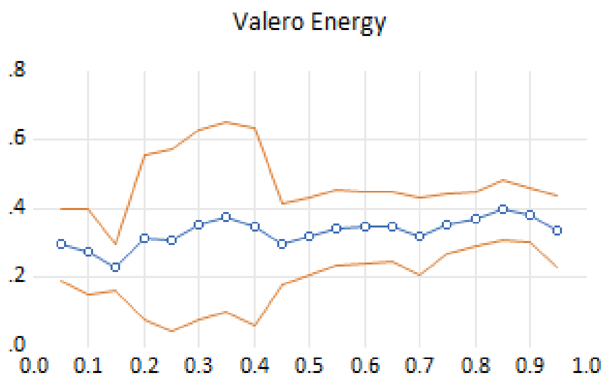
For downstream companies we observe significant values in quantiles for Valero Energy and Oil & Natural Gas. Centrica and Hellenic Petroleum have a few significant quantiles.



Graph 6: Estimation results from quantile regression Exxon. The X-axis represents the different quantiles. The Y-axis represents the oil beta. The blue line represents the quantile distribution curve. The orange lines represent the 95% confidence intervals.



Graph 7: Estimation results from quantile regression ConocoPhillips. The X-axis represents the different quantiles. The Y-axis represents the oil beta. The blue line represents the quantile distribution curve. The orange lines represent the 95% confidence intervals.



Graph 8: Estimation results from quantile regression ConocoPhillips. The X-axis represents the different quantiles. The Y-axis represents the oil beta. The blue line represents the quantile distribution curve. The orange lines represent the 95% confidence intervals.

We have graphed the quantile distrubition in graph 6, 7 and 8, while graphs for the rest of the companies are in appendix 10.2.

We observe from the quantile distribution for Exxon an upward trend in beta values from the lowest quantile to the median, before the values decline in the upper quantiles. This distribution shows that lower stock returns for Exxon can be explained more by the oil price compared to Exxon's higher stock returns.

In the quantile distribution for ConocoPhillips we observe a stronger upward trend compared to Exxon for its lower quantiles. The trend continues sideways and declines in the highest quantiles. This distribution shows that the return in the median and other quantiles are more explained by the oil price compared to the lower quantiles.

In the quantile distribution for Valero Energy we notice that all quantiles are trending sideways. There are little fluctuations, and the returns in all quantiles are almost equally explained by the oil price.

To comment the graphs in appendix 10.3 we start with the integrated companies. We observe an upwarding trend in oil betas for the lower quantiles, before they decline in the higher quantiles. This is relevant for Exxon, Royal Dutch Shell, Total, Eni and PTT where their lower returns are more explained by changes in the oil price compared to their higher returns. Another trend we observe from the graphs is declining oil price beta values for China Petroleum, Gazprom, Equinor, Lukoil, Repsol YPF, Apache and YPF. High returns for these companies will be explained more by changes in the oil price compared to their lower returns. For the rest of the integrated companies there are no clear trend.

For upstream companies we observe positive significant quantiles for most companies. These findigs were expected as this subsector is most influenced by changes in the oil price, and should be reflected in the quantiles. We observe the highest significant quantile of 1.07 by CNOOC in the 0,05 quantile. CNOOC and Occidental Petroleum have high beta values in their lowest quantiles. Hess, TC Energy and ConocoPhillips have an increasing trend from their lowest quantiles, where it trends sideways after the median. These upstream companies lowest returns are less explained by changes in oil price compared to their other returns.

For downstream companies there are no significant values in many quantiles except for Valero Energy and Oil & Natural Gas. Downstream companies are less influened by changes in the oil price than upstream companies, however, we see no clear trend for the downstream companies. Valero Energy have significant values in all quantiles and Oil & Natural Gas has only significant values in the upper quantiles. We see that for both companies their oil beta is increasing, which shows that the higher return of the downstream companies are more explained by changes in the oil price compared to lower returns.

If an investor believe the oil price to increase in the future, one should invest in companies with high beta values in the upper quantiles. This is because high beta values indicate that high stock returns are more influenced by the oil price. If an investor believes the oil price to decline in the future but wish to invest in oil companies. The findings indicate that companies with low oil beta in the upper quantiles could be a good investment. This is because high return in these companies is less related to oil price fluctuations.

Table 11: Estimation results from Wald test for differences between extreme quantiles and the median from Jan 2001 to Dec 2020.

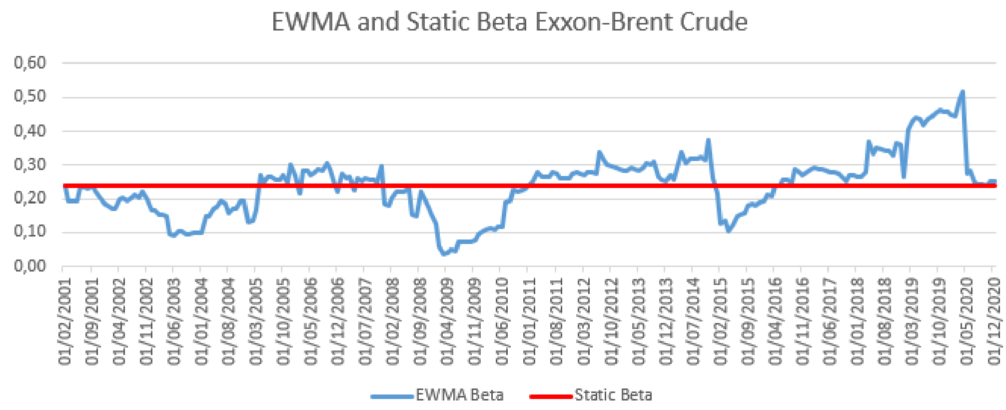
Integrated companies	**Q 0,05 - 0,50**	**Q 0,50 - 0,95**
Exxon	-0,03	-0,03
Chevron	-0,05	-0,02
Royal Dutch Shell	-0,02	0,01
Total	-0,08	0,15**
BP	-0,13**	0,09
Indian Oil	0,04	**-0,29*** **
China Petroleum	0,16	0,05
Gazprom	-0,02	0,02
Equinor	0,00	0,23**
Lukoil	-0,07	0,02
Eni	-0,11	0,03
PTT	-0,16	0,02
Repsol YPF	0,10	-0,02
Apache	0,35	0,10
YPF	0,29*	0,21
Upstream companies		
ConocoPhillips	**-0,13*** **	0,08
CNOOC	**0,45*** **	-0,33
TC Energy	-0,02	-0,04
Occidental Petroleum	0,18	0,11
Hess	-0,24	0,09
Downstream companies		
Valero Energy	-0,03	-0,02
Oil & Natural Gas	-0,03	-0,12**
Blue Dolphin Energy	-0,47	0,18
Centrica	**0,30*** **	0,04
Hellenic Petroleum	0,06	0,02

We analyze whether there are significant differences between the quantiles (0,05 and 0,95) and the median (0,50). This might give information about how exposed the companies are under a bull- and a bear market. The conducted Wald test indicate four significant observations between the quantiles. For ConocoPhillips we observe a negative significant value for the lowest quantile.CNOOC and Centrica have a positive significant value in the lowest quantile, and Indian Oil have a negative significant value in the highest quantile. Indian Oil nor Centrica have a significant median quantile which means that the results from the Wald test can be misleading.

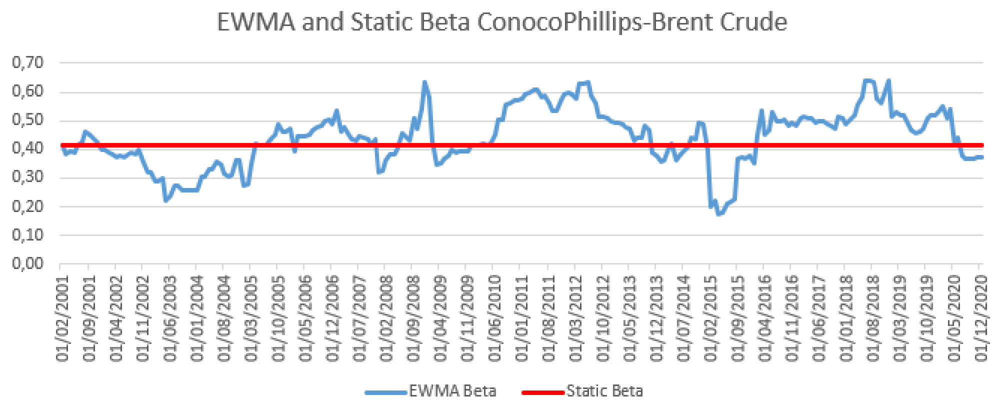
In appendix 10.2 we test for significant differences between the different quantiles. We conduct a Wald test and we are only left with significant observations on a 5%- and 10%-level. Some of these observations are based on the difference between a significant and a unsignificant quantile, which may cause the results to be misleading. We can from this test assume that there are no significant differenes between the quantiles and expect the quantile regression of nearby quantiles to reveal no additional findings.

