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ASSET VALUATION IN A LOW CARBON WORLD

- VALUE IMPLICATIONS OF OIL PRICE SCENARIOS FOR US OIL AND GAS ASSETS

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ABSTRACT

Scientists estimate that in order to contain global warming below 2°C, only around 900 $GtCO_2$, can be emitted between 2013 and 2050. Recent research shows that in order to meet this target, global demand for fossil fuels has to decline. In their 2014 report, The Carbon Tracker Initiative calculated that a global emission restriction in accordance with the 2-degree target would require a market price for oil that equals $75/bbl by 2050. This essay will examine the relationship between carbon emission restrictions, oil prices and asset values within the US oil and gas industry. By the means of a regression model, the impact of changes in oil prices on the S&P Oil and Gas Exploration and Production Price Index will be determined. These results will then be used in a scenario analysis, in order to investigate potential asset values under three different carbon emission scenarios.

KEY WORDS: Emission scenarios, oil price, risk analysis, demand effects, oil restrictions, 2-degree target, carbon budget, asset valuation

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1. INTRODUCTION

The aim of this essay is to provide an introduction to the research field of asset valuations for the oil and gas industry under different carbon emission scenarios. Greenhouse gas (GHG) emission scenarios are often used to make projections of future climate change. The concentrations of GHG emissions in the atmosphere have increased since 1750 due to human activity, leading to a rise in the global average temperature. (IPCC, 2013) The impact of this global temperature rise is what we commonly know as climate change. In order to prevent dangerous climate change, scientists believe that global warming needs to be contained below 2 degrees Celsius. (IPCC, 2007)

The global oil and gas industry is one of the worlds largest and most influential industries, and currently accounts for about 40% of global energy emissions. (IEA, 2013) In 2010 the world market for crude oil rose to a market value of over $2,100 billion. (Reportlinker, 2014) Systematic assessment of climate risk is a necessity in order to provide a reliable forward-looking analysis for both investors and policymakers, especially for such an important investment sector. However, there is limited knowledge of the potential consequences of different emission scenarios for the oil and gas industry. One needs to consider the possibility that future industry performance will not replicate the past. Political, technological and social factors are shaping and reshaping the world that we live in, and there is no telling what the future oil demand and price will be.

1.1 MOTIVATION OF TOPIC

There are very few scientific studies investigating the implications of different carbon emission scenarios. One of these future projections is the 2-degree scenario, based on a global climate target unanimously adopted by the United Nations. This area of research is particularly topical in the midst of the coming United Nations Climate Negotiations, COP21, in Paris 2015. At this conference, the world's leaders will potentially adopt a global, legally binding climate treaty for political actions to be taken post 2020 to lead the way towards a 2-degree scenario.

Previous research is limited and mainly focuses on value at risk in a future with stranded assets (resulting from unburnable coal resources in restricted carbon emission scenarios) for the oil and gas industry. Attempts have also been done to assess the price sensitivity of specific projects within both the oil and coal industry. This essay hopes to fill a gap in the research by combining previously used methods, in order to comprise a study of the potential effects of emission restrictions on oil prices, and the value of oil and gas assets.

It is important to investigate the relationship between oil prices and asset value within the oil and gas industry to fully grasp the potential implications of a future global emission restriction. This information needs to be fully accessible for investors and stakeholders, as well as for politicians and officials negotiating and implementing our global climate targets.

In order to tackle this highly complex area, we have decided to limit the scope of this essay and look solely at the US oil and gas industry – specifically the S&P 500 oil and gas exploration & production index SP5SOGE. In the following regressions and analysis, our dependent variable will thus be referred to as SP5SOGE.

1.2 MAIN OBJECTIVES

A. To examine the impact of oil prices on asset values within the US oil and gas industry.

B. To use this coefficient to investigate the potential financial implications for these assets of three different oil prices, in accordance with the chosen emission scenarios.

1.3 METHOD

By the means of an econometric regression model, this essay will investigate the significance of Brent oil prices on the value of SP5SOGE. The estimated variables will later be used in a scenario analysis, in order to project the value of SP5SOGE under three potential Brent oil prices. These prices are estimates of future Brent oil prices in 2050, each related to different carbon emission scenarios. The scenario analysis will be based on results from the regression model, with values from 2013. By doing so we will provide an estimate of what the value of SP5SOGE could be in 2050, depending on which emission path the world chooses to follow.

1.4 STRUCTURE

This essay will begin with an introduction to the concept of emission scenarios in section 2, mapping the connection between emission restrictions, demand effects and oil price implications. Section 3 will display the different emission scenarios and corresponding oil prices that will later be used in the scenario analysis. The following section will provide the reader with an overlook of previous research in this area. Section 5 will explain the methodologies used in this essay. The subsequent sections will contain an overview of our results, followed by a discussion of the potential implications of these. Section 9 will depict the main findings and conclusions. The final section covers recommendations for future research.

2. EMISSION SCENARIOS AND IMPLICATIONS

2.1 THE TWO-DEGREE TARGET

The main objective of the UN Framework Convention on Climate Change (UNFCCC) is to stabilize greenhouse gas (GHG) concentrations in the atmosphere "at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992). The exact meanings of this statement were under debate for over a decade.

The scientific community, as represented by the Intergovernmental Panel on Climate Change (IPCC), determined that global warming needs to be contained below an average rise in temperature of 2 degrees Celsius above pre-industrial levels, to prevent dangerous climate change. This corresponds to a concentration of GHG gases in the atmosphere of around 450 parts per million of CO_2. (In 2013 the global CO_2, concentration broke the milestone level and reached its highest level yet at 400ppm). (Carrington, 2013; Scripps Institution of Oceanography, NOAA, 2013) These conclusions were presented in the fourth assessment report of IPCC. (IPCC, 2007) In 2010 the convention adopted the 2-degree target as a part of the Cancuun Agreement, and agreed upon the need for urgent action to meet this goal. (UNFCC, 2010)

In their annual World Energy Outlook projections, the International Energy Agency (IEA) presents the "450ppm scenario", a scenario for future energy development that is consistent with the 2-degree target. (IEA, 2014) This will hence be referred to as the 2-degree scenario, 2DS, and used as one of our main scenarios to investigate the potential implications of a low-emission future.

According to the IEA, 40% of global carbon emissions are accounted for by oil. (IEA, 2013) The global carbon budget estimated by the Grantham Research Institute on Climate Change at LSE for 2013-2050 amounts to around 900GtCO_2, which leaves 360GtCO_2 for the oil industry. This carbon budget would give an 80% probability of limiting global warming to 2 degrees Celsius. (CTI, 2013)

2.2 DEMAND AND SUPPLY EFFECTS

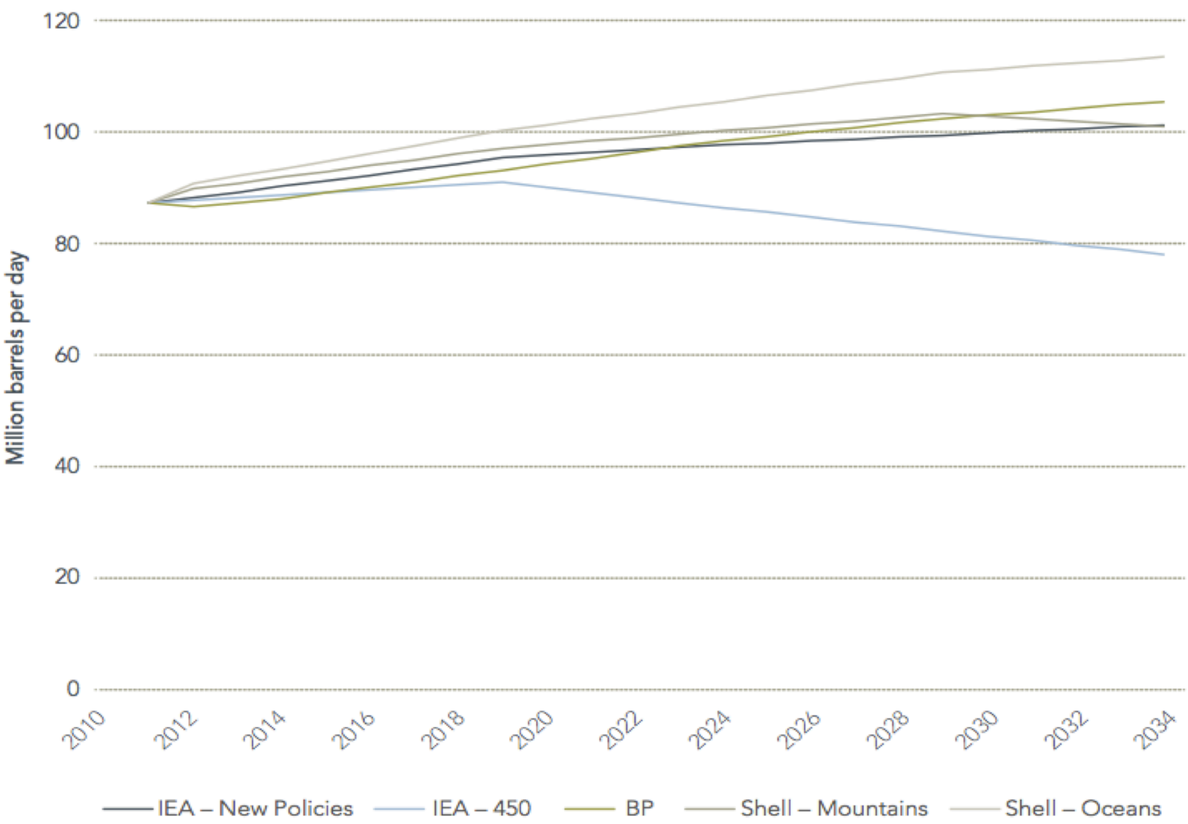
Models assuming continuous demand-growth for oil are often seen as a safe sign of future prosperity, and used to justify investments in the oil sector. However, according to IEA's 450 ppm scenario, oil consumption will not follow the previous theories of demand growth. Instead this scenario will incorporate an oil peak, which is followed by a decline in oil consumption.

