University of Stavanger

Faculty of Science and Technology

MASTER'S THESIS

Study program/Specialization: Industrial Economics/Investment and Finance	Spring semester, 2017 Open
Writer: Thomas Melvin Danielsen	………………………………………… (Writer's signature)
Faculty supervisor: Atle Øglend	
Thesis title: Effect of Exposure to Renewable Energy on Valuation of Oil and Gas Companies	
Credits (ECTS): 30	
Key words: Oil and Gas Renewable Energy Valuation Tobin's q	Pages: 67 + enclosure: 2 Stavanger, 14/06/2017 Date/year

Effect of Exposure to Renewable Energy on Valuation of Oil and Gas Companies

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Spring 2017

Acknowledgements

This thesis was written in the spring of 2017 as a requirement for the degree of Master of Science in Industrial Economics.

I would like to express gratitude to my thesis advisor Atle Øglend for his guidance and support throughout the process. The writing of this thesis has been an interesting experience and I have gained a lot of knowledge and insight into methods and processes that were less known to me before.

I would also like to thank my family for their support during the writing of this thesis, and for always believing in me. This is the second Master's degree I complete while also working full-time, and it would never have been possible without the support and patience of my wife Maren, and my kids Melvina and Møller. I would not have managed without your encouragement.

Abstract

With increasing focus on global warming and sustainable development in the energy sector, a number of oil and gas companies have an expressed interest in increasing investments and exposure towards renewable energy [12, 13, 43, 44]. The purpose of this study is to see if, and how, exposure towards renewable energy will affect the valuation of oil and gas companies. The main challenges have been to find a suitable metric for exposure to renewable energy, and also the oil and gas companies poor reporting practices related to exposure and investments towards renewable energy. To add to the complexity of the process, a number of other factors influence the valuation of oil and gas companies. Nevertheless, by using Tobin's q, the ratio between a company's market value and its replacement cost, as a proxy for company value, we have tested the effect of renewable energy exposure on the company value of a number of oil and gas companies. The analysis has been performed by use of regression analysis and we have tried to isolate the effect of renewable exposure by adding control variables known to affect the valuation of oil and gas companies.

Contents

1 Introduction

In this thesis we will study how exposure to renewable energy affect the valuation of oil and gas companies. We will use Tobin's q as a proxy for company valuation and analyse financial data from six select oil and gas companies to assess the effect of renewable exposure. As no metric for renewable exposure has been found when reviewing the literature, we have proposed our own. The motivation for this thesis, as will be discussed in more detail in section 1.1, is the increasing focus on climate change, a shifting energy mix towards gradual decarbonization, renewable energy and ultimately how oil and gas companies adjust investments in light of this. One limiting factor in the thesis is the absense of data on investment costs and cash flows generated from the renewable energy segments of the analyzed companies. This makes it difficult to assess the profitability of these investments. Unless otherwise stated, figures have been created by the author using data found in the respective companies quarterly and annual reports.

This thesis consists of 3 parts. In the first part, consisting of chapter 1 and 2 we will give some background information, describe the objective and cover some fundamental concepts relevant to the thesis. In the second part, consisting of chapter 3 and 4 we will go through the method used, and data collected in order to perform the analysis. The third part consists of the analysis, discussion and conclusion.

1.1 Background

This section will cover some of the background and motivation for this thesis. First, a summary of the recent climate agreement and the response from some of the oil and gas companies included in the analysis. Since this thesis is concerned with oil and gas companies and their exposure to renewable energy, a quick introduction to both fossil and renewable energy sources will be given in section 1.1.1 and 1.1.2.

The first-ever universal, legally binding global climate agreement was signed by over 190 countries at the Paris Climate Conference (COP21) in December 2015 [2]. The deal outlines a global action plan to limit the global warming to $2^\circ C$. The governments agreed on a need for global emissions to peak as soon as possible, and a rapid decline in emissions thereafter. All in accordance with the best available science [2]. This thesis is motivated in part by the Paris agreement and its potentially large impact on the oil and gas business, and in part by the increasing focus on renewable energy in the media, as illustrated in figure 1, where a simple google news search shows the exponential growth in the number of news articles containing the words “renewable energy”.

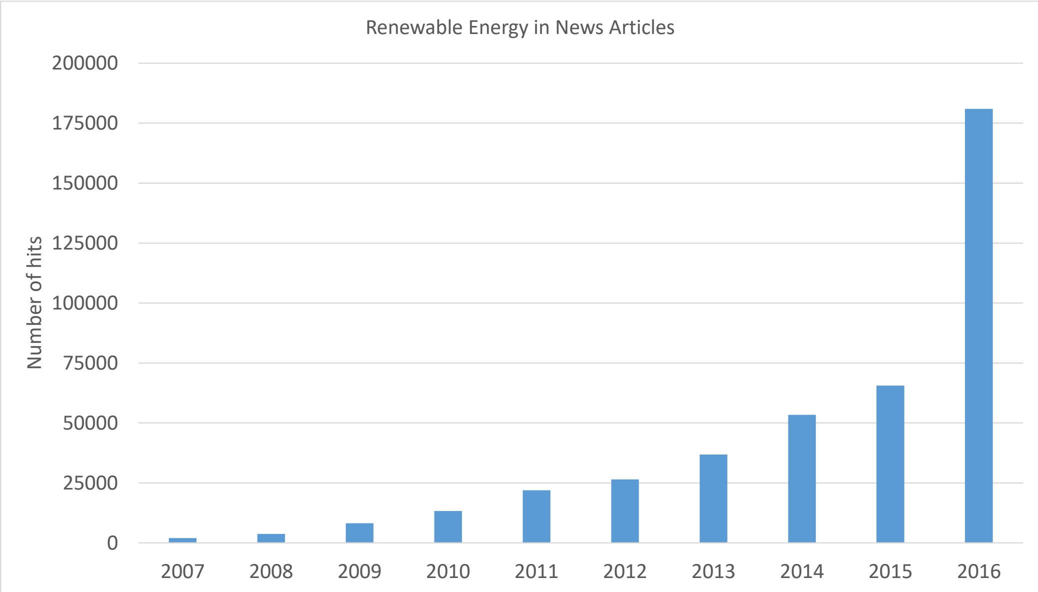

Figure 1: Number of hits on google news for the phrase “Renewable Energy”

Before the Paris agreement, CEOs of many of the biggest oil and gas companies in Europe sent a letter to the top UN official in charge of climate talks at the COP21 meeting, urging the governments to agree to carbon pricing, stating that "we need governments across the world to provide us with clear, stable, long-term ambitous policy frameworks" [41]. In a different letter the CEO's advocated natural gas as the least polluting fossil fuel, wanting to highlight "the major role natural gas can play in addressing climate change" [41]. The CEO's wanted a stable framework, and also promoted gas as a climate "friendly" alternative, and also admitted that "climate change is a critical challenge for our world" [41]. The two American companies, ExxonMobil and Chevron did not want to participate in the European inititiative, with ExxonMobils CEO stating the he did not want to "fake it" on climate change [41].

In the analysis we have included four major European Oil Companies that all signed the aforementioned initiative on climate framework, Statoil ASA, Total SA, BP Plc and Royal Dutch Shell Plc. and two companies that did not sign the initiative, American oil and gas companies, ExxonMobil and Anadarko Petroleum.

Our hypothesis is that with the current focus on climate change, the transition to a low-emission society and increasing popularity of renewable energy investments, as seen in figure 2, oil and gas companies exposed to renewable energy should see an increase in their valuation compared to their peers not exposed to renewable energy. i.e. higher exposure to renewable energy should lead to higher value.

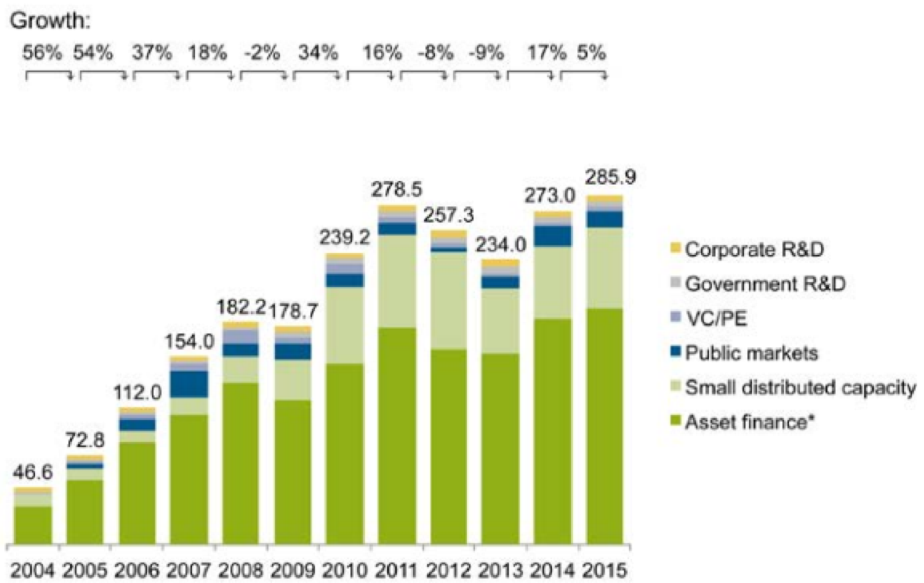

Figure 2: Global new investment in renewable energy by asset class, 2004-2015, $BN, taken from [47]

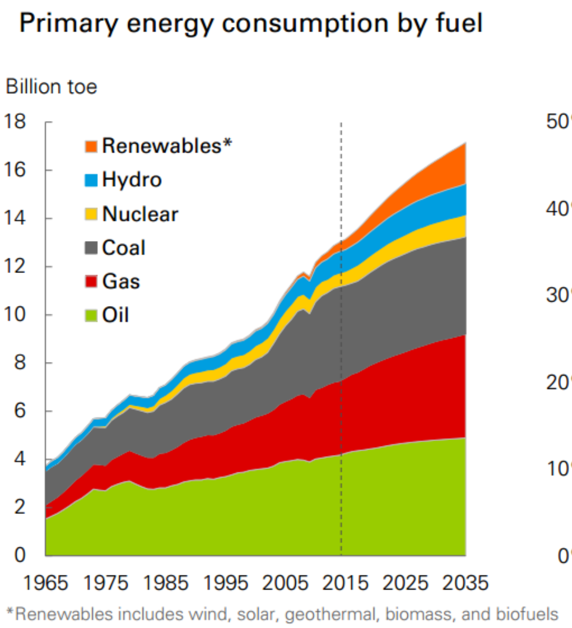

Figure 3: Base case future energy mix from BP's energy outlook 2017 [15].

From figure 3 we can see that most of the growth in energy consumption in the world is predicted to come from renewable energy. It is important to note that BP's energy outlook "considers a base case, outlining the 'most likely' path for global energy markets over the next 20 years based on assumptions and judgements about future changes in policy, technology and the economy" [15]. Many large companies, institutions and government agencies develop their own outlooks to help assess future investment needs. A comparison of contributions to future growth of energy consumption with BP and other energy outlooks can be found in figure 4 .