7.7 Estimation results EWMA oil beta

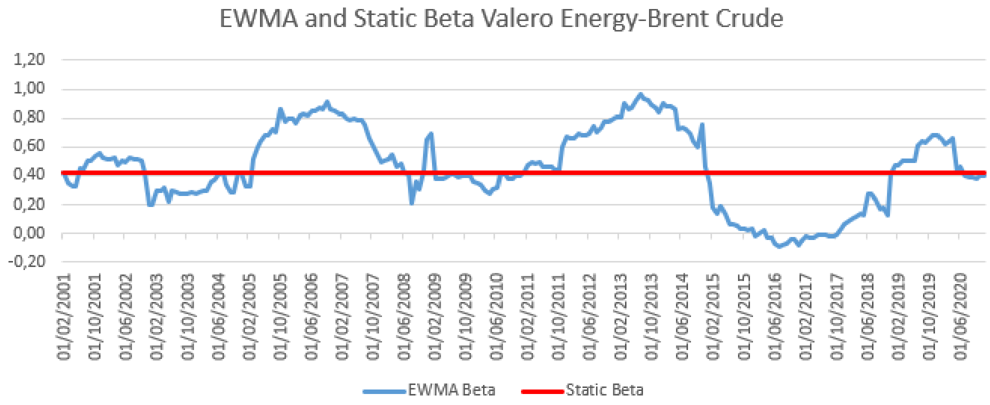
We want to look closer at the EWMA (Exponential weighted moving average) oil beta, as it fluctuates over time. Beta is the product of the correlation and the relative volatility. We will only analyse the beta values as it is a direct measure of the two underlying factors. We graph the EWMA oil beta for Exxon, ConocoPhillips and Valero Energy, and add rest of the companies' graphs in appendix 10.4. The graphs of correlation and relative volatility supplied in appendix 10.5 and 10.6. For equation (9) we use a smoothening factor of 0,94.



Graph 9: EWMA and static oil beta Exxon Jan 2001 to Dec 2020.



Graph 10: EWMA and static oil beta ConocoPhillips Jan 2001 to Dec 2020.



Graph 11: EWMA and static oil beta Valero Energy Jan 2001 to Dec 2020.

Exxon's oil beta fluctuates below- or closely to the static beta from Jan 2001 to July 2008. This shows that Exxon has been less influenced by the oil price than what we would expect in a bull oil market. From Jan 2011 to Dec 2020 we see the oil beta has fluctuated closely to the static beta until it fluctuates above from 2016. This was a bear oil market, and we observe that Exxon becomes more sensitive to oil price fluctuations over the last time period.

ConocoPhillips oil beta fluctuates arround the static beta from Jan 2001 to July 2008 and are at its lowest in 2003. From Jan 2011 to Dec 2020 we observe that the oil beta fluctuates above the static beta, except for in 2015. We notice that ConocoPhillips share the same pattern as Exxon for the whole time period.

Valero Energy's oil beta appears to have the same trend as Exxon and ConocoPhillips, however, the trend is stronger for Valero Energy comapred to the other two. We observe that the oil beta fluctuates over the static beta in 2006 and 2013, while fluctuates below the static beta in 2017. We note that the sensitivity to oil price fluctuations is increased for Valero Energy compared to Exxon and ConocoPhillips.

To comment the graphs in appendix 10.4 we start with the integrated companies. As the companies are sorted from largest to smallest after market capitalization, we notice a trend for large integrated companies. Exxon, Chevron, Royal Dutch Shell, Total and BP have very similar beta values in the whole time period. The beta value for these companies fluctuates little from 2001 to 2008, before the correlation and volatility starts to increase. The beta values decline in 2009 before they start to increase above the static beta for most of the companies until 2020. For integrated companies, the trend is that the beta value fluctuates little between 2001 and 2008. Most of the integrated companies have a higher beta than its static beta value from 2009 to 2014, before a decline in 2015. From 2015 to 2020 the beta values are in an upward trend, before a decline in the beginning of 2020. The largest integrated companies seem to differ from the rest of the integrated companies. This is an interesting finding as it does not correlate with our finding done in the regression analysis for the time period 2011-2020. The regression analysis stated that integrated companies should have a lower beta value on average between 2011 and 2020 compared to 2001 and 2008. However, from the EWMA beta it seem that the largest integrated companies are more sensitive to oil price fluctuations over time compared to the smaller ones.

For the upstream companies there seem to be small trends. All companies have a decline in their oil beta from 2001 and starts to upward trend between 2003 and 2005. From 2005 there is no clear trend, but all companies start to experience a decline in their beta value in 2008, 2015 and 2020. For the downstream companies there seem to be no clear trends, except for Valero Energy and Blue Dolphin Energy who share much of the same patterns.

The findings can be interesting for an investor, as the investor can observe how the company's sensitivity to oil differentiates during different market conditions.

8 Conclusion

In this master thesis we have analyzed the stock returns of twenty-five publicly traded oil and gas companies and their sensitivity to Brent crude oil price fluctuations. The companies are divided into three subsectors to investigate how the sensitivity to Brent crude influence companies across subsectors. All analysis is conducted using monthly logarithmic returns from Jan 2001 to Dec 2020. Further we divided the sample data into two time periods. In the first time period from Jan 2001 to July 2008 there was bull oil market, and in the second time period from Jan 2011 to Dec 2020, there was a bear oil market. Our master thesis is written to give a better understanding to how oil and gas companies are affected by Brent crude price fluctuation under different market conditions. This information can be beneficial for investors and other stakeholders. The findings from our analysis can give insight to which companies to include or exclude from an investment portfolio.

The first analysis investigates the relationship between Brent crude oil and FTSE All World. The estimations result with an oil beta value of 0,13 indicate that Brent crude have a significant effect on FTSE All World in the time period from Jan 2001 to Dec 2020. The calculated R^2 of 0,12 indicate that the changes in FTSE All World are 12% influenced by Brent crude oil price fluctuation. We estimate a model with positive and negative Brent crude oil price changes to analyze whether there exists asymmetry. The estimation results give a significant oil beta for positive changes on 0,14 and a significant oil beta for negative changes on 0,14. A Wald-test is conducted to test for asymmetry. The results indicate that positive Brent crude oil price changes have a greater impact on FTSE All World compared to negative changes.

In the first time period from Jan 2001 to July 2008 we observe a low R^2 of 0,03, and the results indicate that Brent crude have no significant effect on FTSE All World in a bull oil market. In the second time period from Jan 2011 to Dec 2020 we observe a R^2 of 0,28. The results indicate that Brent crude oil price fluctuations have a significant effect on FTSE All World in a bear oil market.

The second analysis investigates the stock return of oil companies and their relationship to Brent crude and FTSE All World. All companies have significant oil betas except for Indian Oil, China Petroleum and Blue Dolphin Energy in the time period from Jan 2001 to Dec 2020. Estimation results show an average oil beta value of 0,24 for integrated companies, 0,44 for upstream companies and 0,21 for downstream companies. This indicates that upstream companies are more influenced by Brent crude price changes compared to the other two subsectors.

The first time period from Jan 2001 to July 2008 where the oil market is in a bull trend, we find significant oil beta values for 13/15 integrated companies, 4/5 upstream companies and 3/5 downstream companies. The average oil beta value was 0,26 for integrated companies, 0,25 for upstream companies and 0,29 for downstream companies. For the second time period Jan 2011 to Dec 2020 where the oil market is in a bear trend, we find significant oil beta values for 12/15 integrated companies, 4/5 upstream companies and 3/5 downstream companies. The average oil beta value was 0,23 for integrated companies, 0,47 for upstream companies and 0,13 for downstream companies. If an investor believes the oil price will be increasing in the future, the findings indicate that companies with a high beta value like upstream companies may be a good investment. If an investor believes the oil price to be declining in the future and the investor is including oil stocks in his portfolio, our findings indicate that one would invest in companies with low oil beta values.