Some oil and gas companies produce their own demand forecasts. Three of these (one from BP and two from Shell) are plotted in Figure 1. All of these scenarios project a steadily rising demand for oil, with the Shell Oceans scenario showing the highest predicted growth rate. Underlying assumptions often include continuous economic growth in the BRIC countries (Brazil, Russia, India and China), global population growth and increased access to unconventional oil types. (BP, 2014; Shell, 2013)

Standard economic theory provides an important framework for the following analysis. When analyzing demand effects for oil, it is important to keep in mind that crude oil is traded on an international market. If countries were to introduce a tax on carbon emissions or some sort of carbon emissions quota, economic theory tells us that the price facing consumers in that country will rise.

This would likely lead to a decrease in the trading volume of oil. Furthermore, this increase in price could give incentives for faster innovation regarding energy substitutes, which would reduce demand for oil at any given price.

Figure 1: Oil demand scenarios



SOURCE: Carbon Tracker Initiative, 2014

If many countries were to introduce oil restrictions, merchants on the world market for oil (acting as intermediaries in international oil trade) will not be able to sell as much oil to these markets. This means that the demand for oil at any given price, or price equivalent, would decrease.

In an economy with the IEA's low-carbon scenario, oil demand can be reduced fairly quickly provided cost-effective technologies being available to improve energy efficiency, especially within the transport sector. The oil intensity of production, measured as total oil consumption per unit of output, has declined throughout the last decades. This can be seen as the result of a range of factors, including more efficient use of oil, fuel-saving technological progress, and a shift in production towards less oil intensive sectors. (CTI, 2014; OECD, 2004; OECD 2014)

Other assumptions behind the decreasing demand projections are technological advances in the production and exploitation of alternative energy sources (e.g. solar, wind, biomass, tidal), and political decisions limiting economic access to resources. Examples of such policies include the use of quotas, carbon pricing, and other restrictive regulations.

Furthermore, the discovery and exploitation of unconventional oil types have contributed to an oil production capacity that is currently growing at such a high rate that supply might outpace consumption, especially in a scenario with global carbon emission restrictions. (HSBC 2013, CTI, 2014) However, it is important to remember that markets do not change overnight, and the demand for oil will not abruptly be switched off.

Comparing the oil companies projected scenarios with the IEA's 450ppm scenario (Figure 1) reveals major discrepancies between the projections. If continuously rising demand is not the case, we have to understand what impact this has on industry business models. And more importantly what impact this has on shareholders investments.

2.3 OIL PRICE IMPLICATIONS

Basic economic theory tells us that a decreasing demand tends to lead to a lower price. Decreasing demand for crude oil would therefor cause a downward pressure on oil prices. We have recently seen this happen during the economic crisis of 2008, where weakened demand lead to a plummet in oil prices reaching $39/bbl by January 2009. (Datastream Professional)

Worth mentioning is the unique configuration of the oil market. The Organization of Petroleum Exporting Countries, more commonly known as OPEC, is a producer cartel with a track record of trying to regulate prices and production within the industry. This situation further complicates the issue of price estimation within the oil and gas industry. Apart from other market factors, analysts also need to consider the potential reactions of OPEC. A weak market, in accordance with a lower oil demand scenario, would likely put pressure on OPEC to let oil prices fall in order to keep its market share. (HSBC, 2013)

Oil price sensitivity is an important indicator to comprehend. A lower oil price resulting from decreased demand would mean a great risk of loss of value within the sector. This uncertainty could cause a reduction in trend investment activity, which in turn could have a negative impact on industry profitability. (HSBC, 2013)

Economic theory shows a connection between demand, supply and price that most of us are already familiar with. In accordance with theory, the estimated oil price can suitably be seen as a representation of the carbon budget, as will be further explained in subsequent sections. On this basis the following analysis will be conducted using potential Brent oil prices as a representative variable for different emission scenarios.

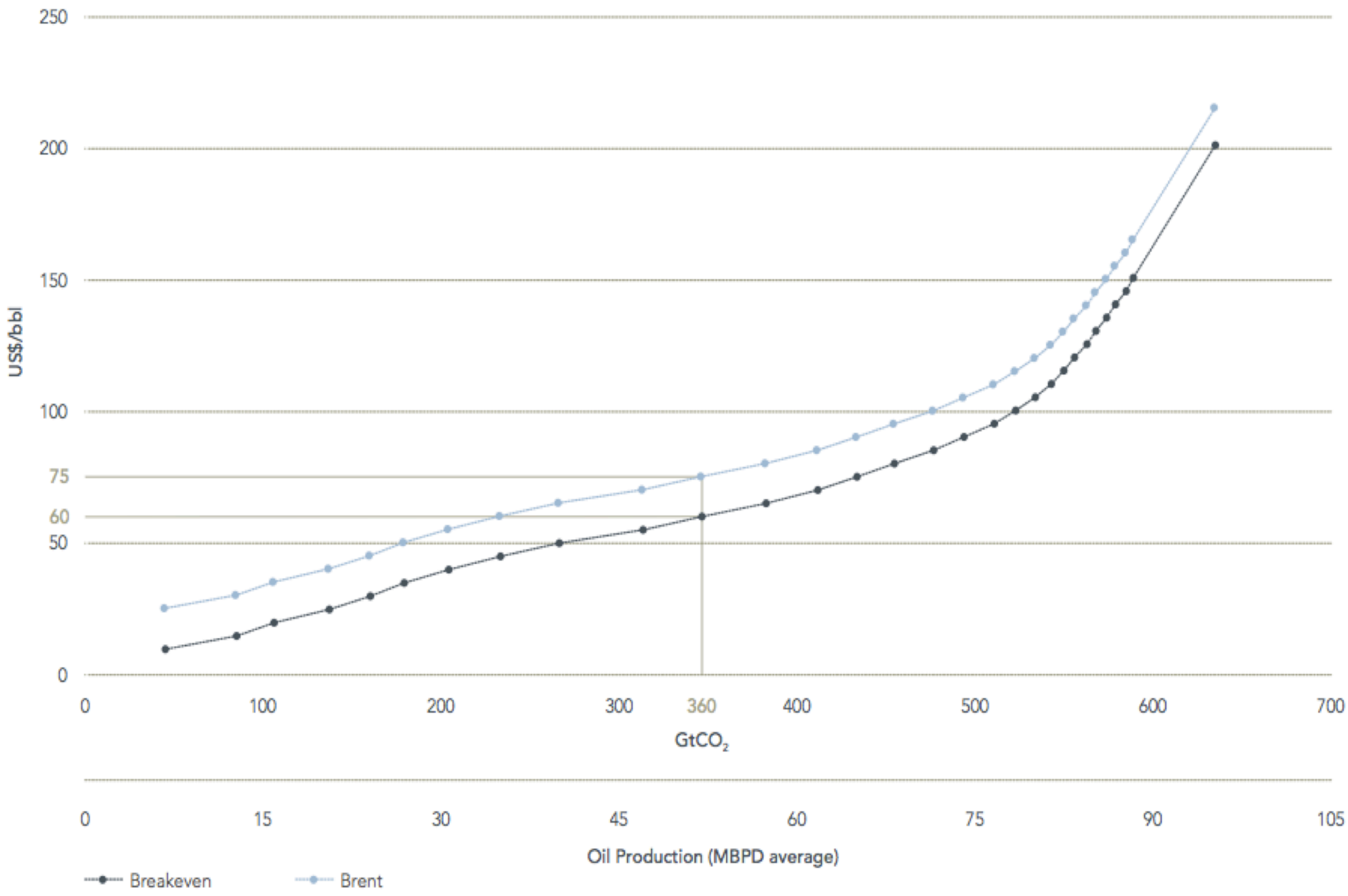
2.4 SUMMARY

A deviation from conventional assumptions of ever-growing production and consumption of crude oil naturally has severe implications. A future scenario of restricted GHG emissions in accordance with the 2-degree target would require a decreasing use of oil, as portrayed by the IEA-450 scenario in Figure 1. Based on standard economic theory and market specific characteristics of the oil and gas industry, there is reason to believe that this decrease in demand would correspond to a lower future Brent oil price.

3. EMISSION SCENARIOS AND CORRESPONDING OIL PRICES

As always when looking into the future, there is a high level of uncertainty behind the projected scenarios. No one knows what energy policies will be implemented, nor which technologies that will be available. As a result, nobody can tell for sure what the Brent oil price will be in 2050. In order to capture this ambiguity, this essay will stress test the asset value of SP5SOGE against Brent oil prices corresponding to three different emission scenarios, 2DS included.

Figure 2: Carbon cost curve of oil production



SOURCE: Carbon Tracker Initiative, 2014

3.1 2DS

If the global carbon budget were to be followed, this level of emissions would correspond to a breakeven price of about $60/bbl (figure2). This in turn matches up to a Brent price of $75/bbl, when market contingency is accounted for.

3.2 LOW DEMAND FUTURE

During the last decade we have seen the Brent oil price fall below $50/bbl both in 2004, and again in 2008/9. This price has been used as a floor value in previous stress tests of fossil fuel assets (HSBC, 2013; CTI, 2014). With this information at hand it seems reasonable to stress test our US oil and gas index against oil prices that range from $50/bbl, up to a maximum projected price level.

3.3 BUSINESS AS USUAL

The highest point on the Carbon Cost Curve of Oil Production (Figure 2) is 635GtCO_2. This number represents the total potential production up to 2050 of liquids (oil, condensates and natural gas liquids) by listed oil and gas companies, based on data obtained from The Rystad UCube Database. (CTI, 2014) As seen on the graph, this level of production corresponds to a required Brent oil price of $215/bbl.

Many of the projects included in the potential production are within the area of unconventional oil types, extracted using other methods than conventional oil wells. Examples of such techniques include extra heavy oil, shale oil, oil sands and coal-based liquid supplies. (IEA, 2011) These projects have a higher production cost, and therefor require a higher Brent oil price. In order to be profitable, the 635GtCO_2, scenario entails a growing demand for oil. This projection is further supported by the IEA, which also projects rising energy demand and oil prices for future decades, ceteris paribus (World Energy Outlook, 2014). On this basis, our business as usual scenario will be represented by a $215/bbl Brent oil price.

4. PREVIOUS RESEARCH

Reviewing previous research is interesting for several reasons, one prominent reason being to enable comparison between our results and other research papers. This paper focuses on the US oil and gas market index SP5SOGE, and how an eventual carbon budget would affect oil prices and our chosen index.

Seeing as this is a fairly new research area, and the amount of previous research is very limited, we find it highly relevant to also include studies that are looking at the coal market. These studies share the denominator of looking at how an eventual carbon budget would affect chosen markets within the fossil fuel sector. For an overview we refer to table 1.