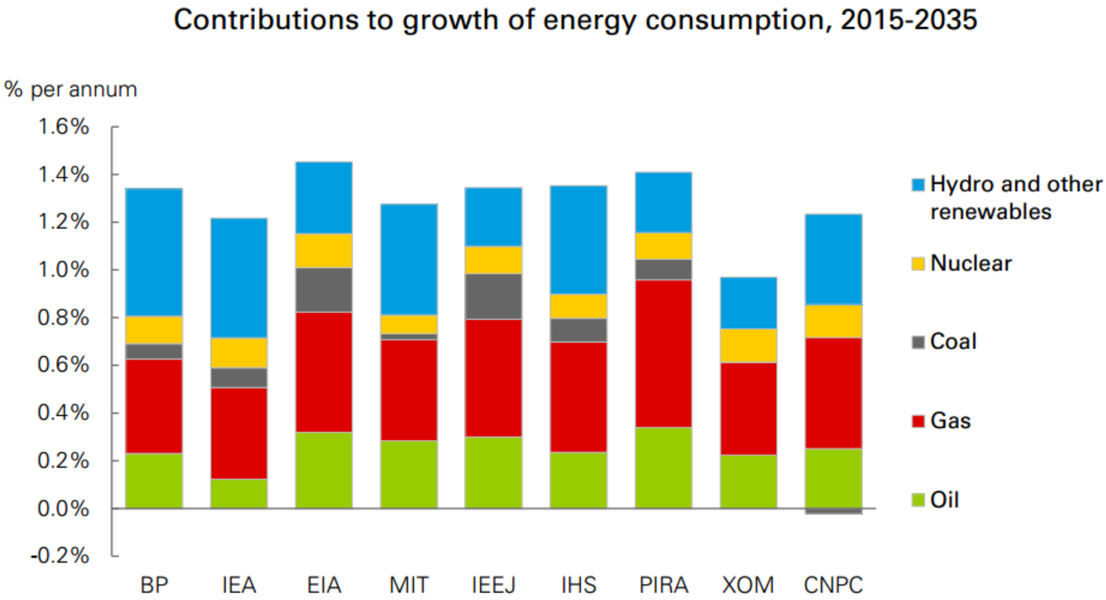

Figure 4: Contributions to growth of energy consumption, 2015 - 2035. Comparison between different energy outlooks. From BP's energy outlook 2017 [15].

1.1.1 Fossil Fuels

Fossil fuels are formed through anaerobic decomposition of organic matter. The fuels and the organisms they are formed from are typically millions of years old, and even though the process of creating more fossil fuels is continous, they are usually thought of as being non-renewable due to the time it takes for them to form, and the fact that they are depleted faster than they form [9]. In 1950, M. King Hubbert, a noted geologist, predicted the peak and decline of U.S crude oil production in 1956 using a simple statistical technique. As seen in figure 5, the prediction turned out to be pretty accurate until the development of tight oil resources proved the original predictions premature [35]. By use of new technology like electric cars, exponential growth in renewable energy, in addition to hopes of limiting global warming to 2 degrees, one can argue that the question now is not how much oil we have left (and if we have enough) but rather how much oil we have to leave in the ground [33].

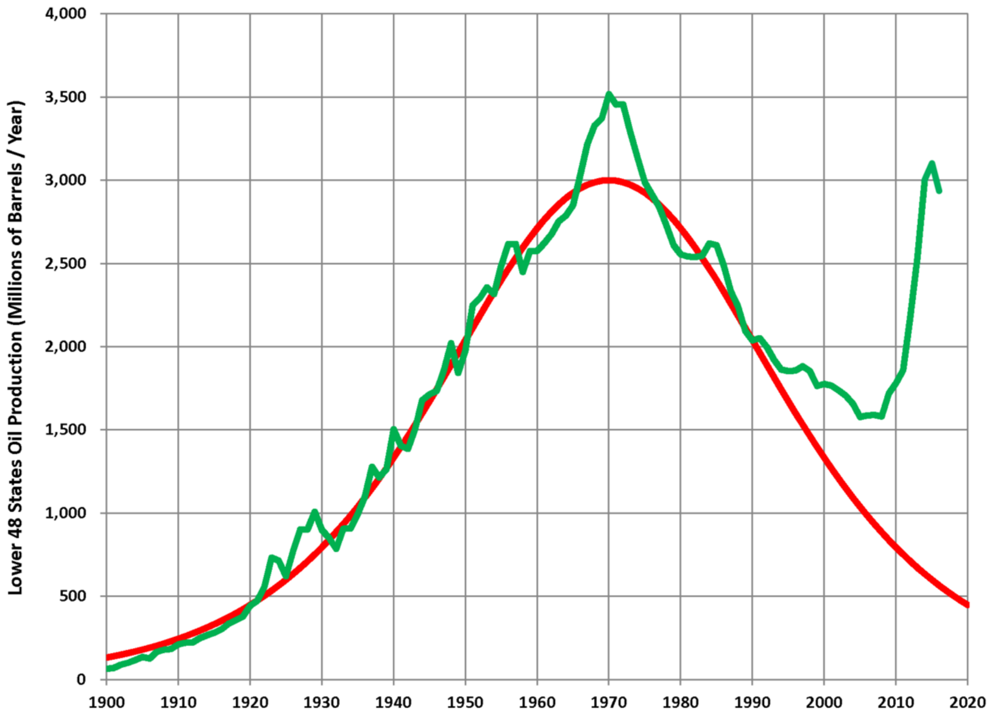

Figure 5: Hubbert's Peak oil prediction for US crude oil production in 1956 and actual production from lower 48 states through 2014. Figure taken from [1].

Oil is a naturally occuring flammable liquid, consisting of a mixture of hydrocarbons of varying molecular weight. The mixture of heavy and light hydrocarbons defines its physical and chemical properties [19]. Oil is particularly valuable because it has some unique qualities that make it an especially advantageous source of energy [48]:

- When it is found, it is one of the easiest energy commodities to produce and use.
- Producing and converting oil to useful products is done with little waste.
- Since it is a liquid it can be transported cheaply by many different methods.
- Compared to coal it is much cleaner and less cumbersome, and is easily converted into gas for use in engines.

These properties make oil particularly valuable for transportation usage, which is its primary market [48]. Oil is arguably the most efficient energy source, however it requires huge long-term investments to produce and use. Consumers also have to make large fixed cost investments in equipment that use oil, like cars, ships, furnaces etc. and those investments are dependent on a reliable flow of petroleum products [48]. Diesel and heating oil will generate around 161 pounds of CO2 per million BTU of energy output [19].

Natural gas is a mixture mostly made up of naturally occuring methane. Natural gas is a considerable source of electricity production, mainly by use of gas and steam turbines, and in 2014 it provided 21.2% of all energy supply in the world, and 21.6% of all electricity generated came from natural gas [8]. Burning natural gas produces 30% less CO2 than oil and 45% less than Coal. With a release of around 117 pounds per million BTU, it is the cleanest fossil energy source [19].

Coals are sedimentary rocks which contain both combustible and incombustible matters in addition to water. Coal can have various compositions and energy content, depending on type. Some of the most common coals are anthracite coal and bituminous coal. Because of the high carbon content, coals generate more CO2 per released energy unit, ranging from 205 - 229 pounds of C02 per million BTU of energy, making it the worst fossil fuel in terms of CO2 emissions [19].

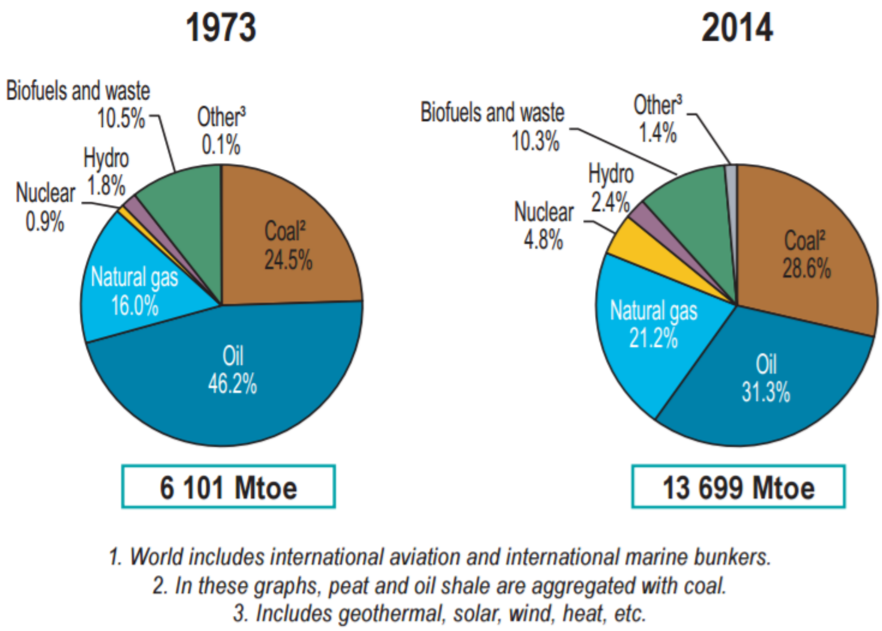

Figure 6: Worlds total primary energy supply in 1974 and 2014. The other category includes geothermal, solar, wind and heat. Figure taken from [8]

Figure 6 shows that in 2014 the fossil fuels (excluding nuclear) still accounted for 81.1% of the worlds total primary energy supply.

1.1.2 Renewable Energy

The term renewables covers a variety of energy sources that are renewable in the sense that unlike oil and gas, they do not exhaust the raw material. This is a truth with modification since ultimately they are all dependent on the sun, which provides energy by burning a finite amount of fuel. They also require raw materials for construction of e.g. wind mills, turbines or solar power [29].

Hydro The most dominant and well-tested renewable energy source is hydropower, which accounted for 2.4% of the total energy supply in the world in 2014, making it bigger than all other renewable energy sources combined. Hydropower is mainly used for electricity generation, where it provided 16.4% of all electricity generated in 2014 [8]. Hydroenergy is created from the kinetic energy of moving water, which originates from the potential energy of dammed water. This moving water is in turn used to drive turbines. Power generation from water is a function of volume and the difference in height between the source and the outlet.

Wind is an energy form that has been used for over two millennia when windmills started harnessing the power of wind to grind corn and pump water. The energy output from wind turbines can be very unreliable because of the variable nature of wind. Energy output from windmills are proportional to the cube of the velocity, so they create little energy with low velocities, and they have to be constrained when velocities are high [29]. As can be seen from figure 7, the global installed capacity for windpower has increased substantially over the last 15 years, with installed capacity set to reach 500 000 MW in 2017.

Solar power harnesses energy from the sun, which is sent towards earth at a rate of about 100PW per year, this is equivalent to $5 * 10^{20}$ Joules per year, wich is enough to satisfy our energy needs seven thousand times [29]. The most common methods for electricity generation from solar power is through solar electric generating systems and photovoltaic cells. Solar electric generaration systems work by use of parabolic mirrors focusing the sun's energy to drive a conventional steam turbine. Photovoltaic cells, or solar cells, converts light into electriciy by use of semiconductor materials. Assemblies of solar cells are what is often referred to as solar panels [19]. As can be observed from figure 8 the global installed capacity in photovoltaic power has increased substantially since 2000, with over 200GW of installed capacity in 2015.