The estimation results from the third analysis with lagged variables indicates few significant values. We find three significant values at a one-percent level when lagging the oil price with one month, and two significant values at a one-percent level when lagging the oil price with two months. We then test if the lagged beta values are significantly different from zero at the same time. The test indicates significant values at a one-percent level for Total, Repsol and Hess. As we observe few significant values between 2001 and 2020, we assume the oil stock market to be efficient. Concluding that oil companies in general do not experience a delay in their stock return as a result of previous oil price fluctuations. An investor is unlikely to yield a return by buying stocks based on previous months' oil prices.

The fourth analysis investigates if there exists asymmetry in how positive and negative Brent crude oil price fluctuations affect the stock returns on the selected companies. The estimation results indicate significant values at a one-percent level for that negative oil price changes have a greater effect on the stock returns for Exxon, Eni, Apache, Occidental Petroleum and Oil & Natural Gas. These results can be beneficial for an investor who believes the oil price to be declining in the future, as the investor can avoid companies with asymmetry which is likely to be more influenced by negative oil price fluctuations.

The fifth analysis investigates the effect extreme oil price changes have on the stock returns of the selected companies and whether these extreme changes give an addition or deduction to the oil beta. The analysis is conducted where we define an extreme oil price change as 12%, 15% or 18%. When we define an extreme oil price change as 12%, the estimation results indicate significant values for extreme negative changes at a one-percent level for Total, Equinor and Centrica. These findings indicate that the oil beta receive an addition for Centrica, and a deduction for Total and Equinor. When we define an extreme oil price change as 15%, we observe significance for extreme negative changes at a one-percent level for Total, BP and Equinor. These findings indicate that the oil beta receive a deduction for Total and Equinor. When we define an extreme oil price change as 18%, we observe significant values for extreme negative changes at a one-percent level for Royal Dutch Shell, Total, BP, Equinor, Eni and Centrica. These findings indicate that the oil beta receive an addition for Centrica, and a deduction for Royal Dutch Shell, Total, BP, Equinor and Eni. If an investor believes the oil price to experience extreme negative changes, the results indicate that the companies which get a deduction in the oil beta can be a better investment.

The sixth analysis investigates the quantiles between Brent crude oil and FTSE All World, where we focus on Brent crude. The estimation results indicate significant quantiles for most integrated- and upstream companies, while we observe no significance for almost all downstream companies. These findings indicate that there exists a relationship where oil price fluctuations affect the company stock returns in different market conditions. The relationship is investigated through a Wald-test where we first test for differences between the median (0,50) and extreme quantiles (0,05 and 0,95), and secondly test for differences between nearby quantiles (0,05, 0,10, 0,25, 0,50, 0,75, 0,90, 0,95). In the first test the estimation results indicate significance between the lowest quantile and the median for ConocoPhillips, CNOOC and Centrica. These results indicate that in the extreme quantiles these companies are either more or less influenced by oil price changes. In the second test the estimation results indicate few significant values at a 5%- and 10%-level, which show that it exists no mentionable differences between the nearby quantiles. The investor can use the significant values based on whether the investor believes the oil price to be increasing or decreasing in the future.

The seventh analysis investigates the EWMA and static beta values. The estimation results indicate that the oil beta fluctuates with different market conditions. In a bull oil market, the beta values seem to fluctuate closer to the static beta compared to a bear oil market. There exists no clear trend for the selected companies, and an investor will have to individually investigate the beta values.

In this master thesis we have chosen to include only the market and oil price fluctuations and their effect on the selected companies' stock return. From the regression analysis we observe R^2 values fluctuate from 0,02 to 0,54. These fluctuations indicate that there exist significant factors which affect the companies' stock return which we have excluded. As our study focus on stock return and oil price sensitivity this was a natural exclusion and we recommend future studies to take this into consideration.

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10 Appendix

10.1 Jarque-Bera values

Jarque Bera values calculated from descriptive statistics. * indicates that sample data is not normally distributed.

Integrated companies	**Jarque Bera**
Exxon	29,553*
Chevron	4,354
Royal Dutch Shell	10,072*
Total	19,797*
BP	2,556
Indian Oil	7,441*
China Petroleum	10,533*
Gazprom	261,919*
Equinor	69,840*
Lukoil	22,514*
Eni	32,276*
PTT	22,723*
Repsol YPF	12,661*
Apache	24045,863*
YPF	45,715*
Upstream companies	
ConocoPhillips	100,078*
CNOOC	3570,336*
TC Energy	24,627*
Occidental Petroleum	8190,155*
Hess	24,289*
Downstream companies	
Valero Energy	30,005*
Oil & Natural Gas	14,997*
Blue Dolphin Energy	393,811*
Centrica	2284,948*
Hellenic Petroleum	30,329*