One of the earlier studies in this area was made by the British multinational banking and financial services company HSBC. The first report "Oil and Carbon – counting the cost" was published in 2008 and investigated how the oil industry were to be affected by carbon pricing under three scenarios.

The paper took base in a scenario analysis in which the European majors' potential cost of carbon was estimated. The results suggest that companies with higher exposure to carbon-intensive operations are the most likely to be put in a competitive disadvantage. This occurs under a combination of a global system-scenario and life-of-company emission approach. A carbon price of $40/ton of CO_2, equivalent emissions was used and this would implicate a significant cost for the European majors.

This paper was revisited by HSBC in 2013 with the report "Oil & Carbon Revisited, Value at Risk from 'Unburnable' Reserves". As the title suggests, the new report focuses on the Value at Risk that these European majors now faced compared to the previous method of estimating the potential cost of carbon. These time ceiling tests were used to assess the Value at Risk of the companies' future projects. The results showed an oil and gas volume at risk ranging between under 1 % for the company BG group and up to 25 % for BP.

HSBC has not only done studies looking at the oil and gas market, but also on the coal market. In their 2012 study "Coal & Carbon – Stranded Assets: Assessing the Risk" the strategic risks for UK mining majors of post-2020 carbon constraints were assessed. Three different demand scenarios were used in DCF valuation assessments on "general index".

Carbon Tracker Initiative refer to themselves as a non-profit organization working to "align the capital markets with the climate change policy agenda". (CarbonTracker, 2014) The research framework of Carbon Tracker has, as well as HSBC, conducted several studies in our chosen area of study. One study of particular importance in regards to our work is their 2014 study of "Carbon supply cost curves: Evaluating financial risks to oil capital expenditures". The potential financial implications of lower demand, price and emission scenarios are investigated with different barrel prices associated with the respective scenarios.

Additional relevant studies from Carbon Tracker are the 2012 study of ”Unburnable Carbon – Are the world's financial markets carrying a carbon bubble?” and the 2013 study of “Unburnable Carbon 2013: Wasted Capital and Stranded Assets”. These reports investigate how the financial markets are aligned with the carbon budget associated to the 2-degree target, and the potential implications of a global Carbon budget.

Lombardi & Ravazzolo (2012) study the correlation between oil and equity prices, and to which extent they can be exploited for asset allocation in their report “Oil price density forecasts: exploring the linkages with stock markets”. The findings of this study suggest that joint modeling of oil and equity prices produce an enhanced point- and density forecast, which results in great portfolio wealth benefits.

Another approach was taken by Lee & Ellis (2013) in “Canada's Carbon Liabilities, The implications of Stranded Fossil Fuel Assets for Financial Markets and Pension Funds”. The implications of Canada's carbon intensity in financial markets were assessed, with focus being on pension funds. The results suggested an estimated amount of $844 billion in carbon liabilities, which is more than 2,5 times their market capitalization.

Matsumura et al (2013) examine the impact of carbon emissions and voluntary disclosure of carbon emissions in the US, and how this affects the American companies. The results of their study were released in the form of a report named “Firm Value Effects of Carbon Emissions and Carbon Disclosures”. Their findings show that for each additional 1000MT of carbon emissions, firm value decreases with an average of $212 000 for sample firms. This points toward an existing market-value penalty associated with carbon emissions.

Table 1: Previous studies within the area

REPORT	OBJECTIVE	METHOD	CONCLUSION
"Unburnable Carbon – Are the world's financial markets carrying a carbon bubble?" *Carbon Tracker Initiative (2012)*	- To investigate how the world's financial markets are aligned with the carbon budget related to the 2-degree target. - To assess potential systemic climate change risks.	Compilation of previous research to give an overview of the current situation, proceeding to a comparison of carbon budget to proven reserves.	To stay within the carbon budget, not all listed reserves can be exploited and burned. The imposition of a global carbon constraint would act as a de facto reduction in demand, which could lead to a reduction in the value of fossil fuel assets.
"Unburnable Carbon 2013: Wasted capital and stranded assets" *Carbon Tracker Initiative (2013)*	- To analyze the potential implications of a global carbon budget. - To examine carbon budgets related to alternative climate targets.	Stress-testing different carbon budgets.	Available carbon budget for an 80% probability of staying under 2 degrees is 900 $GtCO_2$, and for 50% probability 1075 $GtCO_2$. This confirms that the larger part of fossil fuels will remain unburnable.
"Carbon Supply Cost Curves: Evaluating financial risks to oil capital expenditures" *Carbon Tracker Initiative (2014)*	- To investigate potential financial implications of lower demand, price and emission scenarios.	Risk analysis of oil price sensitivity for a range of projects within the oil industry.	In the 2-degree scenario, marginal production above $60 B/E price (required market price of $75/bbl) cannot be produced. Companies with high proportion of future in high-cost potential production are exposed to cost increases and price falls. Smaller operations may not have the financial strength to survive lower demand/price scenarios.
"Oil & Carbon - Counting the cost" *HSBC (2008)*	- To investigate how the oil industry could be affected by carbon pricing under three different scenarios.	Scenario analysis to investigate the European majors' potential cost of carbon.	A carbon price of $40/ton of CO_2 equivalent would mean a significant cost for the European majors. The most severe impact would come from a combination of a global system-scenario, based on life-of-company emissions. Companies with exposure to carbon-intensive operations will likely be put at a competitive disadvantage.
"Coal & Carbon - Stranded Assets: Assessing the risk" *HSBC (2012)*	- To assess the strategic risks of post-2020 carbon constraints for stock valuation, looking specifically at the UK mining majors.	DCF valuation assessment on "general index" (compiled of the four biggest UK mining companies) for three demand scenarios.	A declining coal demand could impact coal asset valuations by up to 44%. Impact on UK major miners could average -7% under the most extreme demand scenario, with a top value of -15% for coal-heavy miners.

"Oil & Carbon Revisited: Value at risk from 'unburnable' reserves." *HSBC (2013)*	- To investigate how a low-carbon world would affect European oils.	Ceiling tests to assess value at risk of European majors' future projects.	Oil and gas volumes at risk range between under 1 % for the BG group and up to 25 % for BP. The value of reserves at risk is lower due to being largely undeveloped.
"Global High-Impact Risks for Banking & Investment: Navigating disruptive change." *Robins, N (2013)*	- To examine at the transition to a low-carbon resilient economy, and how this should be made.	Referring to previous HSBC studies and complementing them with estimating new factors driving low-carbon development.	Seven ideas for the next decade to shift capital markets by 2 degrees Celsius. This will be done by alterations to the financial regulation, financial stability, financial incentives, financial support, capital stewardship, financial disclosure and finally performance targets.
"Carbon Avoidance: Accounting for the emissions hidden in reserves." *ACCA & Carbon Tracker (2013)*	- To investigate existing reporting standards managing company disclosures. - To explore the necessary steps to incorporate future climate change risks into disclosures.	Comparing different markets' reporting requirements.	The existing framework within the fossil fuel sector would have difficulties recognizing warning signals. The need for becoming more climate literate is essential for markets. Investors need improved information regarding fossil fuel reserves to understand their climate risk exposure.
"Canada's Carbon Liabilities: The implications of stranded fossil fuel assets for financial markets and pension funds." *Lee & Ellis (2013)*	- To assess the consequences of Canada's carbon bubble on the financial markets, with focus on pension funds.	Developing a database of 114 operating fossil fuel companies with an estimated amount of their carbon liabilities.	Canada has an estimated amount of $844 billion in carbon liabilities, which represents more than twice the assets of included companies, and more than 2,5 times of their market cap.
"Firm Value Effects of Carbon Emissions and Carbon Disclosures." *Matsumura et al (2013)*	- To examine the impact of carbon emissions and voluntary disclosure of carbon emissions in the US, and how this affects American companies.	Regression analysis to determine the relationship between carbon emissions and firm value, and to estimate firm-value effects. Propensity score matching and doubly robust regression to estimate effects of voluntary carbon disclosure.	For each additional 1000MT of carbon emissions, firm value decreased with an average of $212 000 for sample firms. This indicates an existing market-value penalty associated with carbon emissions. The median market value of US firms voluntarily disclosing their carbon emissions is approximately $2.3 billion higher than that of non-disclosing firms.
"Oil Price Density Forecasts: Exploring the linkages with stock markets." *Lombardi & Ravazzolo (2012)*	- To investigate the extent to which correlations between oil and equity prices can be exploited for asset allocation.	Development of a time-varying Bayesian dynamic conditional correlation model for volatilities and correlations.	The findings suggest that the joint modeling of oil and equity prices produce an enhanced point and density forecast for oil. This results in great benefits in portfolio wealth.

5. METHOD

5.1 SAMPLE AND DATA

The time series analysis has sampled monthly data from the period of 1992-01 to 2013-12. Data for all the variables used in the regression has been collected from the database Datastream Professional, by Thomson Reuters and can be found in the Appendix.

For the purpose of this study we have chosen S&P Oil and Gas Exploration and Production Price Index (SP5SOGE) as our dependent variable. This index was chosen after a thorough comparison with other indices of similar sorts, for example the United States Oil & Gas Index (D1US01$) and the North American Oil & Gas Production Index (F3NAOG$). SP5SOGE includes several larger oil and gas companies that were not included in the other indices. We also found that the chosen index includes an overall larger number of companies. Furthermore, the SP5SOGE Index contains data for a longer time period. The combination of the above-mentioned factors enables a regression analysis with more prominent results.

We expect the oil price (denoted OIL BRENT in the following equations) to have a significant positive impact on the SP5SOGE Index. We anticipate that a rise in oil price should lead to an increase in asset values within the oil and gas market.

Seeing as the chosen dependent variable is a US based index, prevailing conditions on the US stock market are likely to influence the asset value of the same. We have therefor chosen to include a control variable representing the overall US stock market, Standard & Poor's 500. This is a market value weighted index based on the 500 largest NYSE or NASDAQ listed companies. It is seen as one of the leading indicators of the US equities, and commonly used as a benchmark for the US stock market. (Investopedia, 2014) S&P 500 (in our calculations referred to as S_P COMP) should also have a significant positive relationship with the independent variable, as they are both S&P indices with several similarities. This observation also suggests a probable correlation between the two variables, which could prove problematic from an econometric perspective. After careful consideration of possible implication, the value of including S_P COMP as a control variable was deemed to outweigh the risks of complications resulting from eventual correlation.