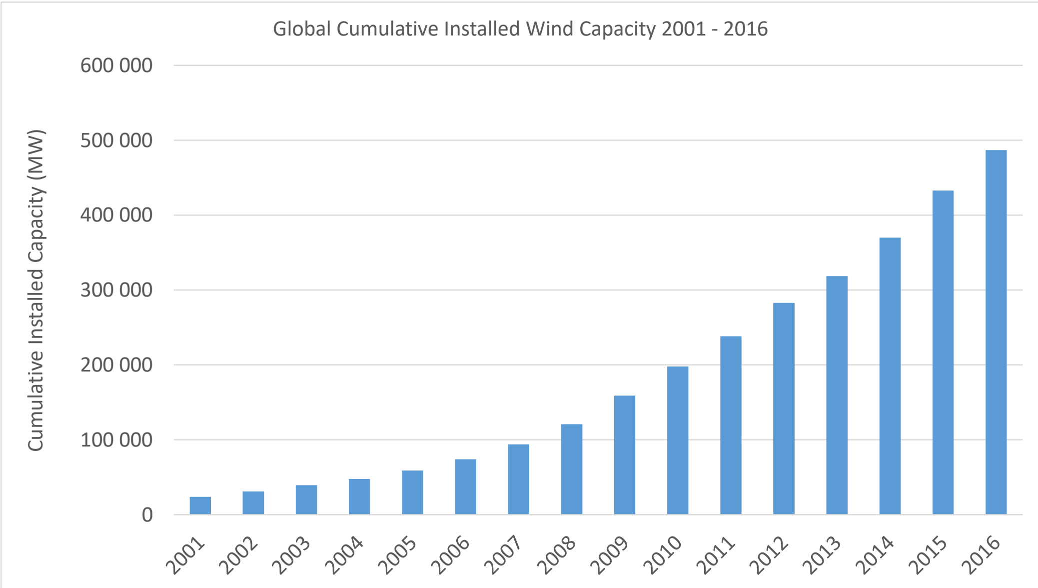

Figure 7: Global Cumulative Installed Wind Capacity from 2001 to 2016. Plot created by author based on data from GWEC [16]

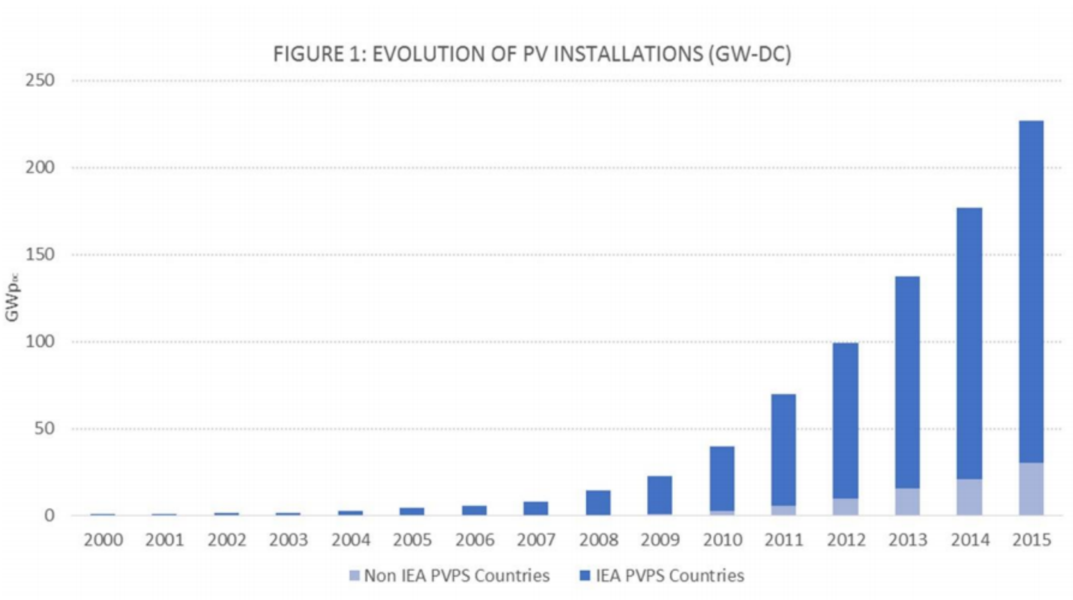

Figure 8: Evolution of photovoltaic installations from 2000 - 2015. Figure taken from [7]

2 Theory

In this chapter we will describe general principles and fundamental concepts related to this thesis. In section 2.1 we will cover the basics of company valuation, and the three most common methods of performing company valuation, the cost method, the discounted cash flow approach and the price/characteristics method. In section 2.2 we will discuss in detail the proxy that we have used for company valuation, Tobin's q, wich is a form of the price/characteristic method. Section 2.3 will give a detailed introduction to valuation of oil and gas companies and some of the characteristics that make them special in terms of accounting.

2.1 Company Valuation

Company valuation is a process used to estimate the economic value of a company. It has been described as the cornerstone of security analysis, and because of its importance, both individuals and businesses spend great amounts of time and effort performing different valuation processes and techniques [32]. The value of a company should not be confused with its price, which is the price agreed upon between a buyer and a seller in a fair market [26], as will be discussed in section 2.1.4. Generally speaking, a company's value can differ between different buyers, and even between buyers and sellers. For investors, creating independent estimates of companies worth and comparing that valuation with the market price is a key driver in deciding if they want to buy, hold or sell a stock. When setting the terms of a loan, bankers assess expected future cash flow and the potential collateral value for businesses. Financial advisors will also offer fair-value opinions for tax purposes as well as employee stock ownership plans [28].

There are three fundamental approaches to valuing a business: The cost method, the discounted cash flow approach, and price/characteristics ratios. They are often referred to as the Cost, Income and Market Comparison methods [28].

2.1.1 Cost Method

Using the cost method for business valuation requires two steps. The first step consists of an appraiser giving estimates for the cost of replicating the assets of the company. In the second step the appraiser adjusts for intangibles. The cost method is commonly applied to the total assets of the company and therefore produces a valuation number for the combined debt and equity holders [28]. There are four common variations of the cost methods that are used when the appraiser gives estimates of the cost of replicating the company assets; Replacement, Adjusted Asset, Liquidization and Book [28]. Heaton at al [28]. lists the first steps in valuation for the four cost approaches as seen in figure 9. The next step in

	Company Value is Equal to:	Approach should be used if:
Replacement	The cost of building a new company with same productive capacity by use of newer technology or processes	New technology or processes make the older prices unusable for the current industry
Adjusted Assets	The estimated market value of the assets on the balance sheet	The book value is notably different than the market values and the market values are predictable
Liquidization	The value of assets if the company where to go bankrupt	The objective is to assess collateral value given that they can be affected by bankruptcy
Book	The book value of an asset on the balance sheet	Book values are close to market values

Figure 9: First step in the Cost method of company valuation according to Heaton et al. [28].

the cost method is to add the company's intangible assets, which are things like brand-name recognition, reputation, experience and knowledge. Heaton et al. [28] notes that although valuation of intangibles is subjective at best, it is necessary in all cost valuation approaches.

2.1.2 Discounted Cash Flow Approach

According to financial theory, the fair market value of a company is the present value of its expected cash flows. This conceptual framework is called the discounted cash flow (DCF) approach to valuation [32]. The steps required to calculate the DCF are simple and straightforward in theoretical execution; simply add the present values of individual cash flow estimates from year 1 to infinity. In practice, however, the calculation will be both complex and highly subjective. The formula for calculating DCF is

$$Value = \sum_{n=1}^{\infty} \frac{CF_n}{(1+i)^n} \tag{1}$$

where CF = cash flow, i = discount rate and n = time periods from one to infinty. It is usually possible to provide acceptable estimates of next year's cash flow, but for each additional year it will become increasingly difficult [32]. Working with time periods that extend to infinity can be difficult in the real world, so when the DCF method is used to value a company, the distant future is usually combined into a value representing the terminal value, or estimated sale price, at a point in the near-future [32]. The formula will then be modified to:

$$Value = \sum_{n=1}^{\infty} \frac{CF_n}{(1+i)^n} + \frac{TV_t}{(1+i)^t} \tag{2}$$

Where TV is the terminal value and n is now time periods from 1 to t. It is typical to calculate the individual cash flows 5 to 10 years into the future and then estimate the terminal value of the company. The DCF approach for valuation is technically the most "correct" approach [32]. But great care is needed when when estimating cash flows, discount rates and terminal values. From figure 10 it is obvious that the discount rate has considerable effect on discounted cash flows, and ultimately the net present value.

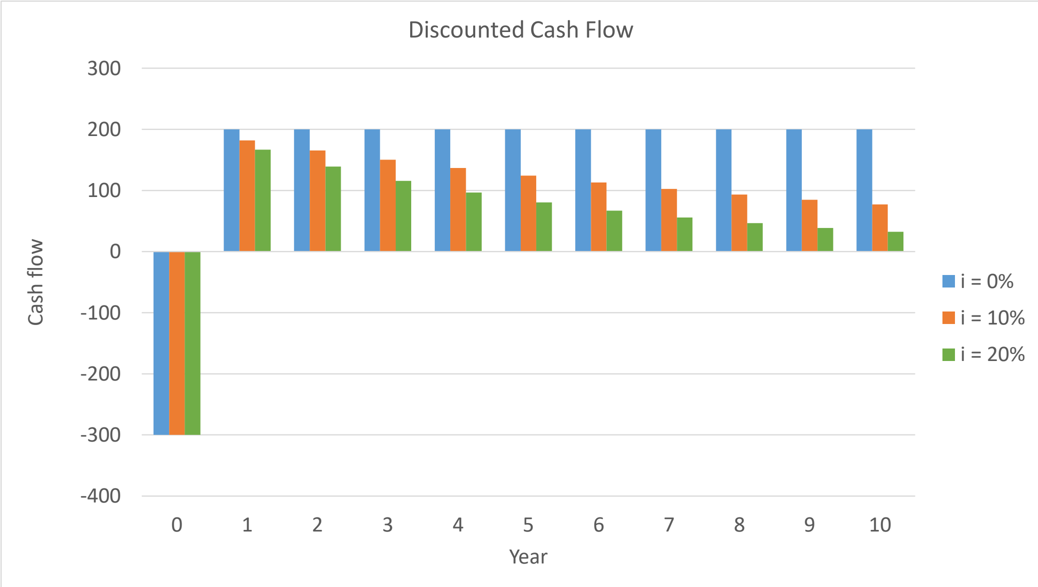

Figure 10: Effect of varying discount rates on discounted cash flows. Figure created by author.

2.1.3 Price/Characteristic Ratio Method

This approach uses ratios from comparable companies with known stock prices. Basically, a value-related number is divided by some characteristic of the company to estimate a price/characteristic ratio. Using the price/characteristics ratio method, like the DCF approach, can seem simple and straightforward at first, but there exists difficulties that can lead to significant misestimates of value if it is not used with care [28]. The price/characteristic ratio method is often used as a complementary method to verify the plausability of the company values obtained by using the DCF method, although it is also used as a valuation alternative [45]. To value a company using the price/characteristics method one would usually identify a set of companies with known values that are comparable to the company that's subjected for valuation. Heaton et al. [28] lists six important issues that should be adressed to determine comparability: 1) Using the ratio of a conglomerate to estimate the price of a less-diversified company can be dangerous. 2) The accounting systems employed in the comparable companies need to be similar to the subject company, since that is where the characteristics come from. 3) It may be necessary to have comparability in customer base, age of assets, management philosophy, size, location and a multitude of other variables to have comparable values. 4) Financial structure of the companies should be very comparable as measured by different financial ratios. 5) Expected growth and risk associated with comparable companies should be considered. 6) A belief in an efficient market is the basis for all price/characteristics methods. Therefore the price/characteristics approach to valuation assumes that publically traded companies are correctly priced [28]. Some of the most common price/characteristics methods are price to earnings ratio, price to book ratio, price to sales ratio or enterprise value over EBIT.

2.1.4 Market Value

The market value is defined as “the price at which a good or a service can be bought or sold, and determined by the interaction of buyers and sellers in a specific market at a specific point of time” [22]. Market price is often also referred to as the market capitalization when talking about publically traded companies. Market capitalization is obtained by multiplying the current share price by the number of outstanding shares. It is easiest to determine for exchange-traded instruments, like stocks. Determining market value for illiquid, assets like businesses or real estate is most difficult and often require the aid of business valuation experts or appraisers. Market value depends on many different factors, such as profitability, debt load, general market environment and which sector the company operates in [5]. Market value is often used as the numerator when calculating Price/Book ratio, and is also used in the calculations of Tobin’s q.

2.1.5 Asset Value

Asset value, or book value, is the value of an asset according to its balance sheet account balance. The book value for an asset is usually based on the original cost minus any depreciation amortization or impairment cost made against the asset [30]. On the balance sheet, cash and cash equivalents are booked at cash value, while other assets, e.g. processing plants, equipment, office buildings etc. are valued based on their aquisition cost. By monthly or annual depreciation, amortization and depletion the book value of these assets are reduced over time [34]. One of the largest uncertainties when calculating Tobin’s q for different companies is with regards to the different companies procedure for discounting the value of their assets.