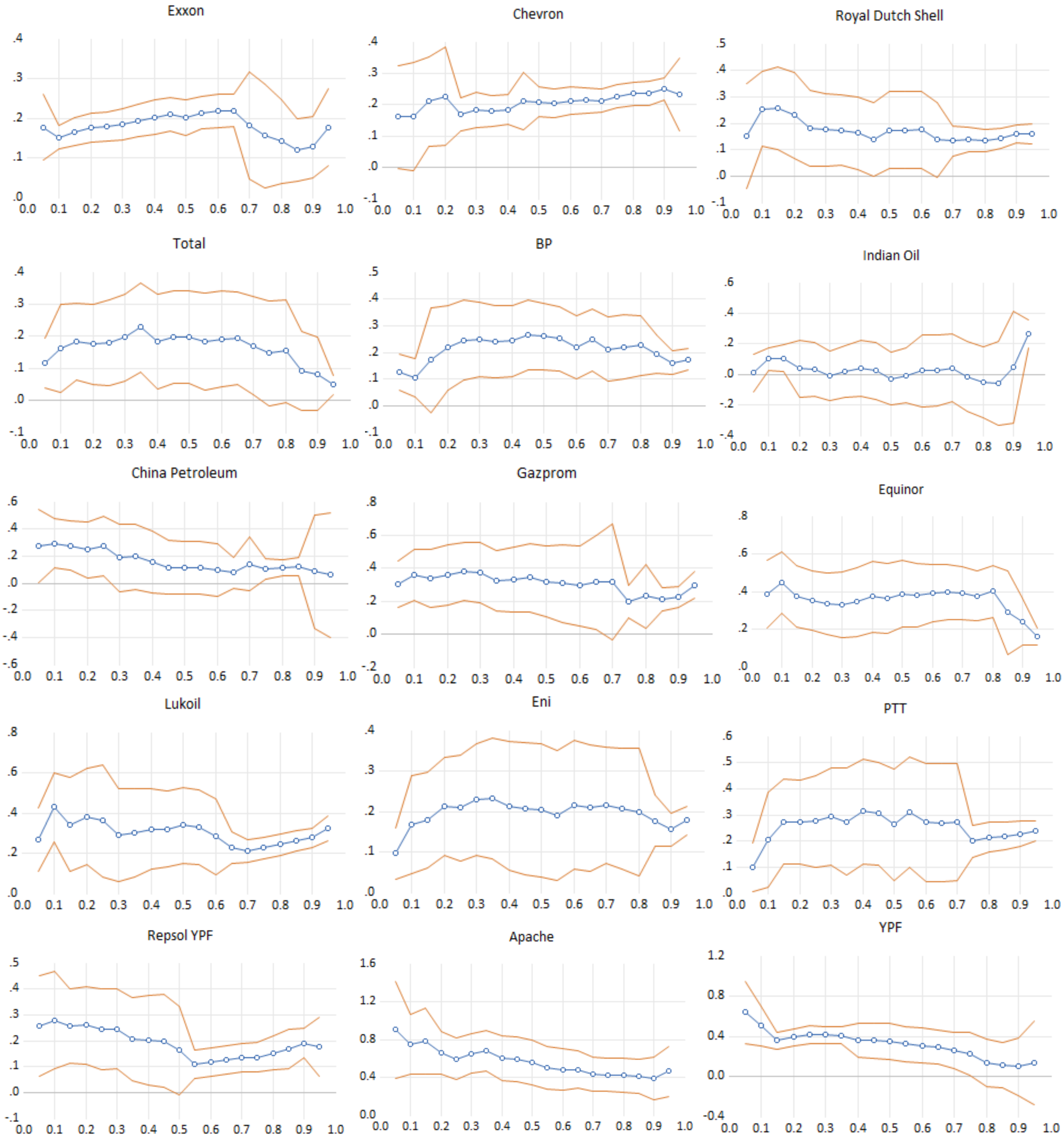
10.2 Wald test for quantile regression

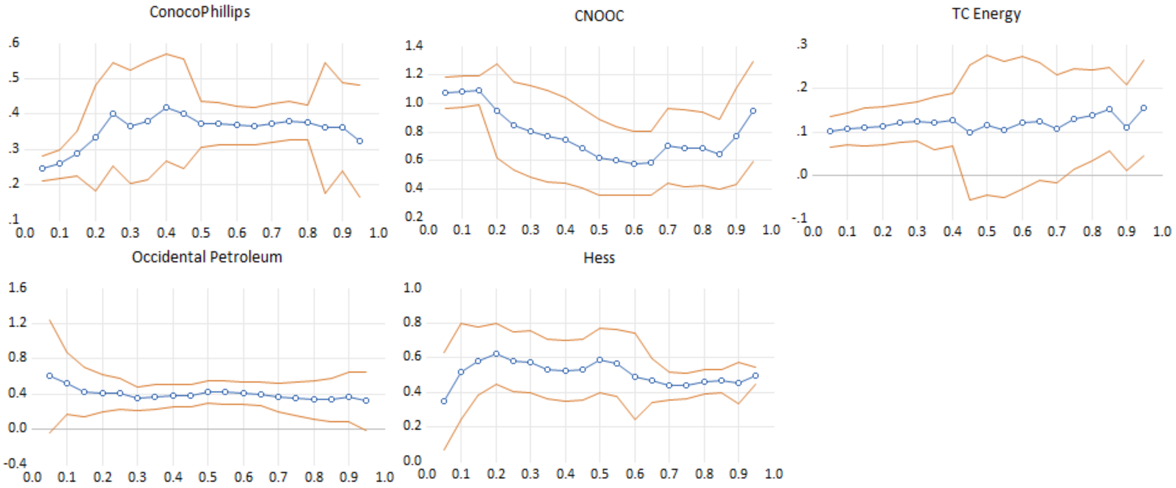
Estimation results from Wald test for differences in nearby quantiles Jan 2001 to Dec 2020.

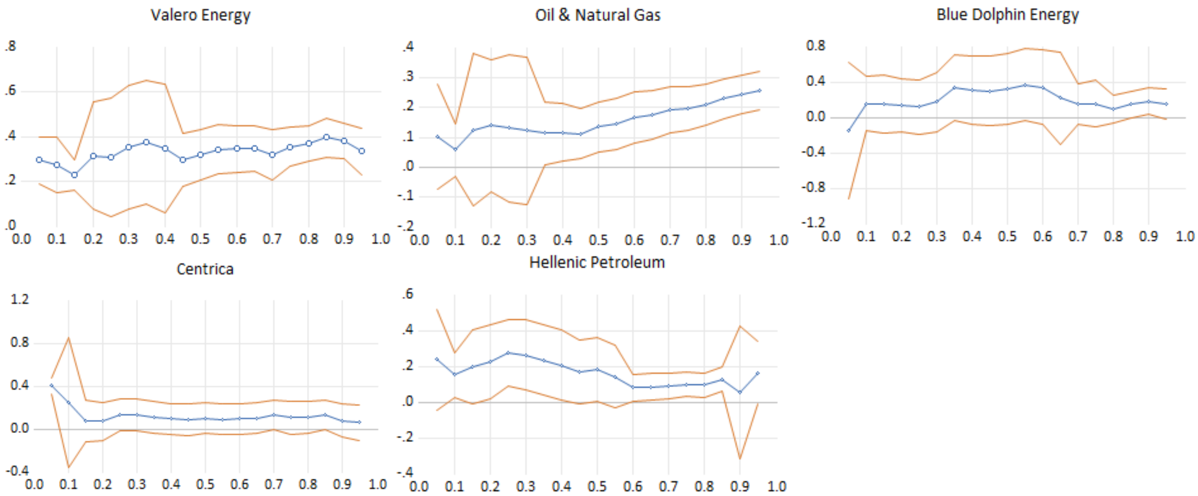
Integrated companies	**Q 0,05 = 0,10**	**Q 0,10 = 0,25**	**Q 0,25 = 0,50**	**Q 0,50 = 0,75**	**Q 0,75 = 0,90**	**Q 0,90 = 0,95**
Exxon	0,03	**-0,03***	-0,02	0,05	0,03	0,04
Chevron	0,00	-0,01	**-0,04***	-0,02	-0,02	0,02
Royal Dutch Shell	-0,10	0,07	0,01	0,04	-0,02	0,00
Total	-0,05	-0,02	-0,02	0,05	0,06	0,03
BP	0,02	**-0,14****	-0,01	0,04	0,06	-0,01
Indian Oil	**-0,09***	0,07	0,06	-0,02	-0,07	-0,22
China Petroleum	-0,02	0,02	0,16	0,01	0,02	0,03
Gazprom	-0,06	-0,02	0,06	0,12	-0,03	**-0,07****
Equinor	-0,06	0,12	-0,05	0,01	**0,14****	0,08
Lukoil	**-0,16****	0,07	0,02	0,11	**-0,05****	**-0,05***
Eni	-0,07	-0,04	0,01	0,00	0,05	-0,02
PTT	-0,10	-0,07	0,01	0,06	-0,03	-0,01
Repsol YPF	-0,02	0,04	0,08	0,03	**-0,05****	0,01
Apache	0,16	0,16	0,03	0,14	0,04	-0,08
YPF	0,14	0,08	0,07	0,12	0,13	-0,04
Upstream companies						
ConocoPhillips	-0,01	**-0,14****	0,03	-0,01	0,02	0,04
CNOOC	-0,01	0,24	0,22	-0,07	-0,09	-0,17
TC Energy	-0,01	-0,01	0,00	-0,01	0,02	-0,05
Occidental Petroleum	0,08	0,12	-0,02	0,08	-0,02	0,05
Hess	-0,17	-0,06	-0,01	**0,15***	-0,02	-0,04
Downstream companies						
Valero Energy	0,02	-0,04	-0,01	-0,04	-0,03	0,05
Oil & Natural Gas	0,04	-0,07	0,00	**-0,06***	-0,04	-0,02
Blue Dolphin Energy	-0,30	0,04	-0,20	0,17	-0,03	0,04
Centrica	0,15	0,12	0,03	0,00	0,03	0,02
Hellenic Petroleum	0,09	-0,12	0,10	0,08	0,04	-0,11

10.3 Graphs from quantile regression

Estimation results from quantile regression for integrated- upstream- and downstream companies Jan 2001 to Dec 2020. The X-axis represents the different quantiles. The Y-axis represents the oil beta. The blue line represents the quantile distribution curve. The orange lines represent the 95% confidence intervals.



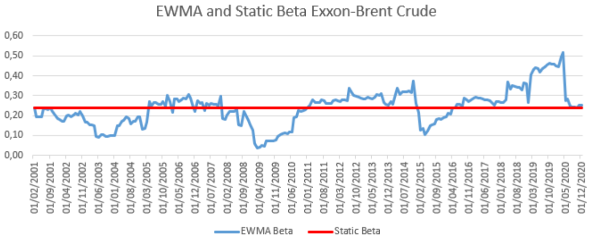

ConocoPhillips
CNOOC
TC Energy
Occidental Petroleum
Hess

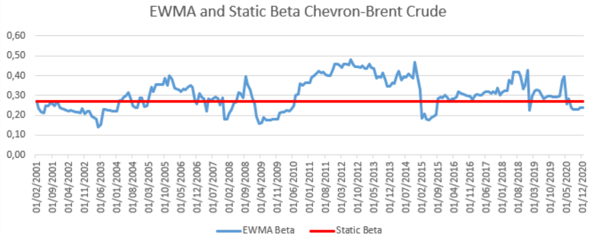

Valero Energy
Oil & Natural Gas
Blue Dolphin Energy
Centrica
Hellenic Petroleum

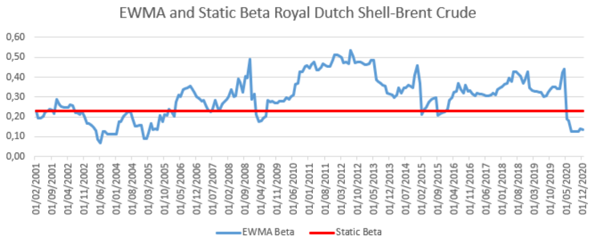
10.4 Static and EWMA oil beta graphs

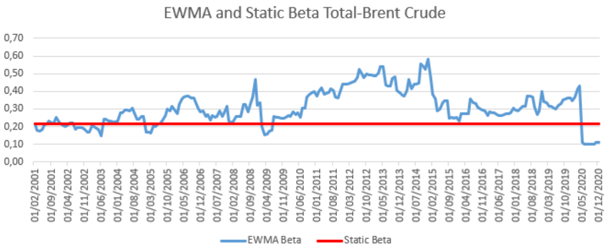
Static and EWMA oil beta for integrated- upstream- and downstream companies Jan 2001 to Dec 2020.