Market interest rates are usually considered important indicators for the economic conditions of different national markets. If the interest rate falls, this usually functions as a stimulus for the asset value of domestic industries. On this basis, we have chosen to include the US 3 month Treasury bill (denoted US TBILL) as a control variable in our baseline regression model. An increased domestic interest rate would likely lead to decreased demand for oil and gas on the same market, and is thus expected to have a negative impact on the asset value of SP5SOGE.

The initial model also contained US GDP as a control variable. Domestic GDP is commonly known as a benchmark for national welfare, and can be seen as an indicator of the wellbeing of a nation's economy. However, we later chose to substitute US GDP with the US confidence Index (referred to as US INDCONQ). We found that controlling for future expectations was more relevant, seeing as our analysis focuses on the US stock market, which in general tends to be more future-oriented. If the expectations of the future for stock investments becomes more positive, the demand and the economy tends to follow, thus likely leading to higher demand for oil and gas. We therefor expect a positive impact of US INDCONQ on SP5SOGE.

In our baseline model, we also chose to include the US Consumer Price Index (US CPI) as a control variable. Economic theory commonly assumes that an increase in the Brent oil price would correspond to an increased rate of inflation. Seeing as OILBRENT is expected to have a positive impact on SP5SOGE, we assume that US CPI will follow a similar path. However, the exact nature of the relationship between US CPI and SP5SOGE is difficult to determine and to analyze.

Table 2: Expected impact of variables

VARIABLE	EFFECT	SOURCE
OILBRENT	+	Datastream
S_P COMP	+	Datastream
US TBILL	-	Datastream
US INDCONQ	+	Datastream
US CPI	+	Datastream

5.2 MAIN MODEL ESTIMATION

The regression model we will use is presented below as equation 1. We will look at the relative percentage change in the asset value of SP5SOGE, to determine the impact of relative percentage changes in oil price.

$$\Delta\ (\text{SP5SOGE}) = \alpha + \beta_1\Delta\ (OILBRENT) + \beta_2\Delta\ (S\_P\ COMP) + \beta_3\Delta\ (US\ TBILL) + \beta_4\Delta\ (US\ INDCONQ) + \beta_5\Delta\ (US\ CPI) + \varepsilon \qquad (1)$$

We initially intended to use a log-log version of the above-mentioned model, to handle an eventual situation with a non-linear relationship between our dependent variable and the independent variables. The meaning of this was to preserve the linear model while making the effective relationship non-linear.

As both our dependent variable and some of our independent variables were log-transformed variables, the interpretation would be a combination of that of linear-log and log-linear models. This means that a percentage change in Y (SP5SOGE) would be expected when our independent variables increased by some percentage. This relationship, when both dependent and independent variables have been log-transformed, is referred to as elastic. By consequence, the coefficients of log X would represent elasticities, defined as the proportional change in X for a given proportional change in our dependent variable. (Dougherty 2011, p.196f) The results from this version of the baseline regression model will be portrayed in section 6, under the subheading "Alternative regressions".

For our main model, which will later be the basis of our scenario analysis, we decided to run the regression on standard, non-logarithmic, delta values for our variables. The reason for this is purely the intention of conducting a more straightforward analysis. With special concern to the scenario calculations, a linear, non-logarithmic regression allows us to use a simple equation, rendering an intuitive interpretation of our results. A log-log regression model based on a logarithmic dependent variable would oblige us to calculate the exponent of all values, in order to receive comprehensible results to later be used in our analysis.

5.3 NULL HYPOTHESIS

Our aim is to test if there is a significant effect of the Brent oil price on the asset value of SP5SOGE. This will be done by the means of a null hypothesis set up against an alternative hypothesis. The estimated regression coefficients deviation from zero will be tested to determine the nature of the relationship between the variables.

The formulation of the null hypothesis: $H_0 : \beta = 0$

Alternative hypothesis: $H_A : \beta \neq 0$

The hypothesis test will be made through a regular t-test with corresponding P values. Under the null hypothesis the P value stands for the probability of obtaining the observed effect. Therefore, a small P value points to the small likelihood of the observed relationship being arisen solely by chance. For that reason, a small P value indicates that the null hypothesis can be rejected. An obtained P value below 0.05 will be observed as statistically significant, and a value below 0.01 as highly significant. This will consequentially be the basis for evaluation also of the null hypothesizes used to test the specification of our chosen baseline regression model.

5.4 REGRESSION SPECIFICATION

The regression will be made using Ordinary Least Squares (OLS), an estimator that is considered optimal in the framework of a classical linear regression model (CLR model). This model consists of several basic assumptions related to the data generation process. There is no scientific consensus regarding the exact number and definition of these assumptions. Consequentially, we have chosen to assess the properties of our model on the basis of the regression model assumptions for time series regressions as presented by Christopher Dougherty (Seen below).

1. THE MODEL IS LINEAR IN PARAMETERS AND CORRECTLY SPECIFIED

2. THE TIME SERIES FOR THE REGRESSORS ARE AT MOST WEAKLY PERSISTENT

3. THERE DOES NOT EXIST AN EXACT LINEAR RELATIONSHIP AMONG THE REGRESSORS IN THE SAMPLE

4. THE DISTURBANCE TERM HAS ZERO EXPECTATION

5. THE DISTURBANCE TERM IS HOMOSCEDASTIC

6. THE VALUES OF THE DISTURBANCE TERM HAVE INDEPENDENT DISTRIBUTIONS

7. THE DISTURBANCE TERM IS DISTRIBUTED INDEPENDENTLY FROM THE REGRESSORS

8. THE DISTURBANCE TERM HAS A NORMAL DISTRIBUTION

SOURCE: Dougherty 2011

Most econometric problems are attributable to some sort of violation of one, or more, of the basic assumptions. For the purpose of this essay, we will delimit the assessment of our model to focus on a selected few of the above listed assumptions. To determine whether our situation differs from the CLR scenario a series of tests will be conducted.

5.4.1 AUTOCORRELATION

The Durbin Watson-test checks for the existence of autocorrelation in the data. Autocorrelation occurs when the variables are not independent of each other, and it is specifically common in time series data, which makes it particularly relevant in this regression. A hypothesis is established where the null hypothesis represents that there is no autocorrelation whereas the alternative hypothesis represents positive autocorrelation.

H_0 : No autocorrelation

H_A : Positive autocorrelation

Table 3: Results from test for autocorrelation

TEST STATISTIC	D-VALUE
DURBIN WATSON	2.1628

In general, a Durbin Watson value of around 2 represents an absence of autocorrelation. A value of less than 2 implies the existence of positive autocorrelation, whereas a value greater than 3 indicates negative autocorrelation. More specifically, a D-value outside the range of the critical D-value means a failure to reject the null hypothesis. (Dougherty 2011, p.436-438) Based on the number of parameters and observations included in our regression, the numerical interval for our critical D-value lies between 1.623 and 1.725 for positive autocorrelation. For negative autocorrelation the interval was determined 2.275 – 2.377.

As indicated by the results above, the established D-value lies outside the interval for both positive and negative autocorrelation. Consequentially, the null hypothesis cannot be rejected, meaning that our baseline regression model does not seem to suffer from autocorrelation. If there is no autocorrelation between variables present - the distributions are considered independent, and the sixth assumption (independent distributions of the disturbance term) is upheld.

5.4.2 MULTICOLLINEARITY

Assumption 3 specifies that there should not exist an exact linear relationship among the regressors. An exact linear relationship between independent variables is very rare. It usually only occurs in situations where the researcher has constructed their own data, and is seldom seen even in those cases. However, an approximate linear relationship is quite common among economic variables. This phenomenon is known as multicollinearity, and leads to serious estimating problems. In fact, the nature of these consequences is so severe that multicollinearity is often seen as a violation of Assumption 3. (Kennedy 2008, p.192f) To test our model for multicollinearity, a correlation matrix was constructed.

Table 4: Correlation matrix

	S_P COMP	OILBRENT	US CPI	US INDCONQ	US TBILL
S_P COMP	1.0000	0.1902	-0.0980	0.4270	0.0304
OILBRENT	0.1902	1.0000	0.0509	-0.0402	0.0287
US CPI	-0.0980	0.0509	1.0000	-0.1321	-0.1093
US INDCONQ	0.4270	-0.0402	-0.1321	1.0000	-0.0405
US TBILL	0.0304	0.0287	-0.1093	-0.0405	1.0000

The matrix above shows the calculated correlation coefficients between all pairs of regressors. As defined in Kennedy (2008, p.195f), an absolute value of about 0.8-0.9 denote a high level of correlation between the two independent variables to which the figure refers.

Our results thereby indicate that there is no multicolliniarity in our model, and that assumption 3 holds. It is however important to keep in mind that the correlation matrix only reveals if two variables are collinear, whereas it does not show an eventual collinearity between three or more regressors in a case where two taken variables alone does not exhibit high correlation.

5.4.3 HETEROSCEDASTICITY

White's test is used to control whether our estimator used in the regression is suffering from heteroscedasticity or not. If the regression is suffering from heteroscedasticity, the variance is not constant over time but rather spread at different occasions. (Dougherty 2011, p.286f) The following hypothesis is therefore established:

H_0 : Homoscedasticity

H_A : Heteroscedasticity

Table 5: Results from test for heteroscedasticity

TEST STATISTIC	P-VALUE*
WHITE	0.0327

Note: *Asterisk denotes inclusion of cross terms.*

A significance level of 5 % implies that a P-value above 0.05 would signify a rejection of the null hypothesis. By consequence, the retained P-value of 0.0327 indicates that our regression is suffering from heteroscedasticity. This statistic violates the fifth assumption of homoscedasticity, and needs to be amended.

The baseline model was adjusted for the presence of heteroscedasticity by choosing heteroscedasticity consistent (HC) standard errors in the regression. These are commonly referred to as Eicker-Huber-White standard errors, and allow for the fitting of a model containing heteroscedastic residuals.

This method provides a consistent estimator of standard errors, without altering the values of the coefficient. However, while significantly improving the accuracy of model, the residuals suffering from heteroscedasticity will still lead to slightly biased estimates.

The baseline model used in this essay is assumed linear in parameters, as the data collected does not indicate otherwise. This correlates to the first assumption, which is considered sustained.