2.2 Tobin's q

Tobin's q, defined as the ratio of the market value of the company to the replacement cost of its assets, has an important role in many financial interactions. It has historically been used to explain a number of diverse corporate phenomena, such as financing, dividend and compensation, investment opportunities and tender offer responses, relationships between managerial equity ownership and company value, cross-sectional differences in investment, and diversification decisions [27]. Tobin's q is commonly used as a proxy for company valuation in the literature, and will be used as the measure for company value in this thesis. Tobin's q was derived by nobel laureate in economics, James Tobin. Tobin hypothesized that the combined market value of all companies on the stock market should equal their replacement cost and is calculated as:

$$Tobin's\, q \;=\; \frac{Total\, Market\, Value\, of\, Company}{Total\, Asset\, Value} \tag{3}$$

according to [3]. As noted in section 2.1.4, the total market value of the company is priced in the stock market and equals the number of shares outstanding multiplied by their market price. If Tobin's q is larger than 1 companies should undertake investments, because installed capital, goods or services are priced higher than their cost. Conversely, if Tobin's q is less than 1 companies should not undertake investments and should reduce their existing capital. However, companies can delay expansion or contraction for some time and only do so if Tobin's q remains significantly above or below 1 [20].

There exist multiple different methods to compute Tobin's q, where some are more complex than others, Dowell et al. [21], proposed to calculate Tobin's q as

$$Tobin's\, q \;=\; \frac{MVE + DEBT}{TA} \tag{4}$$

where MVE are the company's outstanding shares times share price, DEBT is book value of long-term debt and net current liabilities, TA is book value of inventory and net value of physical plant and equipment.

Pacheco de Almaida et al. [18] proposed a slightly different method;

$$Tobin's\, q \;=\; \frac{MVE + PS + DEBT}{TA - CA + BI} \tag{5}$$

where MVE is the company's outstanding shares times share price, PS is the book value of preferred stock, DEBT is long term debt and current liabilities less current assets, TA is total assets, CA is current assets and intangibles and BI is the book value of inventory.

Lindenberg and Ross proposed calculating Tobin's q via the following formula

$$L - R\,q = \frac{PREFST + VCOMS + LTDEBT + STDEBT - ADJ}{TOTASST - BKCAP - NETCAP} \tag{6}$$

where PREFST is defined as the liquidation value of the company's preferred stock, VCOMS is the price of the company's common stock multiplied by number of shares outstanding, LTDEBT is the value of the company's long term debt adjusted for age structure, STDEBT is the book value of the company's current liabilities, ADJ is the value of the company's net short term assets, TOTASST is the book value of the company's total assets, BKVAP is the book value of the company's net capital stock and NETCAP is the company's inflation-adjusted net capital stock [27]. Lindenberg and Ross is one of the more elaborate estimates of Tobin's q and is very often referenced in the literature [21, 27, 42].

Chung and Pruitt [27], noted that many of the calculations of the ratio are computationally intensive, and they proposed an approximate version of Tobin's q as seen in formula 7:

$$Tobin's\,q \;= \frac{MVE + PS + DEBT}{TA} \tag{7}$$

where MVE is the product of a company's share price and the number of common outstanding stock shares, PS is the liquidation value of the company's preferred stock, DEBT is the value of the company's short term liabilities net of its short term assets, plus the book value of the company's long term debt, and TA is total assets. This approximation is very conservative with respect to data requirements and computational effort, and in addition, when performing a cross sectional comparison between L-R q, equation 6, and approximate Tobin's q, equation 7, Chung and Pruitt noted that the two sets of Q ratios were strongly equivalent where the R^2 value from the regressions never fell below 0.966 indicating that at least 96.6% of the variability in L-R q could be explained by the approximate Tobin's q [27]. This supports that we can use approximate Tobin's q for our analysis. A quick analysis on the data in this thesis shows that simplest version of Tobin's q, equation 3, is highly correlated with approximate Tobin's q, with an R^2 of 0.931, meaning that we could also have performed the analysis using this simple version of Tobin's q, see figure 11.

The denominator in the calculation of Tobin's q is the replacement cost of the company's assets. The calculation of this number can be very problematic because it requires estimations of the cost of the company's assets, in current terms [11].

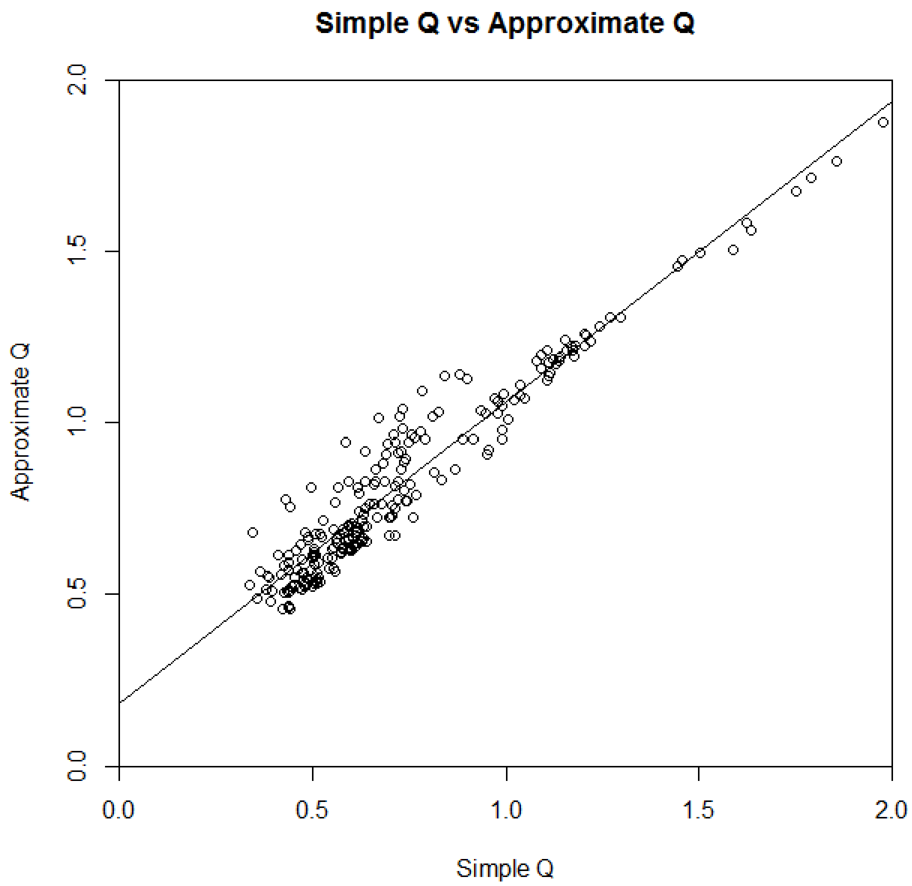

Figure 11: Simple Tobin's q vs. approximate Tobin's q, based on data analyzed in this thesis

A number of procedures have been proposed for estimating these replacements costs, but they are all fairly inconvenient. However, research has shown that book value of total assets can be a relatively unbiased estimate of replacement costs [11, 27, 42]. Figure 12 shows the historical values for Tobin's q for American companies since 1900, showing that Tobin's q has a tendency to fall as low as 0.3 after stock market crashes, and rise as high 1.6 in bullish market conditions.

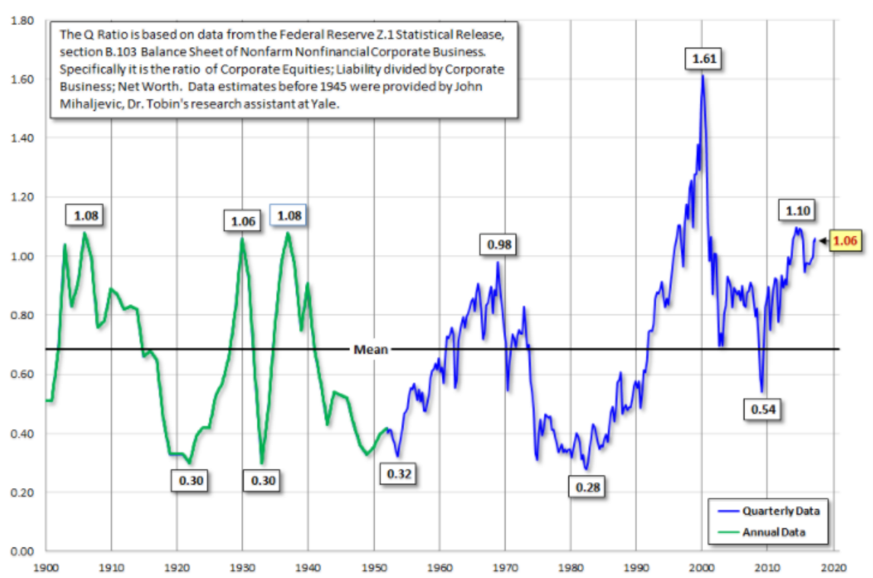

Figure 12: Tobin's q since 1900. Figure taken from [6]

Our hypothesis, as stated in section 1.1, is that exposure to renewable energy should increase the value of a company due to the increasing popularity of environmental technology and the focus on climate change. However, if a company chose to invest capital in renewable projects that have lower financial metrics, e.g. net present value, compared to alternative investment options in oil and gas projects, it follows from the DCF approach to valuation that this could decrease the value of the company [32]. Since Tobin's q > 1 indicates that the market values installed capital higher than its cost, it is a very suitable proxy for valuation in this thesis, as this is what our hypothesis entails.

2.3 Valuation of Oil Companies

Since the petroleum industry is an important global industry, where the largest international oil and gas companies, sometimes referred to as the majors, are among the biggest companies in the world, they are followed by large numbers of investors and financial analyst. These investors primary concern is to evaluate accounting information, and by using valuation techniques, hoping to successfully predict movements in the future stock price. While some studies have shown that accounting information like book value of equity can be value relevant, the common view has been that historical cost accounting is unsuitable in conveying oil and gas company fincancial performance accurately to the market [37]. A consequence of this is that oil and gas companies are required to disclose additional operational and financial data. Some of the reasons for the lack of confidence in historical cost accounting in the oil and gas industry are due to the certain characteristics that distinguish the oil and gas companies from other companies involved in asset acquisition and useage [37]. Misund et al. [36], in continuation of Wright and Gallun's [28] work list some of the primary factors responsible for the different accounting practices in the oil and gas industry:

- The probability of discovering commercial reserves is often low, and the risks are high.
- There often exists a long time lag between the aquisition of permits and licences and the eventual production of reserves
- Expenditures and results are not always correlated
- The underlying value of reserves (which is a major component of the company's worth) is not valued reliably enough to record on the balance sheet
- Discovery of new reserves, which is a major future income event, cannot be valued reliably enough to be recorded as income
- High risk and high cost often results in joint ventures

Osmundsen et al. [40] also note that the historic accounting information gathered and reported by the oil and gas companies has done a poor job of conveying true economic results. They mention that some other particular problems in valuation of and gas companies is the asymmetric response to new information. An implication of this asymmetry is that good information takes longer to be accounted for than bad information, which is more quickly reflected in reserves estimates. Reserves are also noted in current oil price, as opposed to mid-cycle prices [40], implying that reserves change with changing oil price. Also, initial depreciations are too high, and the assets are often times depreciated too quickly. Osmundsen et al. [40] notes that an effect of this may be that new activity is easily punished, while passivity is rewarded. Some other measurement challenges that are specific to the oil and gas business are cyclical investment patterns and long lead times, which can amplify measurement errors. Similar effects might arise due to the discontinuous and stochastic nature of new discoveries [40].

3 Method

In this chapter the method of data analysis is discussed. To illustrate how data analysis will be performed, a brief introduction to regression analysis will be given in section 3.1, together with some of the interpretation methods used to assess the results of the regression. Some potential pitfalls when performing regression analysis will also be covered.

3.1 Regression Analysis

It is often necessesary to solve problems involving sets of variables where it is known that there exists some sort of inherent relationship among the variables, for example how the price of a house is related to its size. We distinguish between dependent variables, variables that depend on some other factor, and independent variables (also known as regressors, variables that are independent of other variables that you might be trying to measure, sometime referred to as the explanatory variables). A commonly used form of the relationship between the response Y and the regressor x is the linear relationship [49]:

$$Y = \beta_0 + \beta_1 x \tag{8}$$

where β_0 is the intercept and β_1 is the slope. If the relationship between x and Y is exact then we can say that there is a deterministic relationship between the two variables and there is no random or probabilistic component to it [49]. However, one would find that in most cases the relationship is not deterministic (ie. a given x does not always give the same value of Y). Since the relationship cannot be viewed to be exact, many important problems will have a probabilistic nature. The objective of regression analysis is to find the best relationship between Y and x, give a measure of the strength of that relationship, and also using methods that allow for predictions of the response values given values of the regressor x. However, in many research problems where regression analysis is applied, more than one independent variable is desired in the regression model. According to Walpole et al. [49], "the complexity of most scientific mechanisms is such that in order to be able to predict an important response, a multiple regression model is needed". A simple multiple regression model with two explanatory variables can be expressed by the formula

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \tag{9}$$

A panel data set, or longitudinal data, is a combination of cross-sectional and time series data, where the aim is to follow the same companies, individuals, etc. across time [50].