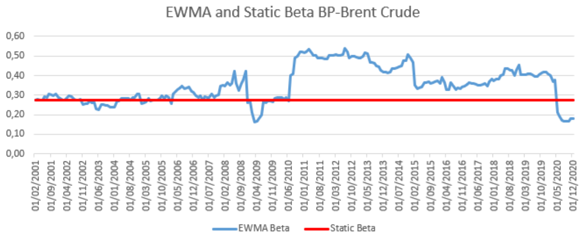
Integrated companies:

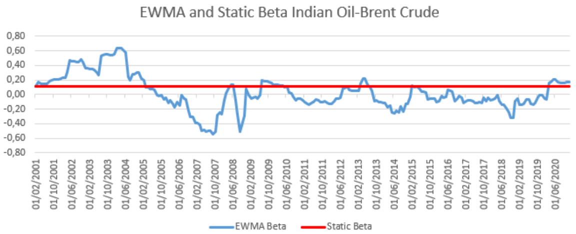


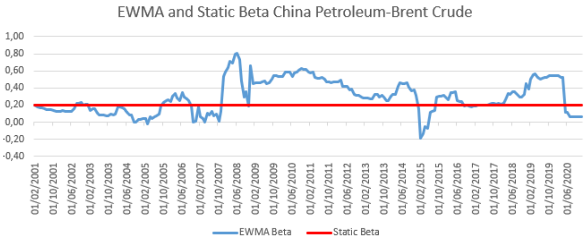


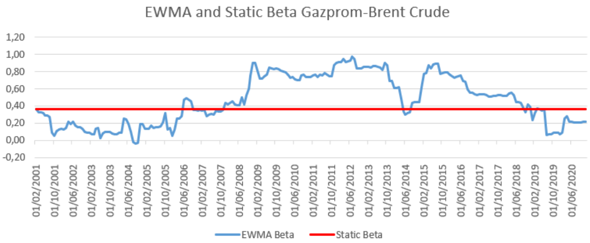


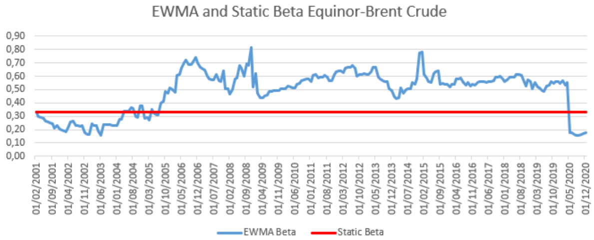


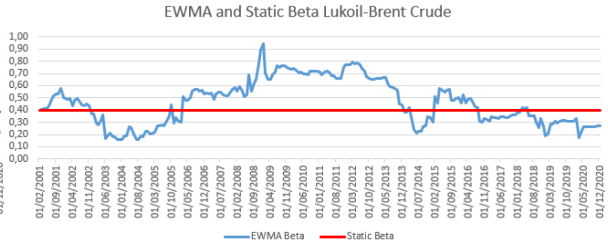


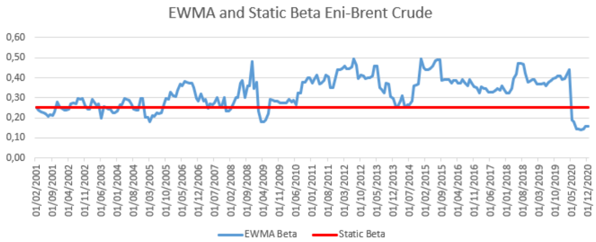


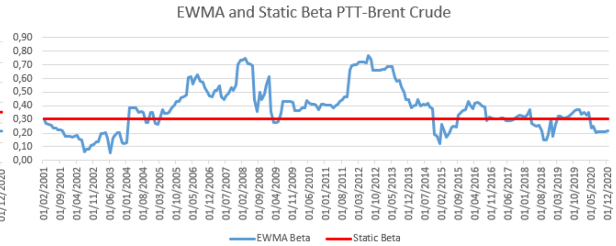


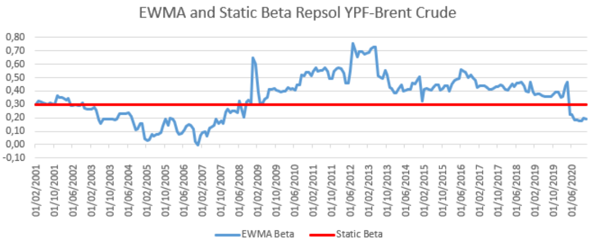


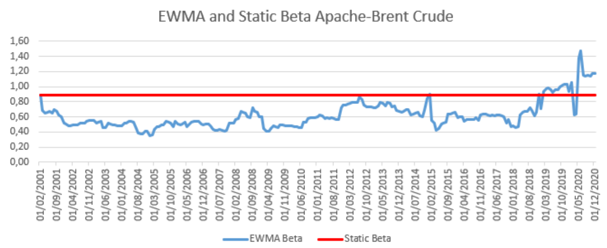


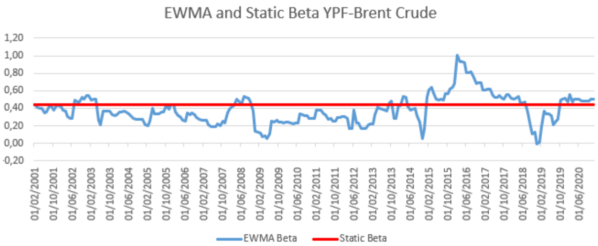




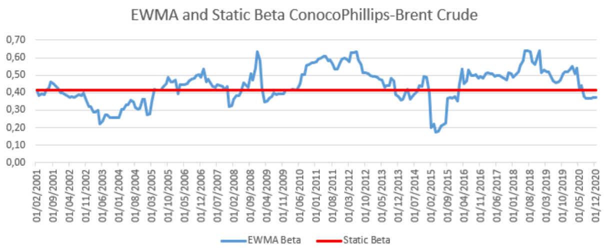


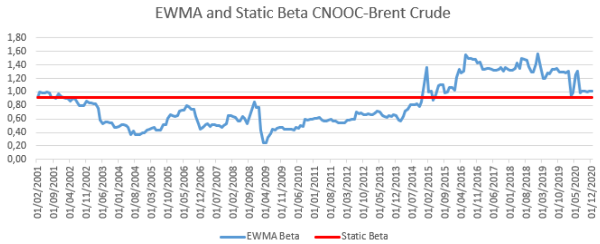


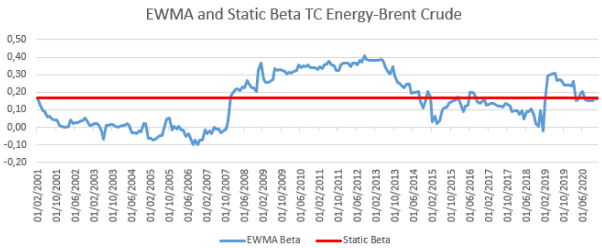


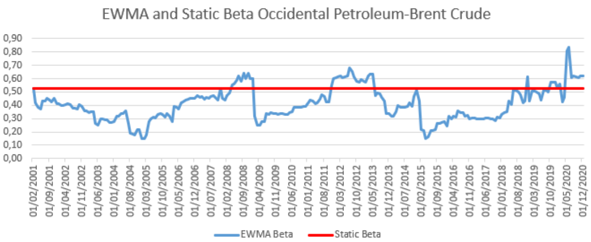


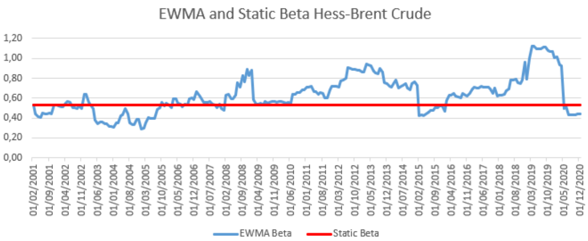
Upstream companies:



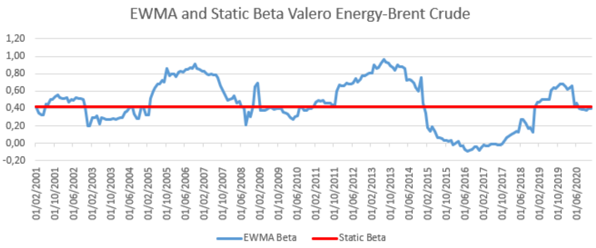


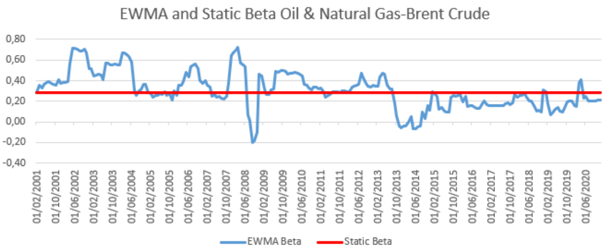


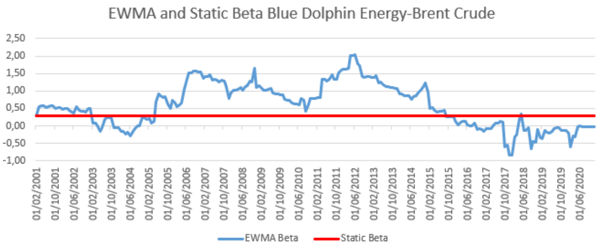


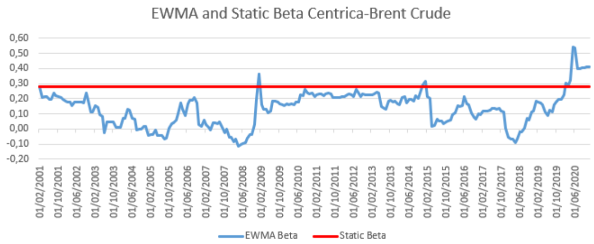


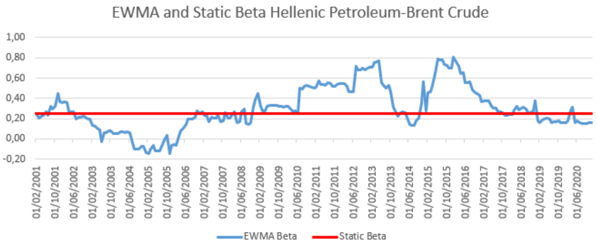
Downstream companies:







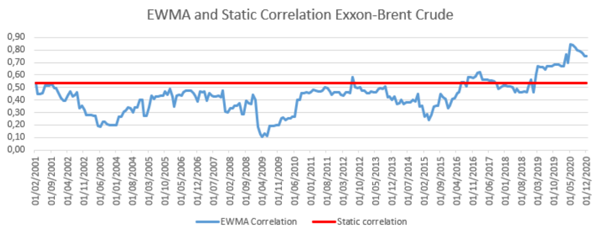


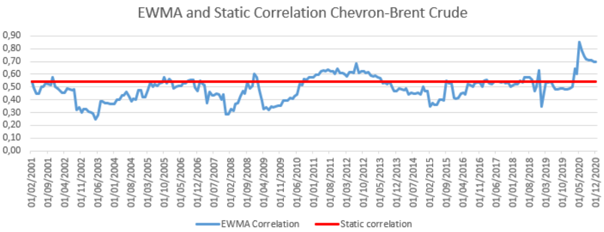


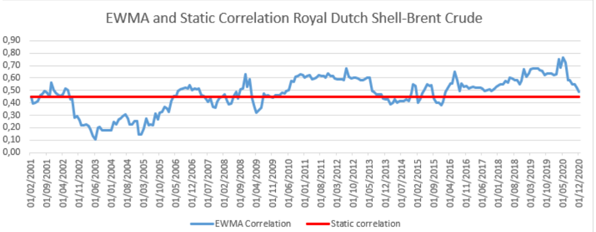
10.5 Static and EWMA correlation graphs

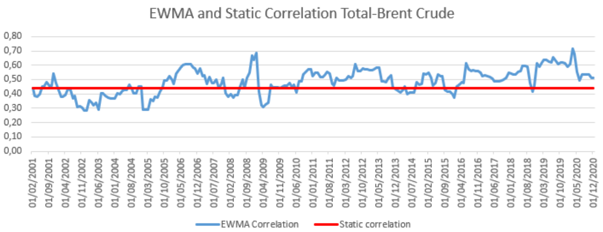
Static and EWMA correlation for integrated- upstream- and downstream companies Jan 2001 to Dec 2020.

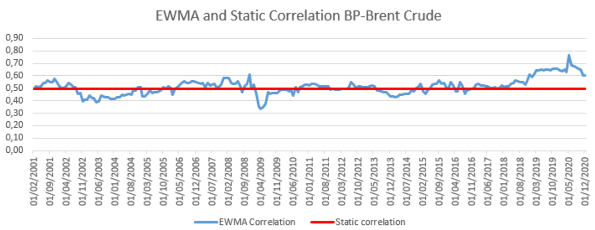
Integrated companies:

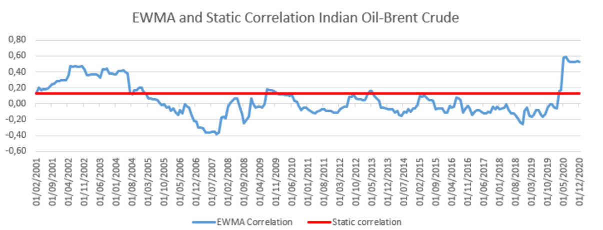


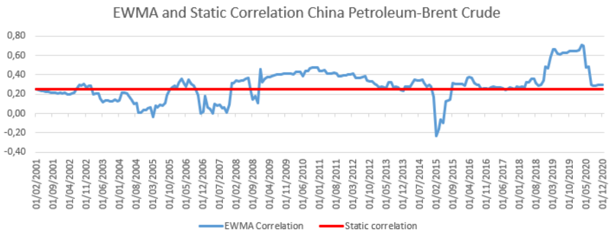


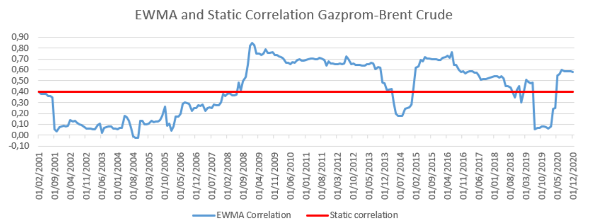


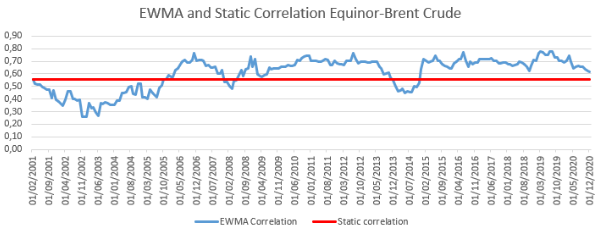


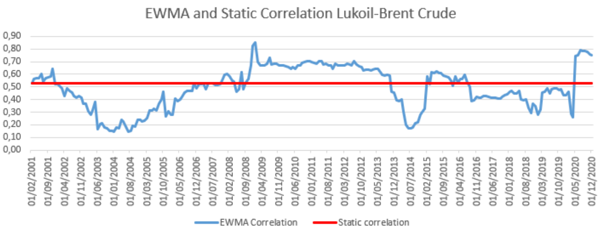


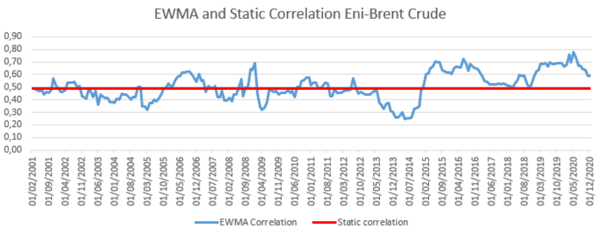


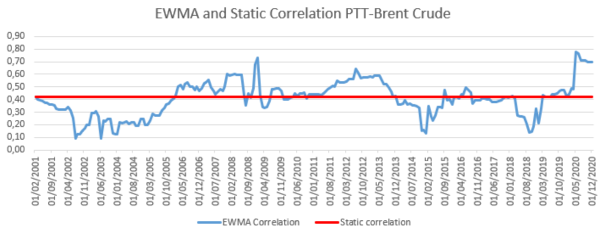


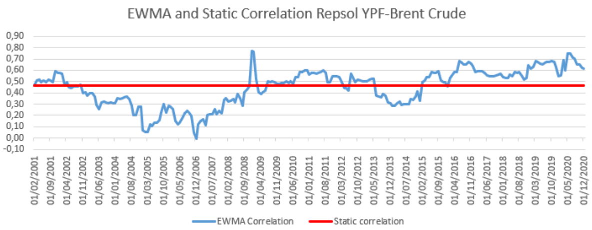


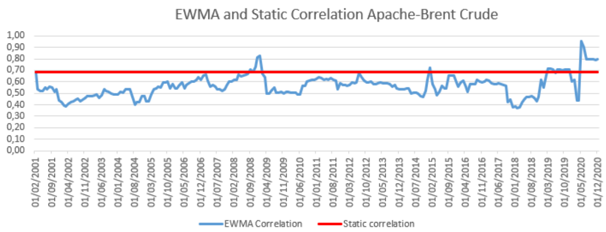


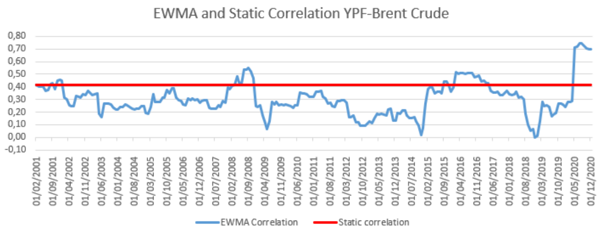




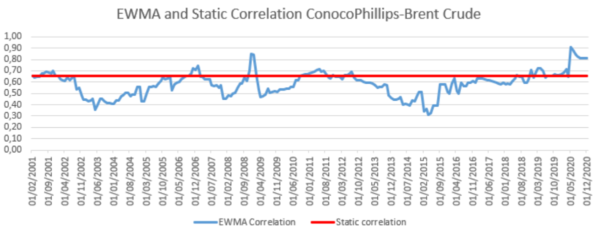


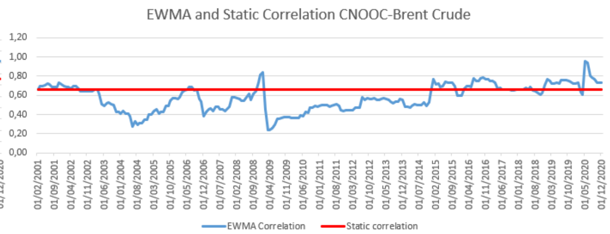


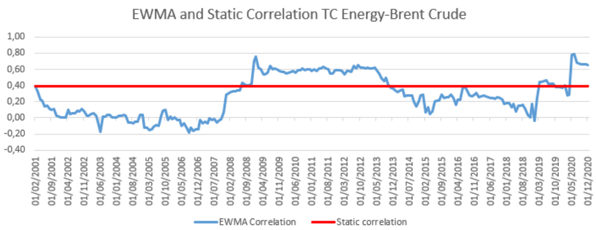


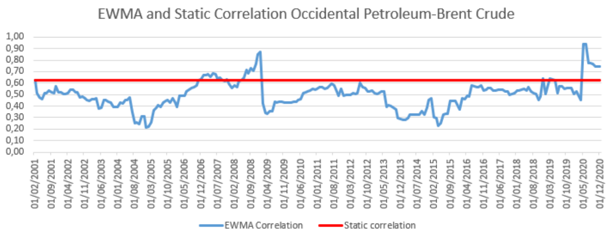


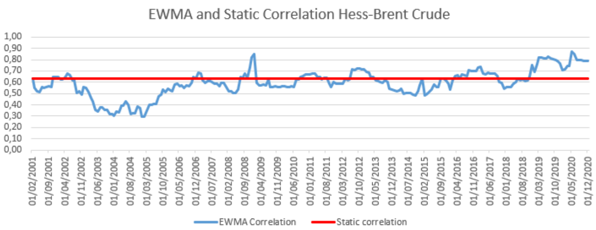
Upstream companies:



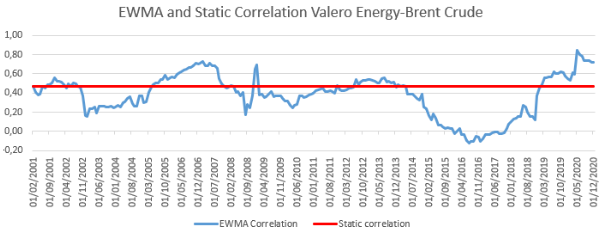


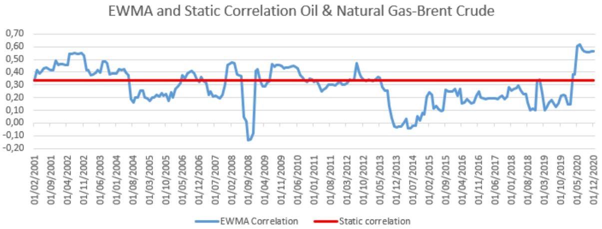


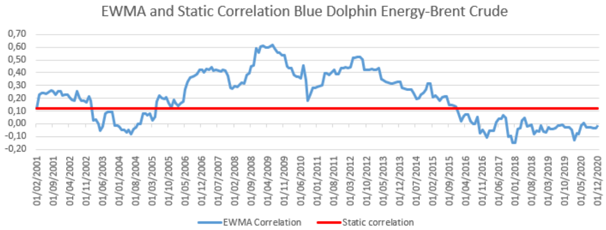


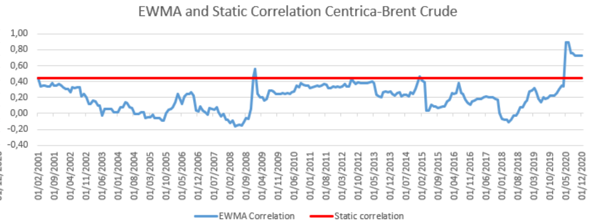


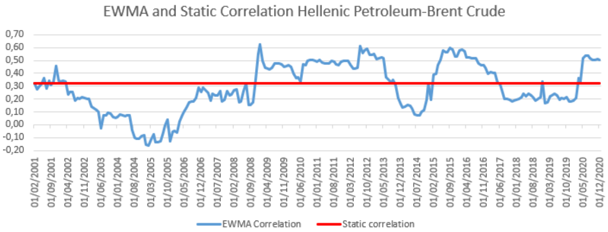
Downstream companies:







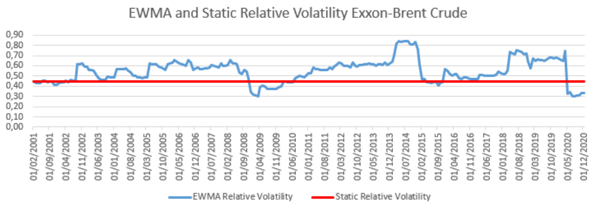


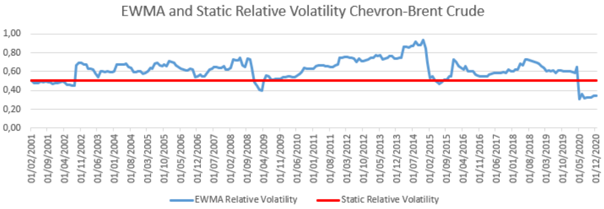


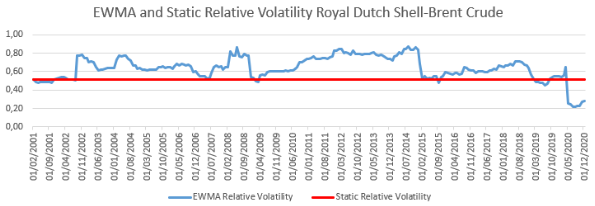
10.6 Static and EWMA relative volatility graphs

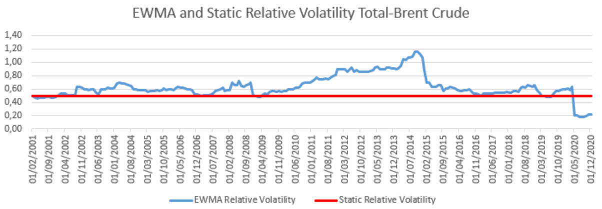
Static and EWMA relative volatility for integrated- upstream- and downstream companies Jan 2001 to Dec 2020.