With respect to the second assumption, related to the time series being at most weakly persistent, this implies that the model cannot be non-stationary. Seeing as the specified regression model is based on the first differential of all included variables, the assumption of non-stationarity is fulfilled.

The seventh assumption states that the disturbance term shall be distributed independently from the regressors. In other terms, the regressors ought to be endogenous. The nature of the included variables indicates that this is indeed the case, with the implication of the seventh assumption being upheld. This provides further support for the argument of using the OLS estimator in our regression, as instrumental variables are not needed for consistent estimation.

With respect to time and size limitations, we have chosen to solely assess and adjust the regression specification on the basis of the above-discussed assumptions. This is an important fact to remember, and will be further addressed in section 10, under "Suggested improvements for similar studies".

5.5 SCENARIO ANALYSIS

In order to assess the value impact of a future with restricted carbon emissions for SP5SOGE, we have chosen to undertake a scenario analysis. This is a commonly used method in previous research (HSBC, 2008; HSBC, 2012; Carbon Tracker Initiative, 2013), which allows us to consider and compare alternative projected emission scenarios. Consequently, this tool enables us to analyze a scope of possible future outcomes.

There is no scientific consensus regarding the optimal range of scenarios to be used in this type of analysis. This being said, the number three is frequently referred to as an appropriate choice to limit the scope of the analysis while still rendering sufficient material for a substantial discussion and comparison. (Aaker 2001, pp. 108 et seq) Hence, we have chosen three projected emission scenarios as a base for this analysis. These scenarios correlate to different required Brent oil prices, as explained previously.

With use of the beta coefficient from the main regression model, we will determine the potential value implications on SP5SOGE of our respective scenario prices. This will be done by the means of a simple percentage change-calculation.

To single out the effect of altering OILBRENT in our respective scenarios, all other variables are assumed constant. Seeing as the original regression is run on delta values of all variables, the control variables (which are hereby presumed constant) will attain a value of zero and therefore be disregarded in the following equation.

As shown in the following section, our results indicate that the C-variable, representing the intercept in our main model, was not significant. Based on these findings, the intercept is not to be included in the following calculations. The natural corollary of these findings is that OILBRENT will be the only variable included.

In mathematical terms, our calculations will be based on the following equation;

$$\Delta Oil\ price \times \beta\ = value\ implication\ on\ SP5SOGE$$

There is no time aspect, as the calculations are based on a linear approximation without a time trend. This allows us to further simplify our equation. Instead of projecting a non-linear path to our scenario prices, we compare these towards the latest recorded value of OILBRENT from our main model regression; December 2013. A percentage change between this price, and our respective scenario prices, will be calculated. This percentage value will then be multiplied with the beta coefficient of OILBRENT, in order to determine the potential value implications on SP5SOGE.

6. RESULTS FROM THE BASELINE MODEL

6.1 NULL HYPOTHESIS

The results of the regression analysis showed an observed P value of 0.0000 for our variable OILBRENT and also for the control variable S_P COMP. These results indicate that there is a highly significant effect, as our results show a value smaller than the critical value of 0.01. Our results suggest that the null hypothesis of □ =0 can be rejected; meaning that there is a significant effect of the two variables and most importantly that there is a highly significant relationship between the price of oil on the SP5SOGE index.

Table 6: Results from the baseline model

VARIABLE	COEFFICIENT	STANDARD ERRORS	P-VALUE
C	-0.0073	0.0113	0.5203
OILBRENT	0.3158	0.0554	0.0000**
S_P COMP	0.8242	0.1272	0.0000**
US TBILL	-0.0054	0.0066	0.4073
US INDCONQ	0.0018	0.0549	0.9744
US CPI	0.2863	0.4426	0.5182

Note: Adjusted R^2 value: 0.3733
Observations = 264
Asterisks denote significance at the 1% (**) level.

6.2 BETA COEFFICIENT

The OILBRENT beta coefficient was estimated to 0.3158. This result suggests that an increase in the delta value on the dollar price of oil has a significant positive impact on the delta value of SP5SOGE, also in US dollars, by the amount of 31,58 per cent. The mirrored interpretation of this result is that a decrease in the price of oil has a significantly negative impact on the SP5SOGE index by the same percentage amount. All values refer to absolute terms.

6.3 ALTERNATIVE REGRESSIONS

To further deepen the understanding of the results from our baseline model, we have chosen to supplement these with five alternative regressions. Each alternative regression is run under the exclusion of one control variable (with the exception of ALT.1, in which all control variables are excepted). The results from these equations are shown below. (Table 7)

Table 7: Results from alternative regression models

VARIABLE	ALT. 1 Coef.	ALT. 1 P-value	ALT. 2 Coef.	ALT. 2 P-value	ALT. 3 Coef.	ALT. 3 P-value	ALT. 4 Coef.	ALT. 4 P-value
C	0.0005	0.9722	-0.0080	0.4775	-0.0073	0.5195	-0.0002	0.9708
OILBRENT	0.3962	0.0000**	0.3153	0.0000**	0.3156	0.0000**	0.3178	0.0000**
S_P COMP	-	-	0.8222	0.0000**	0.8258	0.0000**	0.8201	0.0000**
US TBILL	-0.0016	0.8776	-	-	-0.0055	0.3996	-0.0064	0.3074
US INDCONQ	0.1785	0.0033**	0.0034	0.9509	-	-	-0.0019	0.9719
US CPI	0.1200	0.8320	0.3074	0.4847	0.2850	0.5174	-	-

Note: Adjusted R^2 Alt 1 = 0.2356, ad. R^2 Alt 2 = 0.3847, ad. R^2 Alt 3 = 0.3852, ad. R^2 Alt 4 = 0.3840
Observations = 264

Our initial intention was to conduct and run a log-log regression as our main model. After careful consideration we decided to alter the preliminary equation to a linear, non-logarithmic model. However, we found it interesting to compare the main results of our non-logarithmic model to those of a log-version. For this reason we conducted a log-log regression version, and composed the results in the table below.

We chose to use the logarithms of our dependent variable (SP5SOGE), OILBRENT and US INDCONQ as these variables were expected to have a relative, rather than absolute, affiliation. The assumed nature of this relationship lead us to the idea that logarithmic values, emanating from relative changes, would be more intuitive for our model. As previously mentioned, this was before considering complexity implications for our scenario analysis.

6.3.1 ALTERNATIVE REGRESSION VERSION

The premise of our log-log version consequentially leads to an entirely different interpretation of the estimated coefficients. Instead of signifying an impact in absolute terms, the beta values from our log-transformed variables represent an estimated elasticity. The fact that the coefficients from the respective versions of our baseline model represent such disparate expressions makes an eventual comparison problematic.

Table 8: Results from the alternative regression version

VARIABLE	COEFFICIENT	P-VALUE
LN C	-0.0107	0.3804
LN OILBRENT	0.3011	0.0000**
S_P COMP	0.8428	0.0000**
US TBILL	-0.0041	0.5347
LN US INDCONQ	0.0131	0.8148
US CPI	0.3351	0.4744

Note: Adjusted R^2 value: 0.3812
Observations = 264

However, as can be seen in the table above, neither the beta values nor the p-values differ substantially from the results retrieved by the main version of our baseline regression model. The only variables found significant were OILBRENT and S_P COMP, as was the case in our original regression.

6.4 DISCUSSION OF RESULTS

By the means of a regression analysis, the relationship between OILBRENT and SP5SOGE could be estimated. From our baseline model, we observed a positive significant relationship between the two and an estimated beta value of 0.3158 for the variable OILBRENT. The definitive significance of OILBRENT in all of the conducted regression versions and models further strengthens the hypothesis of a strong positive relationship between oil prices and the value of our chosen indicator of the US oil and gas industry, SP5SOGE.

Evidently, the price of oil and eventual price fluctuations has huge impact on the SP5SOGE index. This impact is with great probability not solely observed within the US oil and gas market index SP5SOGE, but most likely within other similar markets in the US and in other countries. These markets are therefore immensely dependent on the oil price and the future direction in which it is heading. This naturally creates some question marks regarding different future scenarios and the consequences that various probable oil prices can have on invested capital and shareholders rate of return.

7. SCENARIO ANALYSIS

By the means of a scenario analysis, an eventual value implication on SP5SOGE can be determined and measured. The following section will focus on three main scenarios

SCENARIO	CORRESPONDING OIL PRICE	VALUE IMPLICATION ON SP5SOGE
2DS	$75/bbl	-11 %
LOW DEMAND	$50/bbl	-18 %
BUSINESS AS USUAL	$215/bbl	29 %

constructed for the purpose of this analysis; 2DS, Low demand and Business-as-usual.

The table below represents the three chosen scenarios with corresponding Brent oil prices. The value implication on SP5SOGE is denoted on the right-hand column.

Table 9: Results from the scenario calculations

7.1 2DS

As shown in Table 9, the calculated value implications on SP5SOGE of a Brent oil price in accordance with the 2-degree target would be -11%, ceteris paribus, compared to the measured Brent oil price of $113/bbl in 2013-12-02. To put things in perspective, this value can be compared to the actual development of SP5SOGE during the time period of

1993-2013, where the value of SP5SOGE increased by 780%. (Figures from Datastream, 2014)

7.2 LOW DEMAND SCENARIO

A change in Brent oil price from its current level to $50/bbl would according to our calculations mean a negative value impact of -18% for SP5SOGE, ceteris paribus. This emission scenario would have the most far stretching consequences for the US oil and gas industry, as it is furthest away from the industry's own estimates.

7.3 BUSINESS-AS-USUAL SCENARIO

Business-as-usual, based on the total potential production of liquids to 2050, is projected to result in a Brent oil price of $215/bbl. This emission scenario would mean an increase in the value of SP5SOGE amounting to 29%, ceteris paribus.

7.4 DISCUSSION OF RESULTS

A future with lower Brent oil prices than the Business-as-usual scenario would have a significant impact on the US oil and gas industry. The nature of this effect would depend on the magnitude of the discrepancy, where a larger price difference would naturally have a larger impact.

Seeing as the Brent oil price is not likely to fall to projected 2050 levels by tomorrow, one can assume that a low emission scenario would foremost affect future projects within the oil and gas industry. Existing projects enjoy the benefits of sunk costs, and are thereby inclined to have lower cash operating costs. New projects however, need to incur capital expenditures in addition to operating costs, rendering a higher cash cost/bbl. The value of future projects is thereby more sensitive to price changes than existing projects.