When performing the analysis it quickly became evident that there was trending in the data, see figure 13 for an example. This was also evident by the significant correlations between all variables as seen in figure 31 in appendix A. This

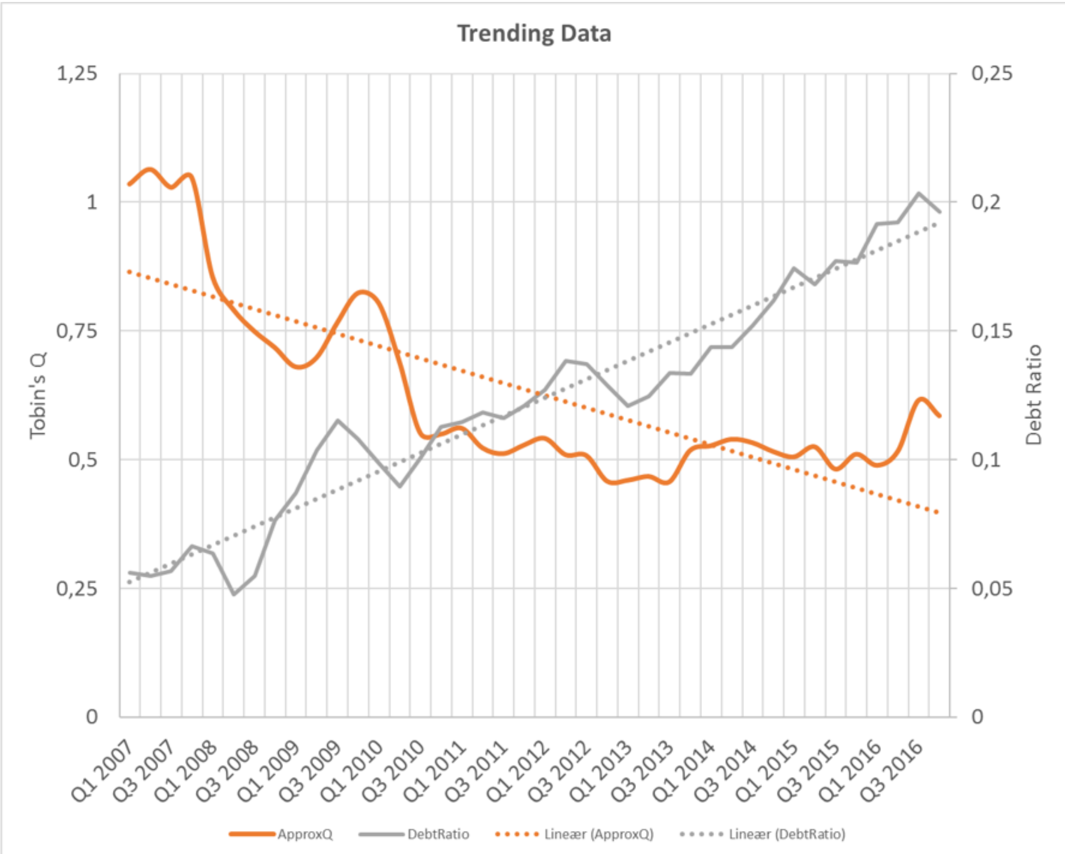

Figure 13: Example of trending data in our analysis

non-stationarity caused some issues with the analysis and resulted in spurious regression results. A more thorough explanation of this and the mitigating measures will be further explained in section 3.1.2

3.1.1 Interpretation of Regression Results

This section will cover some of the descriptives used to interpret the regression results

The Coefficient of Determination or R^2 as it is more commonly expressed as, is a measure of the proportion of variability explained by the fitted model [49].

In an analysis of variance approach to hypothesis testing, one makes use of the error sum of squares:

$$SSE = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 \tag{10}$$

and SST wich is the total corrected sum of squares:

$$SST = \sum_{i=1}^{n}(y_i - \bar{y}_i)^2 \tag{11}$$

SST represents the variation in the response values that ideally could be explained by the model, while SSE is the variaton due to error, or the unexplained variation [49]. Therefore, if $SSE = 0$, then all variance must be explained by the model. This means that the quantity that describes the explained variation is $SST - SSE$. The coefficient of determination, R^2, is defined as

$$R^2 = 1 - \frac{SSE}{SST} \tag{12}$$

If the model's fit is perfect then all residuals must be zero and therefore R^2 must be equal to 1. If however, the difference between SSE and SST is very small, meaning that the model is not adequately predicting the dependent variable, R^2 will be closer to 0. Clearly, adding more explanatory variables can only decrease SSE, and thus increasing R^2. This practice of overfitting can be unwise as it will give inflated R^2 values [49]. To account for the addition of more explanatory variables one can consider the adjusted R^2 instead of R^2. The adjusted R^2 adjusts for the degrees of freedom by dividing SSE and SST by their respective degrees of freedom [49]:

$$R^2 = 1 - \frac{\frac{SSE}{(n-k-1)}}{\frac{SST}{(n-1)}} \tag{13}$$

If more than one explanatory variable is included in the analysis, the reported R^2 will always be the adjusted R^2 in this thesis.

Coefficients The regression coefficients is the collective term for the slopes (β_1, β_2 etc.) in the regression equation. Each coefficient is the expected change in the dependent variable when a explanatory variable increases by one unit, while keeping all other explanatory variables constant. The sign in the coefficient lets us easily distinguish if an explanatory variable has a positive or negative impact on the dependent variable [10].

P-value The p-value or probability value is the lowest level of significance at which the observed value of the test statistic is significant [49]. A low p-value (usually within some preselected significance level) can lead to the rejection of the null hypothesis, which in turn leads to the acceptance of an alternative hypothesis, the hypothesis one would usually like to test. The most commonly used significance levels are 95% and 99%.

3.1.2 Trends and Seasonality

Many different time-series, including economic ones, have a common tendency of growing over time. To be able to draw causal inference when utilizing time-series data it is important to recognize that some series contain a time trend. If one does not take into account that two sequences are trending in the same or in the opposite direction, it can lead to false conclusions regarding how much changes in one variable are caused by changes in another variable [50]. It is noted by Wooldridge [50] that in many cases, two time-series processes appear to be correlated only because they are both trending over time for reasons related to other unobserved factors. Because of these characteristics, an issue when performing time-series regression when the variables exhibits trends is that they tend to have very high R^2, especially compared to R^2 for cross-sectional data [50]. Noriega et al. [38] also points out that since trending mechanisms can be common features in the long-run behaviour of many macroeconomic time series, caution should be used regarding inferences drawn from OLS regression analysis and the probability of finding nonsense correlations between independent series with either deterministic or stochastic trends will be high in finite samples, and also it will grow with increasing sample size [38].

To account for trends in the data a typical solution is to include a time trend as a dummy variable in the regression. Rather than regressing y on x and t it is possible to remove the trend from y and each of the variables in x by regressing each variable on t and saving the residuals. One then obtains a detrended y^* and detrended explanatory variables x^* [50].

Another method of detrending the data is using the first difference method, where one simply subtract from each point the point that came before it so that the regression equation becomes

$$\triangle Y = \beta_0 + \beta_1 \triangle x_1 + \beta_2 \triangle x_2 \tag{14}$$

where

$$\triangle Y = Y_t - Y_{t-1} \tag{15}$$

and the same for $\triangle x1$ and $\triangle x2$. Several diagnostics tests exists for discovering trends and serial correlation. Some of the most common ones are the Dickey-Fuller test to check for stochastic trends and Wooldridge's first-difference test for serial correlation [17]. The first difference method proved most effective in removing non-stationarity and serial correlation issues and has been applied in this thesis.

3.1.3 Multicollinarity

Inclusion of explanatory variables that are highly correlated with other explanatory variables in the model will introduce a problem called multicollinarity. The problem being that when explanatory variables are highly correlated with eachother, it is very difficult to sort out their separate influence on the dependent variable. Highly correlated explanatory variables in the model can also cause regression coefficients to change sign, the implication of which is that a variable that should have a positive impact on the dependent variable is interpreted to have a negative impact instead [10]. Wooldridge [50] however, states that if B_1 is the variable we are interested in, as long as x_1 is uncorrelated with x_2 and x_3, it does not matter how much correlation there is between x_2 and x_3. A lot of statistics for determining the severity of multicollinearity exists, but it is easy to misuse because it is difficult to specify how much correlation among explanatory variables is "too much" [50].

3.1.4 Autocorrelation of Residuals

When a variable is correlated with its own previous value, typical in a time-series dataset, it is said to have autocorrelation. The implication of autocorrelation of residuals in a model is that e.g. an overprediction in one month is followed by an overprediction in the following month and vice versa [10].

3.1.5 Z-scores for identification of outliers.

Z-scores, or standard scores are used to test for outliers. Outliers are observations that seem to deviate from other observations in the data set. Z-scores is simply the variable values transferred to zero mean and unit variance [25].

4 Data

A brief introduction to Tobin's q as the dependent variable will be given in this chapter. Then, the measure for exposure to renewable energy will be established, before a description of the control variables that have been assessed in the thesis in addition to the data sources that have been used. Finally, a quick introduction to the companies included in the analysis.

The analysis will cover Tobin's q of six companies using quarterly data from the last 10 years, providing a total of 40 datapoints per company. We will perform yearly cross-sectional regressions, perform a full panel data regression, and also a company specific regression.

The basic regression equation to be estimated is

$$Y = \beta_0 + \beta_1 x \tag{16}$$

Where Y and x will be introduced in this chapter. The correlation tables for the dependent and explanatory variables were created using IBM SPSS. Since SPSS has some shortcomings when it comes to panel data regressions, these where performed by writing simple R scripts utilizing the plm package. R was also used to perform the time-series regressions. Only the R script for running diagnostics is included in the appendix.

4.1 Dependent Variable

Although many measures of valuation exists, in this thesis we have chosen to use Tobin's q as a measure for valuation of the companies included in the analysis. Because of the computationally intensive data often needed to calculate Tobin's q, we chose the approximate form of Tobin's q, proposed by Chung and Pruitt [27], as the dependent variable. The approximate form is far more conservative with respect to data requirements and computational effort, which made the data gathering more manageable. A detailed description of approximate Tobin's q can be found in section 2.2.

The dependent variable is then defined by equation 7 in section 2.2, as

$$Tobin's\,Q = \frac{MVE + PS + DEBT}{TA} \tag{17}$$

The dependent variable has been calculated for all companies on a quarterly basis, using data in the companies quarterly and annual reports in addition to stock information. The calculation has been as follows: MVE has been calculated using the average stock price for the quarter multiplied by the average number of outstanding shares found in the quarterly report. Preferred stock has been taken from the quarterly balance sheet. Long term debt, short term assets, short term liabilities and total assets were also readily available from the balance sheet for all companies. Introducing Tobin's q as the dependent variable in the basic regression gives:

$$Tobin's\, Q = \beta_0 + \beta_1 x \tag{18}$$

4.2 Measure for Exposure to Renewable Energy

No metric that expresses oil and gas companies' exposure to renewable energy has been found in the literature. Therefore we will propose our own; Megawatt of installed capacity of renewable energy per thousand barrels of oil equivalents produced per day:

$$RenewableExposure = \frac{MW installedRenewableEnergy}{Kboepd} \tag{19}$$

Hereby shorted to

$$RenewableExposure = \frac{MW}{KBoepd} \tag{20}$$

This measure should be able to address the oil and gas companies' relative exposure towards renewable energy since it is a ratio between installed capacity and production. The metric will scale well to oil and gas companies of different sizes since production measured by kboepd is a good proxy for size [39], making it easy to compare the exposure towards renewable for large as well as small companies. As we can see from figure 14 there is a wide spread in renewable exposure for the companies included in the analysis. BP has the highest ratio, close to 0.5, whilst Statoil and Shell are fairly flat around 0.07 and 0.15. We note that installed capacity does not equal energy generation, wich is found by multiplying the capacity by number of operation hours, e.g number of hours a windmill is active. One of the limitations of using installed capacity is that the actual operating hours, or capacity factor, is different for different renewable energy sources. Electricity generation from hydro and fossil fuels generally have significantly higher capacity factors compared to wind and solar [23]. The metric does not distinguish between types of renewable energy, meaning that one megawatt of installed capacity of wind energy is as valuable as one megawatt installed capacity of, for example, solar. Another thing to note is that some companies are also exposed to biofuels, another type of renewable energy, but that has not been included in the analysis. The same applies to carbon capture and storage. Since BP sold its solar division in 2011, Total is the only company exposed to solar power, the rest is mainly wind.