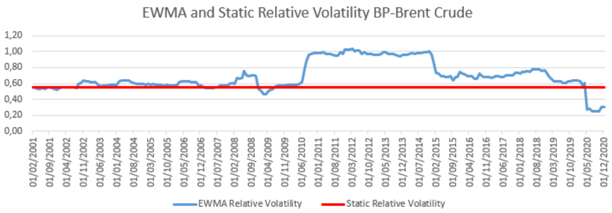
Integrated companies:

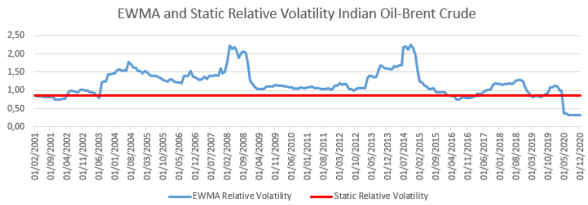


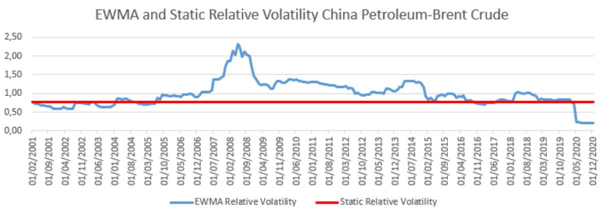


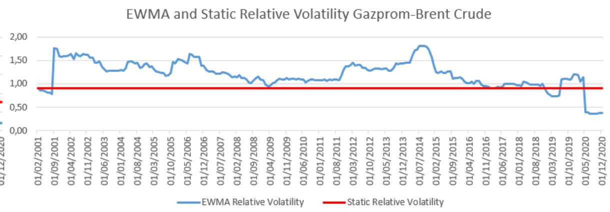


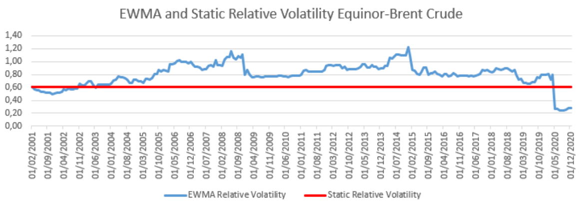


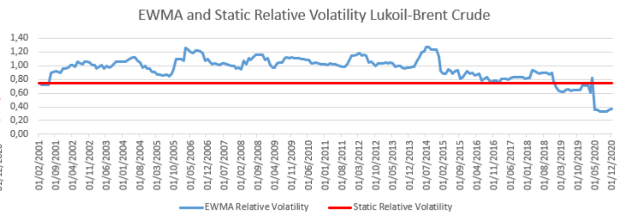


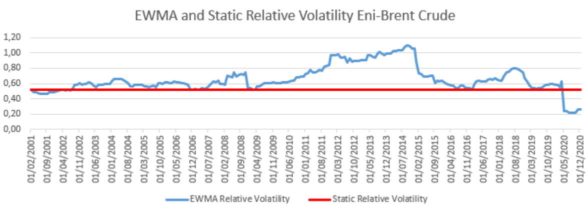


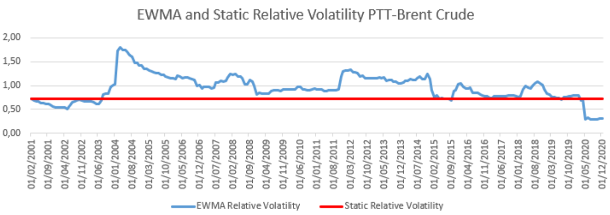


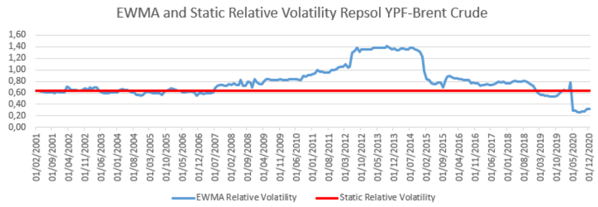


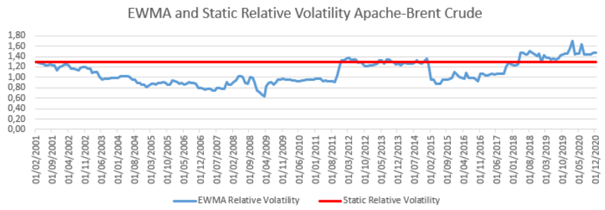


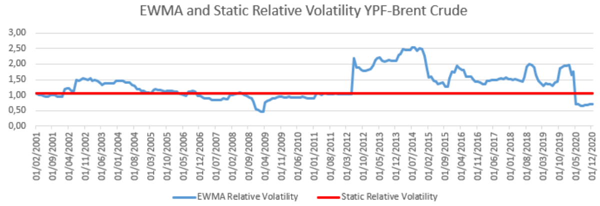




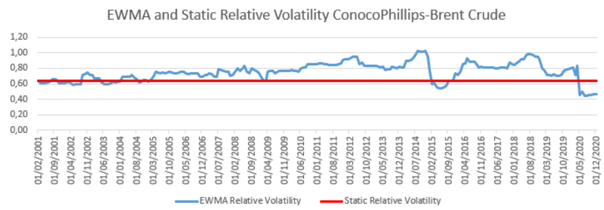


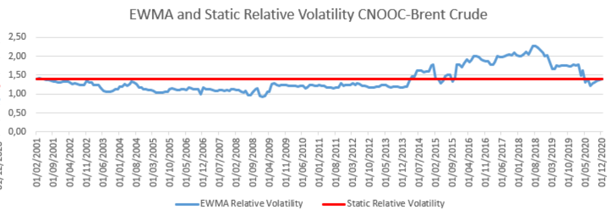


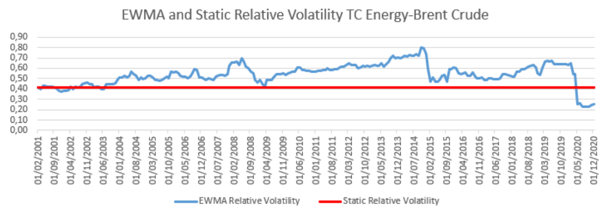


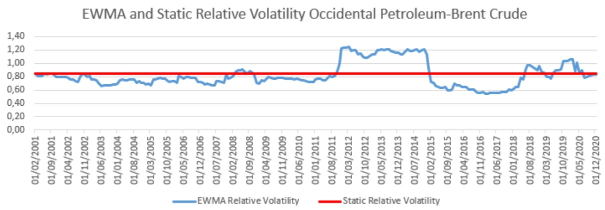


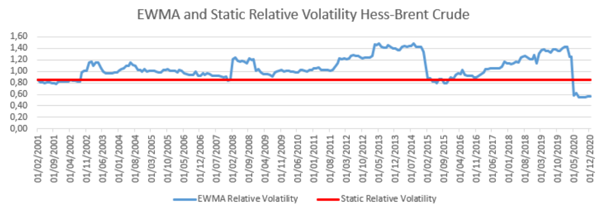
Upstream companies:



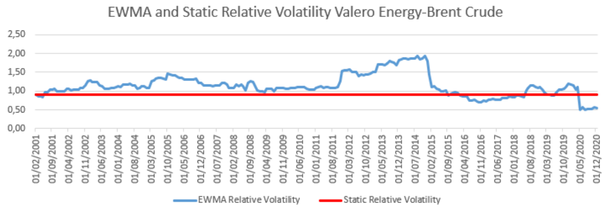


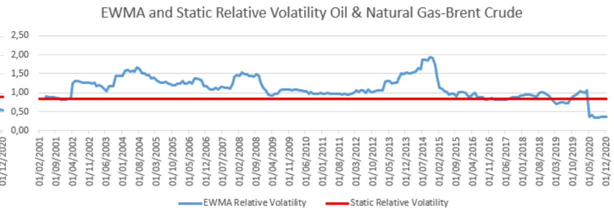


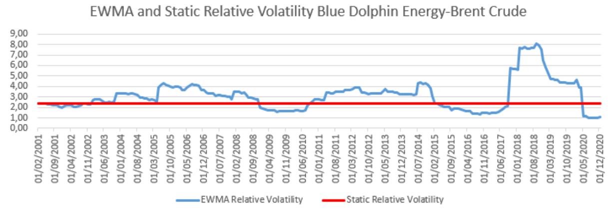


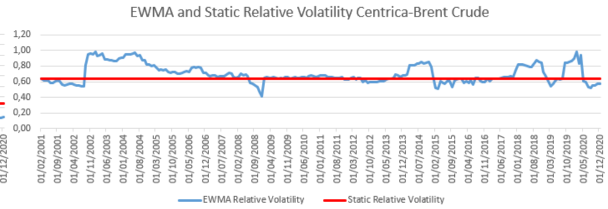


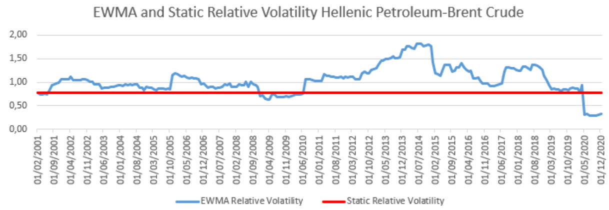
Downstream companies:











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