Furthermore, the production and extraction of unconventional oil types would likely be negatively impacted by a lower Brent oil price. These projects tend to have higher production costs/bbl, making them more vulnerable to price decreases. Even if some unconventional oil projects would be commercial in a low emission scenario, a lower Brent oil price would make many of these high-cost oil types obsolete. (CTI, 2013; CTI, 2014; HSBC, 2008; HSBC, 2013)

8. CONSIDERATIONS AND IMPLICATIONS OF RESULTS

8.1 TIME-LINE CONSIDERATIONS

The time horizon in our time series analysis was including years 1992 to 2013, which is a period of 21 years. We covered more than 2 decades of data in the regression, however a longer time duration would still have been preferred. Adding an additional 10 or 20 years to the time series would impact the results in a positive manner, presenting a greater value to the results. On the other hand, restricted data for the chosen variables comes into play, which only allows for a certain amount of years. To get past this problem one might do a similar time series analysis on a different index that has been recorded for a longer time period. An alternative would be to do a similar regression with another country that has similar data available for a longer time span.

8.2 SAMPLE SIZE AND VARIABLES

In this paper we chose to observe how the price of oil affects the US oil and gas market of SP5SOGE. The variables used in our analysis originate from the US, as we narrowed the scope of the regression analysis to look solely at the US market. As previously mentioned a larger sample size would be beneficial for future studies. In addition to this, we also believe that including some additional variables might be of positive effect, particularly if there are variables that might have been omitted in this analysis.

8.3 IMPLICATIONS FOR INVESTORS AND STAKEHOLDERS

In a carbon-restricted future, the investments in oil and gas companies may face a decreasing rate of return. The reason behind this is the fact that the continued investments in exploring and extracting new sources of fossil fuels might go to waste, as the reserves by several reasons may stay unburned.

Since invested assets might be in the danger zone of becoming stranded assets, investors need to take into account future carbon budgets to properly evaluate their investment risks. Investors and stakeholders ought to demand valuation models that do not only address business as usual - but also a variety of different outcomes, one example being the 2-degree scenario.

Enhanced risk management and transparency are crucial for preserving the market, and therefore escape the most severe climate impacts and the case of wasted capital. Current business models based on strategies the usage of shareholder funds to further develop fossil fuel projects should be challenged. Instead of using the regular holdings of these companies, carbon-adjusted indices should be used as a new benchmark.

8.4 IMPLICATIONS FOR POLICYMAKERS

This region of analysis is particularly interesting in the midst of the coming United Nations climate conference, COP21, in Paris 2015. COP21 is referred to by the organizing committee as a "decisive stage in negotiations on the future international agreement on a post-2020 regime". The objective of the conference is to reach a global, legally binding climate treaty for all the nations of the world. (France Diplomatie, 2013)

In accordance with the 2-degree target, this treaty would aim at containing global GHG to the levels of 2DS. If successful, the results from our analysis indicate that this would have substantial negative implications on asset values within the sector. These economic consequences would not be limited to the US oil and gas industry, but would affect the entire fossil fuel sector. As mentioned in the introductory section of this essay, the global oil and gas industry is one of the world's most influential industries. It is therefore likely that the financial implications of an UN climate treaty would have a substantial impact on the global economy.

For highly fossil fuel dependent economies, such as the US, China, India and all of the oil producing nations, the findings of this essay indicate that there might be economic incentives to block the UN negotiations in Paris 2015. By preventing a global climate treaty from being reached, these parties could protect their economies from negative value developments within the oil and gas industry, as portrayed in our calculations.

It is of essential need that climate change is incorporated in an international process of managing and assessing risk in the financial markets. Policymakers ought to work with organizations like the International Organization of Securities Commissions, with the G20 being an additional suitable convention for this process.

Authorities should require extractive companies to disclose the CO_2 potential of their oil and gas reserves. This would enhance transparency, and render an opportunity to detect carbon-budget risk. Furthermore, an explanation of how the companies business models are harmonious with accomplishing the carbon budget should be required.

9. CONCLUSION

It is hard to predict the true nature of potential value implications of different oil price scenarios. The valuation process within the oil and gas industry is highly complicated, and depends on a range of factors – with Brent oil prices being one of the most significant. Furthermore, seeing as global carbon restrictions are an unprecedented phenomenon, the exact effect of a low emission future on oil prices is unknown. All that we can say with certainty is that further research on this topic is of utter importance.

In this essay, we have examined the impact of oil prices on the value of the S&P Oil and Gas Exploration and Production Price Index (SP5SOGE). With the help of an econometric regression model, we received an estimated beta value of OILBRENT amounting to 0.3158. The coefficient was found significant, and discloses a positive relationship between Brent oil prices and the asset value of SP5SOGE. These results give grounds for the theory that increasing Brent oil prices has a positive impact on asset values within the US oil and gas industry.

The estimated coefficient for OILBRENT was used in a scenario analysis, with the purpose of investigating the potential financial implications for these assets of three different oil prices, in accordance with our chosen emission scenarios.

The first scenario of decreasing CO_2 emissions consistent with the 2-degree target (2DS scenario), would mean a negative impact on the asset value of SP5SOGE amounting to -11%, ceteris paribus. The corresponding value for our second scenario (Low demand scenario), was -18%, ceteris paribus. A value decrease of this magnitude would have vast consequences not only within the US oil and gas industry, but also for the entire world economy.

These figures can be compared to our third and final scenario (Business-as-usual scenario), based on the total potential production up to 2050 of oil, condensates and natural gas liquids by listed oil and gas companies. A Brent oil price corresponding to this level of emissions would mean a positive impact totalling at 29% for the asset value of SP5SOGE, ceteris paribus. Depending on which emission scenario is realized, the picture of the world economy will likely be of very different sorts.

A global climate treaty in accordance with a scenario of decreasing CO_2 emissions would have a significant impact on asset values within the US oil and gas industry, and likely influence the valuation process in the entire sector. However, it is important to keep a critical mind when reviewing the results of this essay. Many of the baseline assumptions of the calculations are unlikely to cohere with the real world scenario. The empirical reality tells us that the process of market adjustment towards a new equilibrium price is not of an immediate nature. This development is usually successive – it takes time for large markets to fully internalize new information resulting from policy and/or societal changes.

Nonetheless, there is enough evidence to support the case of recommending investors and stakeholders within the oil and gas sector to require disclosure of demand and price assumptions behind new investments. This information is especially important for decisions regarding projects within the field of unconventional oil types, as these types of projects tend to require a higher break-even price.

Furthermore, our essay highlights an important field for investors to consider; transparency. It is of the upmost importance for investors and stakeholders within the oil and gas industry to demand insight into the business models and tactics behind companies' development strategies. This information will become increasingly important in the future post 2015, as policymakers reveal which direction the industry must take.

One step in this direction would be for investors and stakeholders to urge companies within the oil and gas industry to stress-test capital expenditure projects against possible emission/oil price scenarios. These results would preferably be published on an annual basis, and improve transparency into business practices and prioritizations of oil and gas companies.

Based on the results of this essay, there is also a case to be made for increased demands and requirements on the industry in the form of new policies and regulations. One potential tool in the process of managing and assessing climate risk in the financial markets could be to legally require disclosure of the CO_2 potential in extractive companies' oil and gas reserves. Furthermore, policymakers ought to collaborate with political as well as independent organizations to internalize climate risk as a natural part of the international process of financial risk assessment.

In the context of the upcoming climate negotiations in 2015, this essay presents policymakers with many important takeaways. Potential negative value developments within the oil and gas industry as a result of a global climate treaty could present fossil fuel-intense economies with skewed interests in the negotiations. These financial consequences need to be considered. If a global climate treaty is to be reached at COP21, policymakers have to be prepared to make sacrifices, and potentially compensate those who stand to make the gravest losses.

10. FUTURE RESEARCH

10.1 SUGGESTED IMPROVEMENTS FOR SIMILAR STUDIES

There are a few different ways to go about the analysis of an eventual carbon budget's effect on the financial markets of oil and gas companies. For studies based on similar methodology as contained in this essay, it would be highly recommended to increase the scope of the analysis. Further assessment and adjustments of the chosen regression model, and the included variables, would be of great value.

Another option to receive information on how prepared and vulnerable different oil and gas companies are, is to create a regression based on a restricted sample of the largest companies, and include company specific data as control variables. Such a regression can be made with the use of market capitalization data from sample companies. This way allows investors to gain knowledge about specific companies, and their potential performance in a carbon-restricted future.

However, a time series regression based on specific companies and company specific variables is much more complicated than the model presented and used in this essay. As a comparison will be made between different companies, one has to take into consideration which variables are relevant to add depending on which company one is analyzing. A deeper look into the chosen companies' business activities will be of great significance to be able to draw proper conclusions regarding their future prospects and how well they will be able to handle potential stranded assets.

10.2 OTHER AREAS OF STUDY

The oil and gas companies are not standing solely responsible for the greenhouse gas emissions. Along with them we find coal companies, which might also be held responsible for keeping emission within an eventual greenhouse gas limit. The budget of 900 $GtCO_2$ is set for coal, oil and gas companies. The coal market is facing the exact same problem as the one we have been researching. Naturally this means that there exists a great need of further studies regarding assets invested in the coal market.

As mentioned above an analysis that proceeds from company specific variables has the potential to look at the listed coal reserves among the companies and by the means of this display how a carbon budget would impact for instance their market capitalization development.

In addition, depending on how much the different companies are investing in the search for new potential carbon sources there might be a significant amount of wasted capital in a situation where these assets are not allowed to be used.