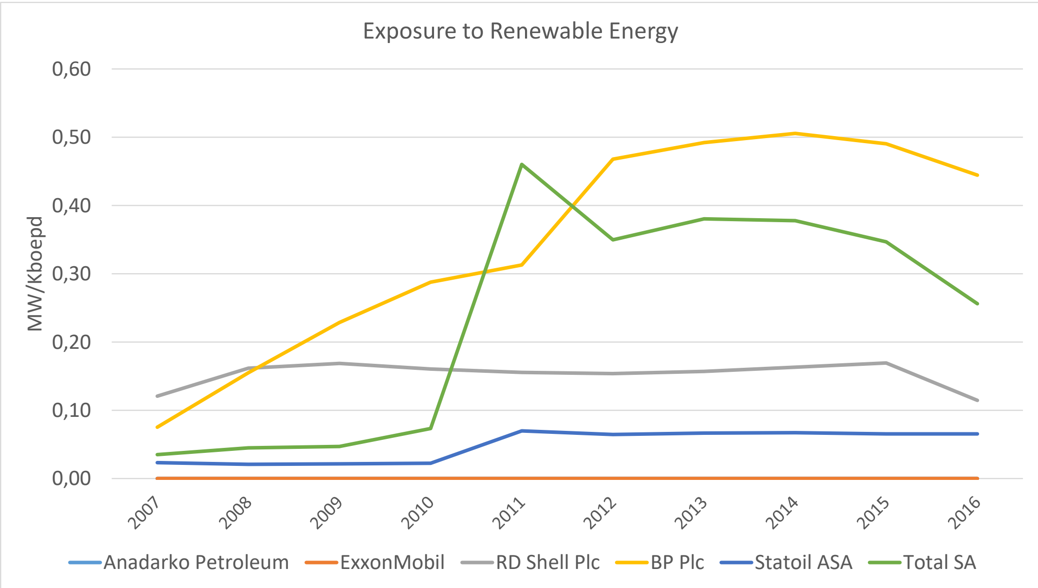

Figure 14: Our proposed measure for exposure to renewable energy for the companies included in the analysis.

The measure for exposure to renewable energy will be the independent variable in this thesis, which means it replaces the x in equation 18.

$$Tobins\, q = \beta_0 + \beta_1 * \frac{MW}{Kboepd} \tag{21}$$

4.3 Control Variables

It is often necessary in regression analysis to include control variables in order to isolate the causal effect of the particular variable we are interested in [50]. We've chosen to include control variables that have been discussed in previous research on the subject[39, 40].

4.3.1 Oil Price

When performing analysis of oil companies in a time-series setting, the evaluation would have to adjust for oil and gas price volatility [40]. It is important to uncover whether good or bad company performance is merely due to favourable or unfavourable oil market conditions, or if a better or worse performance in the stock market can be attributed to changes in the company's underlying operation [40]. This normalization for oil price is important also in a cross-sectional setting since it allows for comparison of companies with differing portfolios. Companies will have different exposure to refinery margins and the oil and gas price fluctuations [40]. As noted in [40], integrated oil and gas companies spread their activities

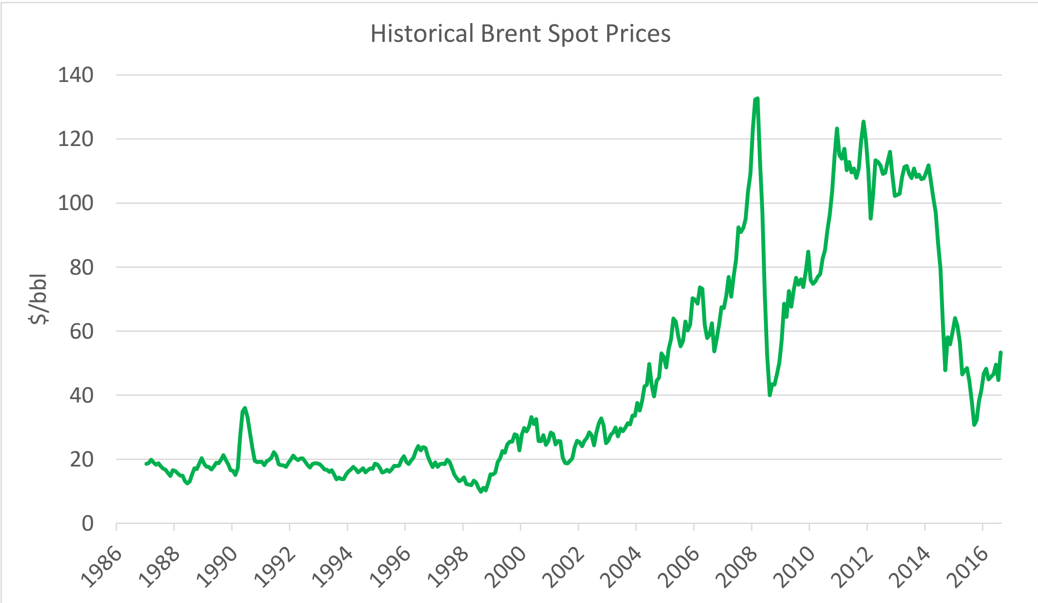

Figure 15: Historic Brent Oil Prices from 1987 to 2016. Graph made by author using data from [24].

across the value chain and thus reduce their exposure to oil price volatility. This means that a decrease in oil price that hurts the upstream portfolio, might be perceived to benefit the downstream activity. Anadarko Petroleum is the only independent oil and gas company included in the analysis, meaning that it should be more sensitive to oil price fluctuations.

4.3.2 Reserve Replacement Ratio

The reserve replacement ratio (or RRR) is the ratio between the exploitation of reserves and the discoveries of new reserves, and is an indicator of the company's ability to replenish annual production volumes and grow its reserves and thus is a measure of company performance [39]. It was found by Osmundsen et al. [39] to have a modest, positive effect on market value but with marginal significance. The reserve replacement ratio for the companies included in the analysis can be seen in figure 16.

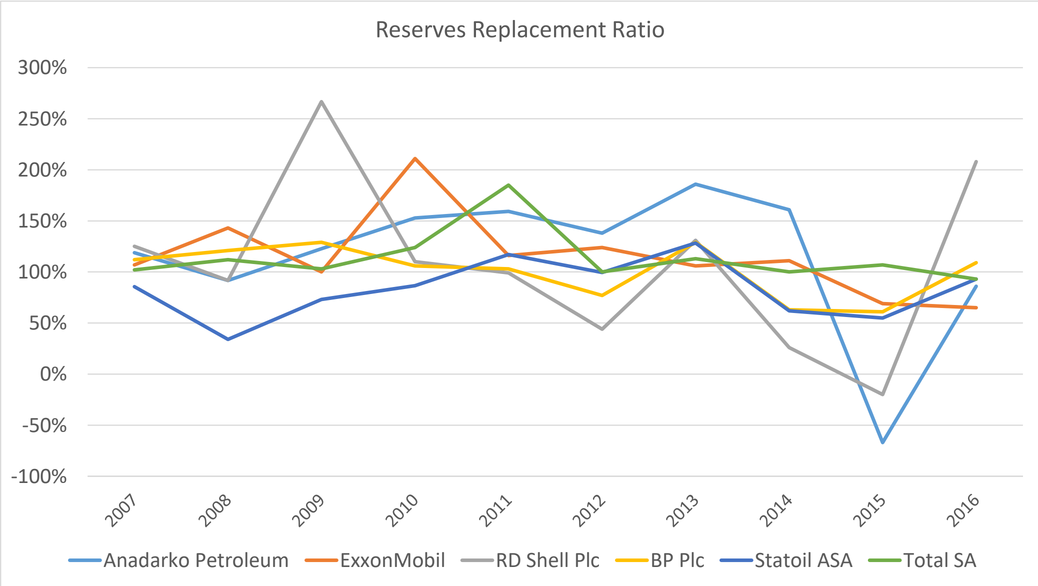

Figure 16: Reserve replacement ratio for the analyzed companies

4.3.3 Production (As a Proxy for Company Size)

There are many reasons for why company size is important when pricing international oil companies. Osmundsen et al. mentiones some of them [40]:

- The size of the company might have a positive reputational effect on governments licensing of new blocks for oil and gas exploration.
- Larger companies might have bigger growth potential in their portfolios.
- The larger companies have better opportunities to pursue shifting of tax regimes.
- They might have the opportunity to apply a cream-skimming strategy due to larger opportunity sets when it comes to geological deposits.

Some of the downsides to size might include higher co-ordination cost and less specialization [40]. Osmundsen et al. noted in [39] that oil and gas production had a material and robust influence on market valuations, and as the production fluctuations over time are minimal, this serves as a proxy for company size. Therefore we will use production as our metric in describing company size. Production from the companies in the analysis can be seen in figure 17.

4.3.4 Debt/Asset Ratio

To address if capital structure might affect the valuation, a control variable of long term debt to total assets is included. This ratio represents how much of a

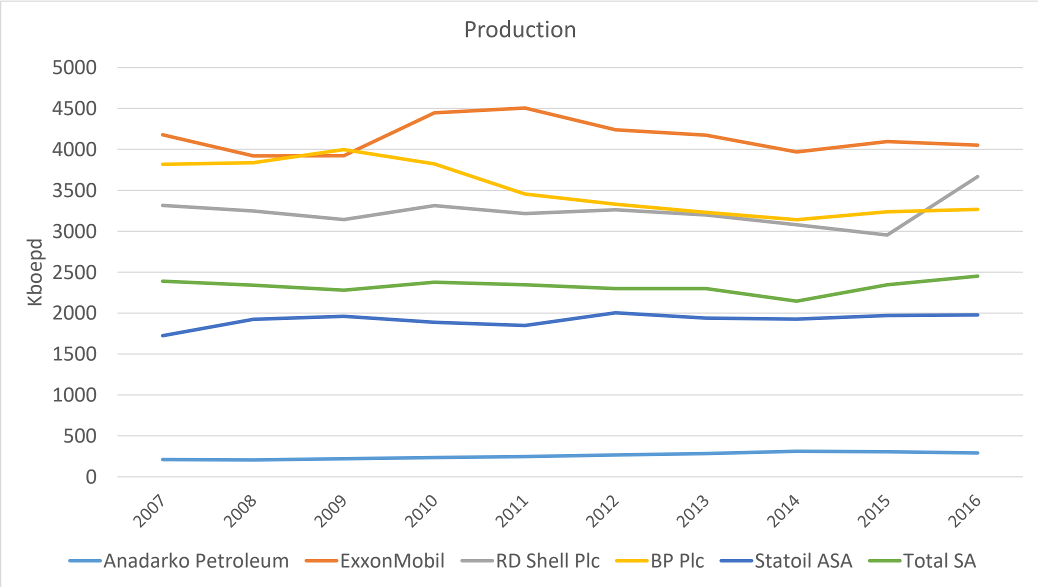

Figure 17: Average daily production of the companies included in the analysis.

company's assets are financed with loans. A high debt/asset ratio might suggest a higher degree of risk, since increasing leverage also increases the probability of going bankrupt [31]. Figure 18 shows the debt/asset ratio for the companies included in the analysis.

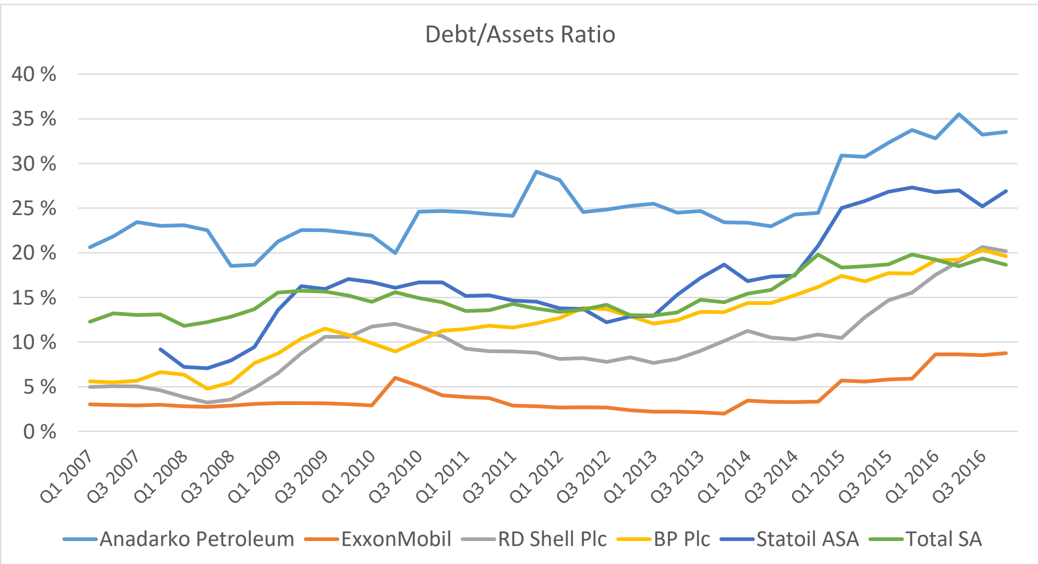

Figure 18: Long term debt to total assets ratio for the companies included in the analysis.

The introduction of control variables expands the model to a multiple regression model, and the regression equation to be solved becomes:

$$Tobin's\,Q = \beta_0 + \beta_1 \frac{MW}{Kboepd} + \beta_2 OilPrice + \beta_3 Size + \beta_4 RRR \ldots \tag{22}$$

4.4 Data Sources

All company-related data was gathered by the respective companies quarterly and annual reports, which were readily available on their websites. Historical stock prices for the individual companies were downloaded from yahoo.finance.com. Quarterly averages were computed to calculate the respective companies market capitalizations, for use in the Tobin's q analysis. The data gathering would probably be easier with access to a financial database, but that was unavailable to us. Because of this, a lot of time has been spent manually going through quarterly and yearly reports for the different companies.

As mentioned in section 4.2, finding data on renewable exposure has been challenging since most of the companies in the study which invests in renewable, usually report earnings etc. from this category together with other data. For example, incomes and asset values from wind power can be reported together with the downstream business segment, or solar might be reported together with natural gas sales. The criteria for renewable energy to be included is that the capacity is mentioned in either the company's annual report, quarterly report or sustainability report (in MW or KW). For wind- and hydro energy, installed capacity is quoted. Operated solar fields and solar panel manufacturing plants will use installed capacity and yearly production capacity of solar panels respectively. The company's ownership in the different renewable projects have been accounted for so that all capacities are quoted as net numbers. For the analysis, installed capacity is first counted when the project has started. For some of the control variables and the measure for exposure to renewable energy only yearly data exists. It was decided to use the yearly values for all quarters in that year so to not limit the number of observations significantly. Running the regressions with yearly instead of quarterly data for these variables resulted in only minor changes to the p-values, coefficients and R^2.

The limitations and reliability of the data will be discussed in section 5.4

4.5 Introduction to Oil and Gas Companies Included in the Analysis

This section will present some background information on the companies included in the analysis, together with their production and installed capacity of renewable energy. Four of the companies are exposed to renewable energy, either through wind, solar or hydropower. As stated in section 4.2, biofuels have not been included in the measurement for exposure to renewable energy.

4.5.1 Statoil ASA

Statoil is a Norwegian oil and gas company founded in 1972, currently employing approximately 20,500 people. According to their 2016 annual report they are an "energy company commited to long-term value creation in a low carbon future". Statoil produced 1,978 kboepd in 2016, and with their portfolio of new energy solutions they are currently delivering wind power to 650,000 british households. Statoil reports their renewable energy projects through the New Energy Solutions business segment, which reflects Statoil's long term goal of complementing its oil and gas portfolio with profitable renewable energy. However, when it comes to reporting, NES falls under the "other" reporting category together with technology projects and drilling (TPD) and Global Strategy and Business Development (GSB) [12]. Statoil's installed renewable capacity can be seen in figure 19.

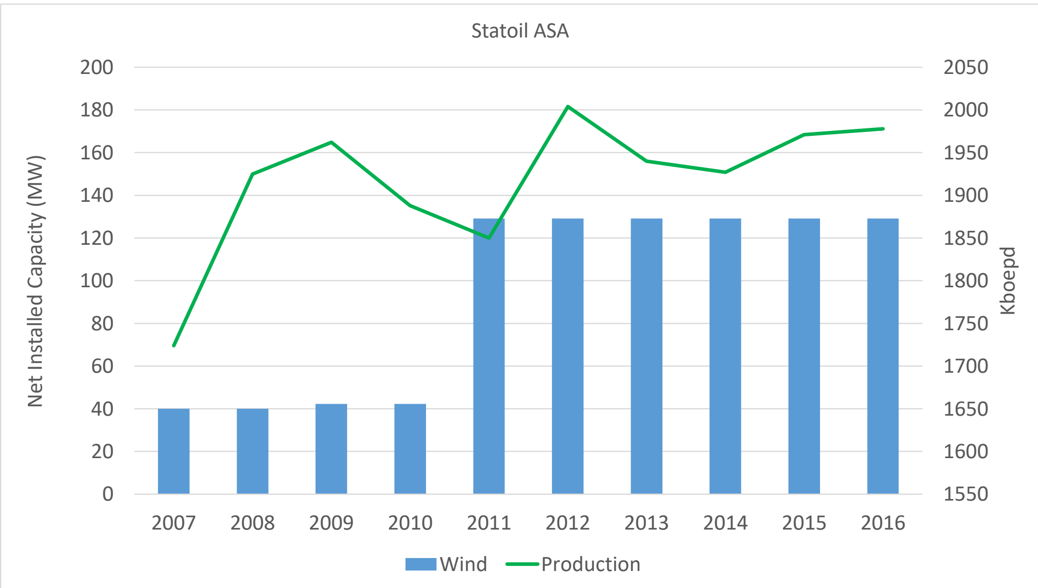

Figure 19: Statoil's production and installed capacity from renewable energy

4.5.2 Total SA

Total is a french energy company with operations in over 130 countries. They are a top tier international oil and gas company and describe themselves as a major player in solar energy through their ownerships in SunPower and Total Solar. Their ambition is to become the responsible energy major and are positioning themselves towards an energy mix with decreasing carbon intensity that takes into account the 2° C scenario. Total SA produced 2,450 kboepd in 2016 and the company employs over 102,000 people [44]. Total's installed capacity for renewable energy can be seen in figure 20.

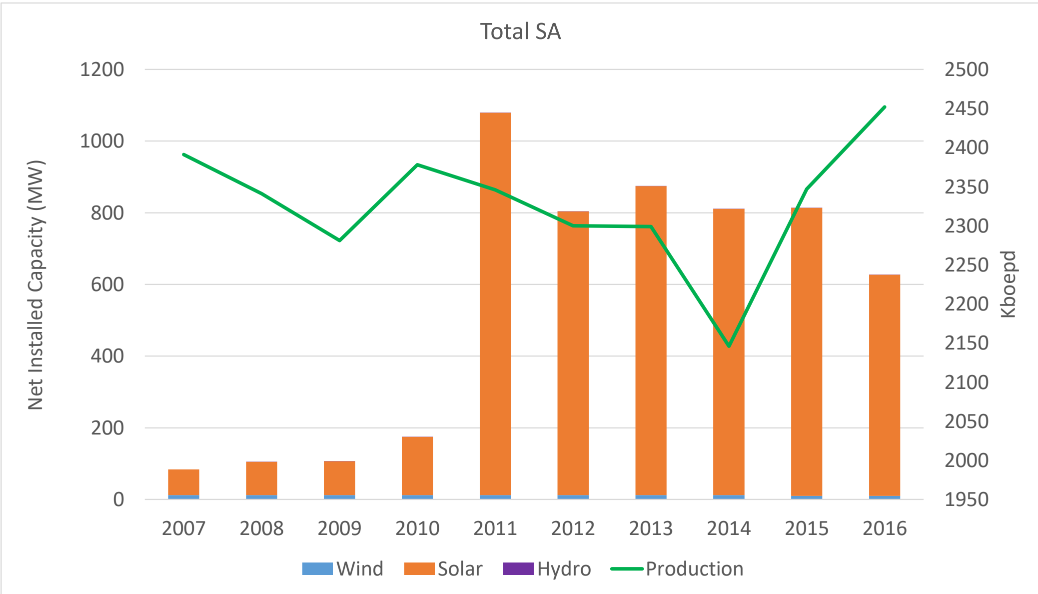

Figure 20: Total's production and installed capacity from renewable energy

4.5.3 Royal Dutch Shell Plc

Royal Dutch Shell is one of the largest independent energy companies in the world in terms of market capitalization, operating cash flow and production. They operate in over 70 countries, employ 92,000 people, deliver 1% of the global supply of energy and produced 3,668 kboepd in 2016. Shell has been active in wind energy since 2001 and is a big producer of biofuels [43]. See figure 21 for an overview of RDS's installed renewable energy capacity. mer i [46]

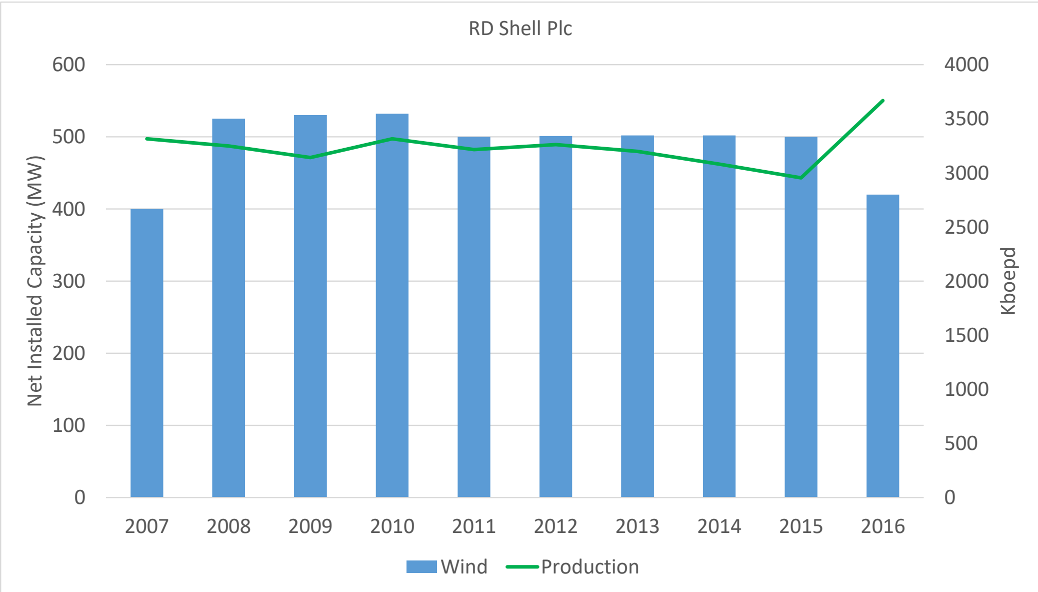

Figure 21: RD Shell's production and installed capacity from renewable energy

4.5.4 BP Plc

BP is a global energy company with operations in over 70 countries, a daily production of 3,300 kboepd, and as of 2016, 74,500 employees. BP has the largest operated renewables business among its oil and gas peers, mostly through its interest in onshore wind in the US and biofuel production in Brazil [14]. According to BPs 2016 annual report, new technology and consumer preferences for low carbon energy are leading to changes in the fuel mix towards decarbonization, and BP is gearing up to meet the shifting demand by increasing its gas and renewables activities [13]. See figure for BP's installed renewable energy capacity.