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APPENDIX

EXHIBIT 1: RAW DATA USED FOR REGRESSION ANALYSIS

TIME	SP5SOGE	OILBRENT	S_PCOMP	US TBILL	USINDCONQ	US CPI
1992-01-02	146,96	18,25	419,34	3,85	50,2000	138,3
1992-02-02	134,9	18,35	409,53	3,84	47,3000	138,6
1992-03-02	132,3	17,35	412,85	4,04	56,5000	139,1
1992-04-02	118,66	18,9	401,55	3,96	65,1000	139,4
1992-05-02	118,68	19,9	412,53	3,63	71,9000	139,7
1992-06-02	128,85	21,2	414,59	3,71	72,6000	140,1
1992-07-02	111	20,75	411,77	3,24	61,2000	140,5
1992-08-02	123,8	20,15	425,09	3,17	59,0000	140,8
1992-09-02	152,41	20	417,98	3,14	57,3000	141,1
1992-10-02	153,31	20,42	410,47	2,63	54,6000	141,7
1992-11-02	143,05	19,23	419,92	3,03	65,6000	142,1
1992-12-02	131,37	18,28	429,91	3,3	78,1000	142,3
1993-01-02	132,44	18,02	435,71	3,08	76,7000	142,8
1993-02-02	137,27	18,36	447,2	2,93	68,5000	143,1
1993-03-02	159,31	19,03	449,26	2,94	63,2000	143,3
1993-04-02	162,6	19,07	441,39	2,91	67,6000	143,8
1993-05-02	163,69	19,03	442,46	2,87	61,9000	144,2
1993-06-02	165,25	18,21	452,49	3,03	58,6000	144,3
1993-07-02	146,8	16,67	445,84	2,95	59,2000	144,5
1993-08-02	144,58	16,56	449,27	3,08	59,3000	144,8
1993-09-02	164,63	16,27	461,34	2,94	63,8000	145
1993-10-02	159,18	17,12	461,29	2,92	60,5000	145,6
1993-11-02	151,96	15,93	463,02	3,09	71,9000	146
1993-12-02	131,05	14,17	464,89	3,11	79,8000	146,3
1994-01-02	128,2	13,47	465,44	3,03	82,6000	146,3
1994-02-02	143,62	15,33	480,71	3,13	79,9000	146,7
1994-03-02	129,08	13,73	463,01	3,48	86,7000	147,1
1994-04-02	122,77	13,66	445,77	3,48	92,1000	147,2
1994-05-02	127,48	15,98	453,03	4,02	88,9000	147,5
1994-06-02	122,77	16,37	460,13	4,12	92,5000	147,9
1994-07-02	121,63	18,38	446,2	4,2	91,3000	148,4
1994-08-02	119,44	18,39	461,45	4,33	90,4000	149
1994-09-02	113,39	16,03	470,99	4,55	89,5000	149,3

1994-10-02	110,55	16,86	461,74	4,73	89,1000	149,4
1994-11-02	117	17,98	467,91	5,1	100,4000	149,8
1994-12-02	102,25	16,25	453,3	5,63	103,4000	150,1
1995-01-02	100	15,85	459,11	5,53	101,4000	150,5
1995-02-02	97,16	17,3	478,64	5,8	99,4000	150,9
1995-03-02	110,1	17,36	485,42	5,72	100,2000	151,2
1995-04-02	117,43	17,82	501,85	5,7	104,6000	151,8
1995-05-02	116,29	19,25	520,48	5,66	102,0000	152,1
1995-06-02	118,82	18,2	532,51	5,42	94,6000	152,4
1995-07-02	111,87	16,44	547,09	5,46	101,4000	152,6
1995-08-02	115,23	16,28	558,75	5,42	102,4000	152,9
1995-09-02	122,08	16,54	563,84	5,29	97,3000	153,1
1995-10-02	116,38	16,46	582,34	5,35	96,3000	153,5
1995-11-02	106,77	16,87	590,57	5,31	101,6000	153,7
1995-12-02	114,63	17,44	606,98	5,29	99,2000	153,9
1996-01-02	117,44	19,61	621,32	5,05	88,4000	154,7
1996-02-02	114,45	17,1	635,84	4,85	98,0000	155
1996-03-02	110,12	18,73	644,37	4,86	98,4000	155,5
1996-04-02	115,66	21,19	655,88	5,01	104,8000	156,1
1996-05-02	118,22	19,94	641,63	5	103,5000	156,4
1996-06-02	121,42	18,25	667,68	5,08	100,1000	156,7
1996-07-02	132,32	19,41	672,4	5,1	107,0000	157
1996-08-02	130,09	19,88	662,49	5,07	112,0000	157,2
1996-09-02	130,65	22,86	654,72	5,17	111,8000	157,7
1996-10-02	139,11	24,04	692,78	4,91	107,3000	158,2
1996-11-02	141,85	22,38	703,77	5,03	109,5000	158,7
1996-12-02	152,35	24,36	748,28	4,92	114,2000	159,1
1997-01-02	151,12	24,38	748,03	5,04	118,7000	159,4
1997-02-02	147,9	23,11	786,73	4,98	118,9000	159,7
1997-03-02	127,87	19,22	795,31	5,1	118,5000	159,8
1997-04-02	130,53	17,53	750,32	5,13	118,5000	159,9
1997-05-02	137,6	17,85	812,97	5,1	127,9000	159,9
1997-06-02	146,97	18,5	845,48	4,92	129,9000	160,2
1997-07-02	139,34	18,4	916,92	5,01	126,3000	160,4
1997-08-02	143,45	19,39	947,14	5,14	127,6000	160,8
1997-09-02	154,96	18,34	927,86	5,01	130,2000	161,2
1997-10-02	155,47	21,83	965,03	4,9	123,4000	161,5
1997-11-02	155,13	19,54	938,99	5,11	128,1000	161,7
1997-12-02	140,08	18,04	976,77	5,12	136,2000	161,8
1998-01-02	136,64	16,12	975,04	5,18	128,3000	162
1998-02-02	131,41	15,08	1006	5,12	137,4000	162
1998-03-02	137,77	13,37	1052,02	5,09	133,8000	162
1998-04-02	148,13	14,1	1122,7	4,95	137,2000	162,2
1998-05-02	147,74	14,88	1121	4,89	136,3000	162,6
1998-06-02	129,16	14,24	1082,73	5	138,2000	162,8
1998-07-02	128,44	12,68	1146,42	4,94	137,2000	163,2
1998-08-02	107,36	12,16	1112,44	4,98	133,1000	163,4
1998-09-02	85,65	13,34	982,26	4,71	126,4000	163,5
1998-10-02	104,12	14,47	1002,6	4,12	119,3000	163,9

1998-11-02	110,68	12,06	1110,84	4,39	126,4000	164,1
1998-12-02	87,3	9,96	1150,14	4,34	126,7000	164,4
1999-01-02	93,05	10,48	1229,23	4,37	128,9000	164,7
1999-02-02	81,94	10,84	1272,07	4,37	133,1000	164,7
1999-03-02	81,6	11,09	1227,7	4,49	134,0000	164,8
1999-04-02	102,98	14,69	1293,72	4,31	135,5000	165,9
1999-05-02	122,83	17,02	1354,63	4,47	137,7000	166
1999-06-02	116,33	14,9	1299,54	4,52	139,0000	166
1999-07-02	124,85	17,97	1391,22	4,55	136,2000	166,7
1999-08-02	123,53	19,55	1322,18	4,7	136,0000	167,1
1999-09-02	126,5	21,32	1357,24	4,78	134,2000	167,8
1999-10-02	115,37	24,03	1282,81	4,74	130,5000	168,1
1999-11-02	107,21	22,64	1354,93	4,97	137,0000	168,4
1999-12-02	106,44	26,17	1433,3	5,1	141,7000	168,8
2000-01-02	104,32	25,73	1455,22	5,27	144,7000	169,3
2000-02-02	100,62	27,85	1424,97	5,46	140,8000	170
2000-03-02	94,13	29,93	1409,17	5,63	137,1000	171
2000-04-02	115,44	24,32	1505,97	5,69	137,7000	170,9
2000-05-02	127,48	25,33	1415,1	5,74	144,7000	171,2
2000-06-02	138,47	29,62	1477,26	5,7	139,2000	172,2
2000-07-02	136,48	32,52	1469,54	5,75	143,0000	172,7
2000-08-02	126,95	28,14	1452,56	6,05	140,9000	172,7
2000-09-02	152,41	35,35	1520,77	6,09	142,5000	173,6
2000-10-02	153,15	30,6	1426,46	6,06	135,8000	173,9
2000-11-02	141,68	31,16	1426,69	6,2	132,6000	174,2
2000-12-02	146,6	31,05	1315,23	6,05	128,6000	174,6
2001-01-02	168,95	24,54	1347,56	5,53	115,7000	175,6
2001-02-02	149,94	29,79	1349,47	4,93	109,3000	176
2001-03-02	157,3	25,68	1234,18	4,72	116,9000	176,1
2001-04-02	144,31	24,44	1106,46	4,05	109,9000	176,4
2001-05-02	150,14	27,7	1248,58	3,75	116,1000	177,3
2001-06-02	157,59	28,61	1260,67	3,59	118,9000	177,7
2001-07-02	135,55	25,17	1234,45	3,58	116,3000	177,4
2001-08-02	141,13	25,47	1214,35	3,44	114,0000	177,4
2001-09-02	128,98	26,6	1133,58	3,3	97,0000	178,1
2001-10-02	113,99	20,74	1072,28	2,19	85,3000	177,6
2001-11-02	127,95	19,57	1087,2	1,97	84,9000	177,5
2001-12-02	123,91	19,53	1129,9	1,75	94,6000	177,4
2002-01-02	131,15	20,1	1165,27	1,7	97,8000	177,7
2002-02-02	123,98	20,9	1122,2	1,73	95,0000	178
2002-03-02	133,6	21,61	1131,78	1,74	110,7000	178,5
2002-04-02	149,35	26,66	1125,4	1,76	108,5000	179,3
2002-05-02	146,29	26,22	1073,43	1,73	110,3000	179,5
2002-06-02	137,23	23,81	1040,68	1,74	106,3000	179,6
2002-07-02	132,54	25,86	953,99	1,69	97,4000	180
2002-08-02	115	25,71	864,24	1,6	94,5000	180,5
2002-09-02	126,4	26,56	878,02	1,61	93,7000	180,8
2002-10-02	128,07	28,42	818,95	1,54	79,6000	181,2
2002-11-02	127,33	25,39	900,96	1,41	84,9000	181,5

2002-12-02	128,42	26,13	920,75	1,21	80,8000	181,8
2003-01-02	133,55	32,15	908,59	1,2	78,8000	182,6
2003-02-02	128,13	30,69	860,32	1,16	64,8000	183,6
2003-03-02	132,01	33,52	834,81	1,18	61,4000	183,9
2003-04-02	131,78	26,48	876,45	1,09	81,0000	183,2
2003-05-02	130,02	23,59	930,08	1,1	83,6000	182,9
2003-06-02	145,18	28,03	971,56	1,06	83,5000	183,1
2003-07-02	138,21	28,36	985,7	0,85	77,0000	183,7
2003-08-02	130,93	30,27	980,15	0,93	81,7000	184,5
2003-09-02	138,37	28,08	1026,27	0,95	77,0000	185,1
2003-10-02	138,19	29,39	1029,85	0,92	81,7000	184,9
2003-11-02	136,89	27,71	1059,02	0,94	92,5000	185
2003-12-02	143,72	29,32	1064,73	0,92	94,8000	185,5
2004-01-02	158,8	29,67	1108,48	0,91	97,7000	186,3
2004-02-02	156,97	29,86	1136,03	0,92	88,5000	186,7
2004-03-02	164,3	33,23	1151,04	0,95	88,5000	187,1
2004-04-02	165,58	30,89	1141,81	0,93	93,0000	187,4
2004-05-02	175,6	35,68	1117,49	0,99	93,1000	188,2
2004-06-02	172,62	36,62	1116,64	1,15	102,8000	188,9
2004-07-02	185,99	35,5	1125,38	1,27	105,7000	189,1
2004-08-02	189,74	42,41	1099,69	1,46	98,7000	189,2
2004-09-02	188,58	41,4	1113,63	1,62	96,7000	189,8
2004-10-02	207,14	47,01	1131,5	1,67	92,9000	190,8
2004-11-02	203,98	45,8	1143,2	1,92	92,6000	191,7
2004-12-02	211,83	38,19	1191,17	2,17	102,7000	191,7
2005-01-02	201,78	38,4	1202,08	2,29	105,1000	191,6
2005-02-02	227,94	43,39	1189,89	2,44	104,4000	192,4
2005-03-02	258,98	53,23	1210,47	2,7	103,0000	193,1
2005-04-02	273,25	54,53	1172,92	2,74	97,5000	193,7
2005-05-02	255,41	50,65	1161,17	2,85	103,1000	193,6
2005-06-02	259,79	52,62	1196,02	2,94	106,2000	193,7
2005-07-02	290,9	56,69	1194,44	3,1	103,6000	194,9
2005-08-02	310,49	60,03	1245,04	3,38	105,5000	196,1
2005-09-02	329,04	66,35	1218,02	3,38	87,5000	198,8
2005-10-02	365,86	62,01	1226,7	3,54	85,2000	199,1
2005-11-02	329,83	59,23	1219,94	3,85	98,3000	198,1
2005-12-02	338,6	55,52	1265,08	3,9	103,8000	198,1
2006-01-02	350,19	61,6	1268,8	4,07	106,8000	199,3
2006-02-02	375,98	62,97	1264,03	4,37	102,7000	199,4
2006-03-02	357,04	62,74	1287,23	4,5	107,5000	199,7
2006-04-02	359,69	67,53	1297,81	4,55	109,8000	200,7
2006-05-02	377,32	73,42	1307,85	4,7	104,7000	201,3
2006-06-02	352,62	69,38	1288,22	4,69	105,4000	201,8
2006-07-02	371,48	73,75	1280,19	4,96	107,0000	202,9
2006-08-02	382,9	76,22	1280,27	4,98	100,2000	203,8
2006-09-02	371,25	68,06	1311,01	4,89	105,9000	202,8
2006-10-02	346,06	57,03	1334,11	4,78	105,1000	201,9
2006-11-02	371,35	56,25	1364,3	4,96	105,3000	202
2006-12-02	400,58	64,44	1396,71	4,9	110,0000	203,1

2007-01-02	364,13	57,29	1416,6	4,92	110,2000	203,437
2007-02-02	382,84	57,1	1448,39	5,01	111,2000	204,226
2007-03-02	362,75	61,6	1387,17	4,98	108,2000	205,288
2007-04-02	394,07	67,95	1437,77	4,91	106,3000	205,904
2007-05-02	414,52	65,49	1502,39	4,76	108,5000	206,755
2007-06-02	435,15	68,22	1536,34	4,66	105,3000	207,234
2007-07-02	443,17	72,74	1524,87	4,81	111,9000	207,603
2007-08-02	431,45	75,84	1433,06	4,72	105,6000	207,667
2007-09-02	410,96	73,26	1473,99	3,91	99,5000	208,547
2007-10-02	465,03	77,85	1539,59	3,86	95,2000	209,19
2007-11-02	513,57	91,85	1509,65	3,52	87,8000	210,834
2007-12-02	479,98	88,16	1472,42	2,99	90,6000	211,445
2008-01-02	533,36	98,45	1447,16	3,16	87,3000	212,174
2008-02-02	502,77	90,96	1395,42	2,06	76,4000	212,687
2008-03-02	598	101,8	1331,34	1,67	65,9000	213,448
2008-04-02	601,28	103,72	1369,31	1,38	62,8000	213,942
2008-05-02	637,76	113,78	1413,9	1,47	58,1000	215,208
2008-06-02	673,7	125,88	1377,65	1,82	51,0000	217,463
2008-07-02	685,79	144,07	1262,9	1,81	51,9000	219,016
2008-08-02	536,04	123,98	1260,31	1,63	58,5000	218,69
2008-09-02	517,14	104,46	1274,98	1,67	61,4000	218,877
2008-10-02	414,99	89,16	1099,23	0,5	38,8000	216,995
2008-11-02	369,07	59,79	966,3	0,49	44,7000	213,153
2008-12-02	344,85	42,89	870,74	0,02	38,6000	211,398
2009-01-02	359,67	38,8	931,8	0,08	37,4000	211,933
2009-02-02	332,03	42,2	838,51	0,32	25,3000	212,705
2009-03-02	255,01	41,93	696,33	0,27	26,9000	212,495
2009-04-02	327,14	50,47	842,5	0,21	40,8000	212,709
2009-05-02	361,36	51,29	877,52	0,15	54,8000	213,022
2009-06-02	414,72	65,8	931,76	0,14	49,3000	214,79
2009-07-02	340,8	64,99	896,42	0,17	47,4000	214,726
2009-08-02	405,75	73,22	1002,63	0,19	54,5000	215,445
2009-09-02	386,7	66,49	1003,24	0,15	53,4000	215,861
2009-10-02	423,47	66,45	1025,21	0,1	48,7000	216,509
2009-11-02	437,5	75,81	1045,41	0,06	50,6000	217,234
2009-12-02	441,6	77,76	1099,92	0,06	53,6000	217,347
2010-01-02	478,14	77,4	1115,1	0,06	56,5000	217,466
2010-02-02	480,96	75,8	1097,28	0,1	46,4000	217,251
2010-03-02	481	78,93	1118,79	0,14	52,3000	217,305
2010-04-02	480,99	82,93	1178,1	0,16	57,7000	217,376
2010-05-02	486,56	88,15	1202,26	0,17	62,7000	217,299
2010-06-02	431,06	73,21	1102,83	0,14	54,3000	217,285
2010-07-02	391,2	71,48	1022,58	0,17	51,0000	217,677
2010-08-02	437,57	82,66	1120,46	0,16	53,2000	218,012
2010-09-02	413,15	74,87	1104,51	0,14	48,6000	218,281
2010-10-02	440,04	82,93	1146,24	0,16	49,9000	219,024
2010-11-02	460,83	85,53	1197,96	0,13	57,8000	219,544
2010-12-02	496,58	90,65	1224,71	0,14	63,4000	220,437
2011-01-02	523,81	96,1	1271,87	0,15	64,8000	221,082

2011-02-02	562,55	101,88	1307,1	0,14	72,0000	221,816
2011-03-02	571,15	115,35	1330,97	0,13	63,8000	222,955
2011-04-02	603,67	118,4	1332,41	0,07	66,0000	224,056
2011-05-02	591,23	124,02	1356,62	0,03	61,7000	224,918
2011-06-02	563,02	115,09	1300,16	0,04	57,6000	224,99
2011-07-02	561,64	110,85	1339,67	0,02	59,2000	225,553
2011-08-02	561,08	115,19	1260,34	0,02	45,2000	226,149
2011-09-02	489,1	113,74	1173,97	0,02	46,4000	226,674
2011-10-02	394,89	105,61	1099,23	0,02	40,9000	226,761
2011-11-02	512,41	112,61	1261,15	0,01	55,2000	227,136
2011-12-02	515,01	109,82	1244,28	0,02	64,8000	227,093
2012-01-02	482,57	111,74	1277,06	0,02	61,5000	227,666
2012-02-02	506,09	112,85	1344,9	0,08	71,6000	228,138
2012-03-02	534,45	124,48	1369,63	0,07	69,5000	228,732
2012-04-02	519,83	125,61	1413,38	0,08	68,7000	229,184
2012-05-02	494,6	116,9	1391,57	0,09	64,4000	228,884
2012-06-02	423,56	98,36	1278,04	0,07	62,7000	228,825
2012-07-02	457,81	100,78	1374,02	0,09	65,4000	228,779
2012-08-02	455,67	108,98	1390,99	0,09	61,3000	229,952
2012-09-02	478,66	115,64	1406,58	0,09	68,4000	231,086
2012-10-02	499,51	109,62	1450,99	0,09	73,1000	231,652
2012-11-02	491,16	106,51	1414,2	0,09	71,5000	231,19
2012-12-02	485,7	112,67	1409,46	0,1	66,7000	231,099
2013-01-02	501,3	113,16	1459,37	0,08	58,4000	231,321
2013-02-02	527,61	116,9	1513,17	0,06	68,0000	232,599
2013-03-02	517,63	110,89	1518,2	0,11	61,9000	232,075
2013-04-02	536,71	108,73	1553,69	0,06	69,0000	231,707
2013-05-02	529,16	104,63	1614,42	0,05	74,3000	232,124
2013-06-02	563,43	102,01	1640,42	0,05	82,1000	232,86
2013-07-02	561,44	105,88	1615,41	0,05	81,0000	233,252
2013-08-02	604,41	108,98	1709,67	0,04	81,8000	233,433
2013-09-02	598,63	115,26	1639,77	0,02	80,2000	233,743
2013-10-02	624,98	110,18	1678,66	0,03	72,4000	233,782
2013-11-02	647,9	106,83	1761,64	0,04	72,0000	234,033
2013-12-02	626,75	112,84	1795,15	0,06	77,5000	234,594