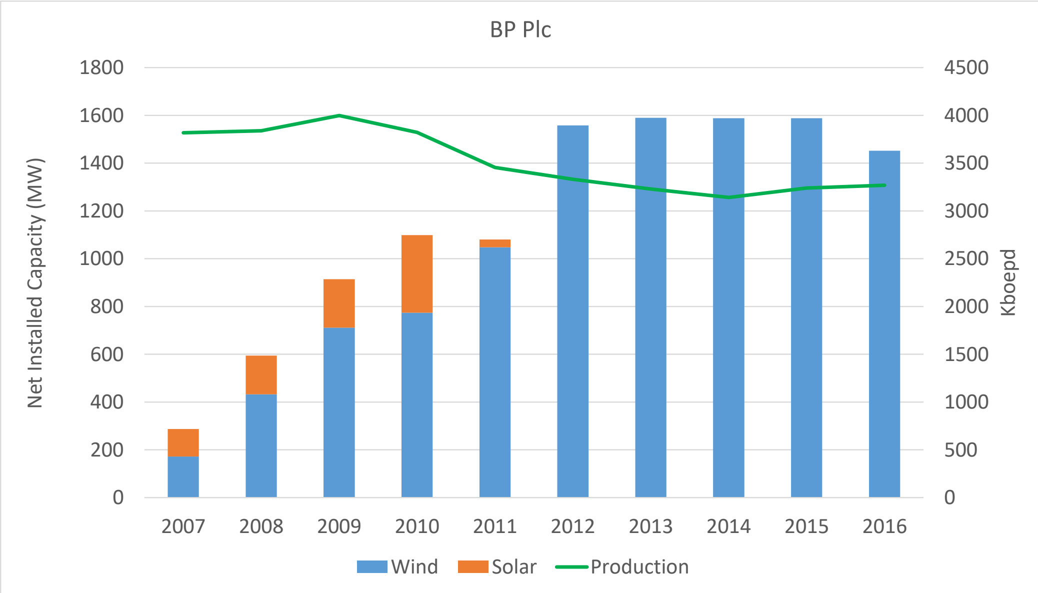

Figure 22: BP's production and installed capacity from renewable energy

4.5.5 ExxonMobil

ExxonMobil is the worlds largest publicly traded international oil and gas company. They employ over 70,000 people and had a production of 4,100 kboepd in 2016. It is noted from figure 23 that ExxonMobil does not have any exposure towards renewable energy.

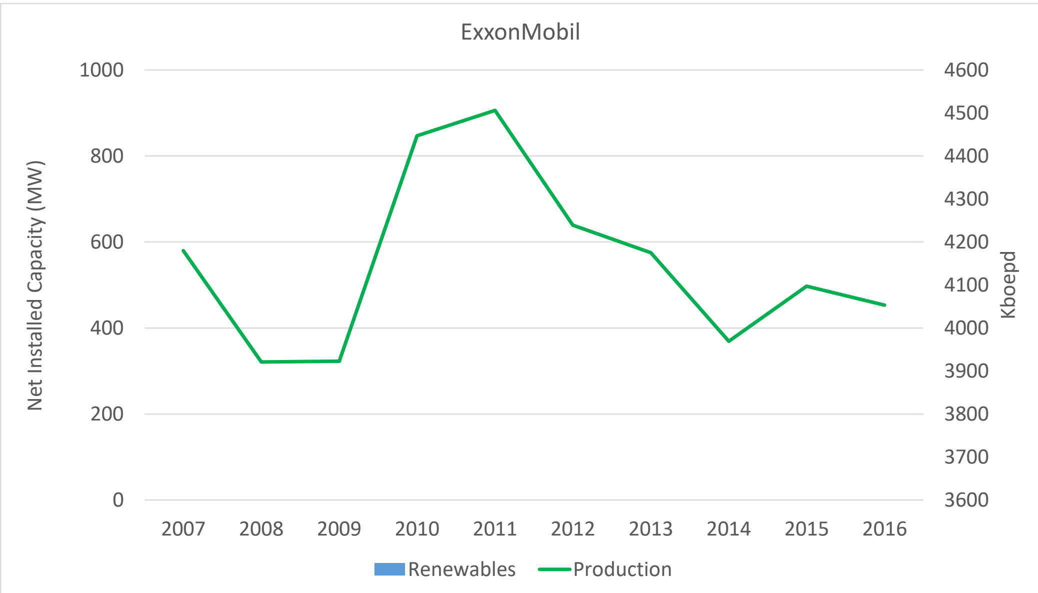

Figure 23: ExxonMobil's Production and installed capacity from renewables

ExxonMobil's climate strategy has historically had an emphasis in compliance, sound science and consideration of economic impact affects its approach to the problem of climate change. ExxonMobil opposed the kyoto protocol, an international treaty that commits nations to reduce greenhouse gas emissions, as a “premature international initiative” and argues against it because it was 1) too expensive 2) unfair and 3) it would not work [46]. In a stockholder meeting in 2015, ExxonMobil’s CEO Rex Tillerson stated that “we do not choose to lose money” on questions about investment in renewable energy [4].

4.5.6 Anadarko Petroleum

One of the largest independent E&P companies in the world with over 4,900 employees worldwide. Their vision is to be the premier independent E&P company. From figure 24 it is evident that Anadarko does not have any exposure towards renewable energy. Note also the scale on the production axis, Anadarko is less than 1/10 the size of ExxonMobil in terms of production.

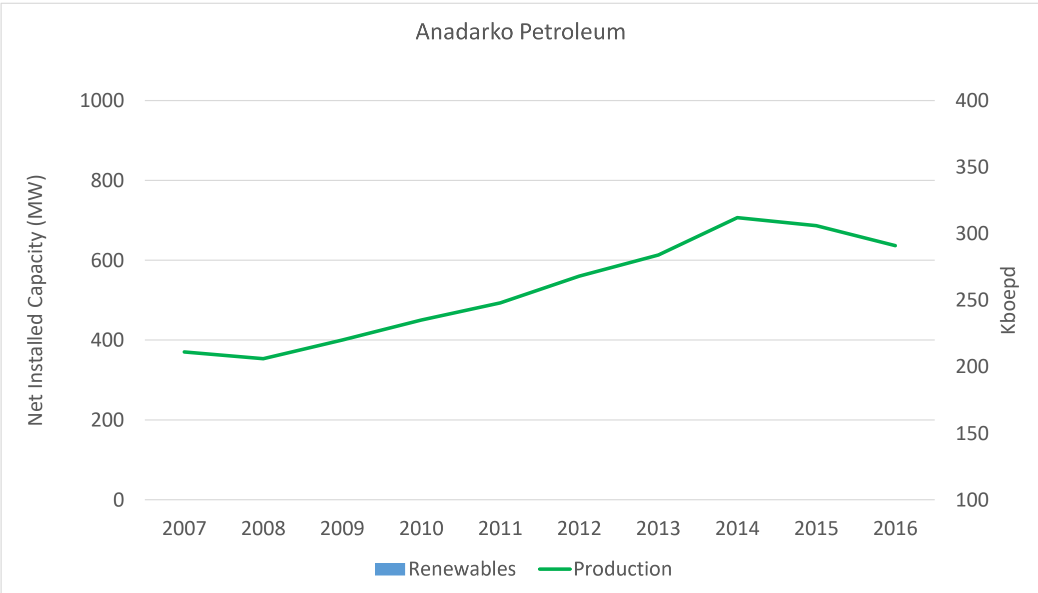

Figure 24: Anadarko Petroleum’s production and installed capacity from renewables

5 Results

This section will discuss the results from the analysis that has been performed. The data is presented using graphs and tables. First, a simple cross-sectional regression of the six companies included in the analysis will be presented, secondly we will perform a panel data regression for the entire dataset, then we will perform the analysis on a company-by-company basis. Finally, as a sensitivity, we use market capitalization as the dependent variable (as a proxy for company value) instead of Tobin's q.

From the outset, one interesting thing to note is that the two American companies generally trades at a higher Tobin's q than their European counterparts. The average Tobin's q for the two American companies is 1.10, while the average Tobin's q for the four european companies is 0.69. This might just be a coincidence since the sample is fairly small, but could be something worth looking into in further studies. All companies have Tobin's q values varying in the interval between 0.4 and 2, While the average lies in the 0.8 to 1.2 range. The average Tobin's q for all companies over the 10 year time period is 0.832.

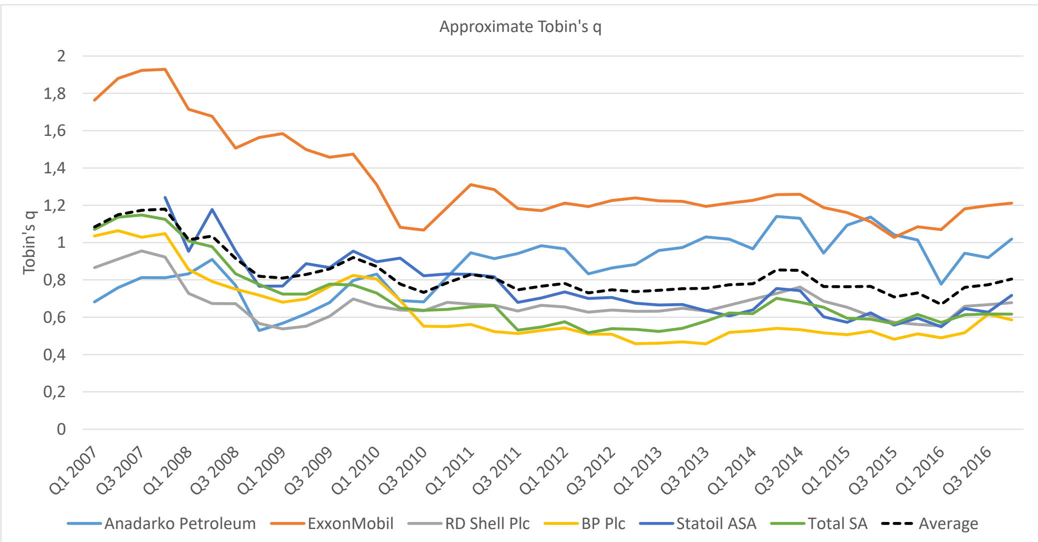

Figure 25: Calculated approximate Tobin's q for all companies included in the analysis

If our hypothesis that increased exposure towards renewable energy leads to higher company valuation is correct, then a first pass check is to see if there exists a greater positive trend in Tobin's q for the companies more exposed to renewable energy. i.e. that the companies more exposed to renewable energy should have a greater slope (higher growth) in Tobin's q compared to their peers not exposed to renewable energy. We see from figure 26 that the only two companies with a positive development in Tobin's q the last quarters are Statoil and Anadarko, where Statoil has an increased focus on investments in renewable energy and Anadarko does not. When assessing the change in Tobin's q over the last year, figure 27, we observe that Statoil is the only company with increasing Tobin's q while Total and BP have a fairly flat development. This implies to some degree that, at least 3 of the 4 companies with stated interest in renewable energy are maintaining or increasing their value over the last year, whereas both companies without renewable exposure are declining in value. However, as previously discussed, there are multiple possible explanations for this as the factors that control the valuation of oil and gas companies are many. We hope to get a better picture of the driving forces behind the valuation when performing the regression analysis, where we will control for other factors that affect company valuation so that we can isolate the value-contribution coming from exposure to renewable energy.

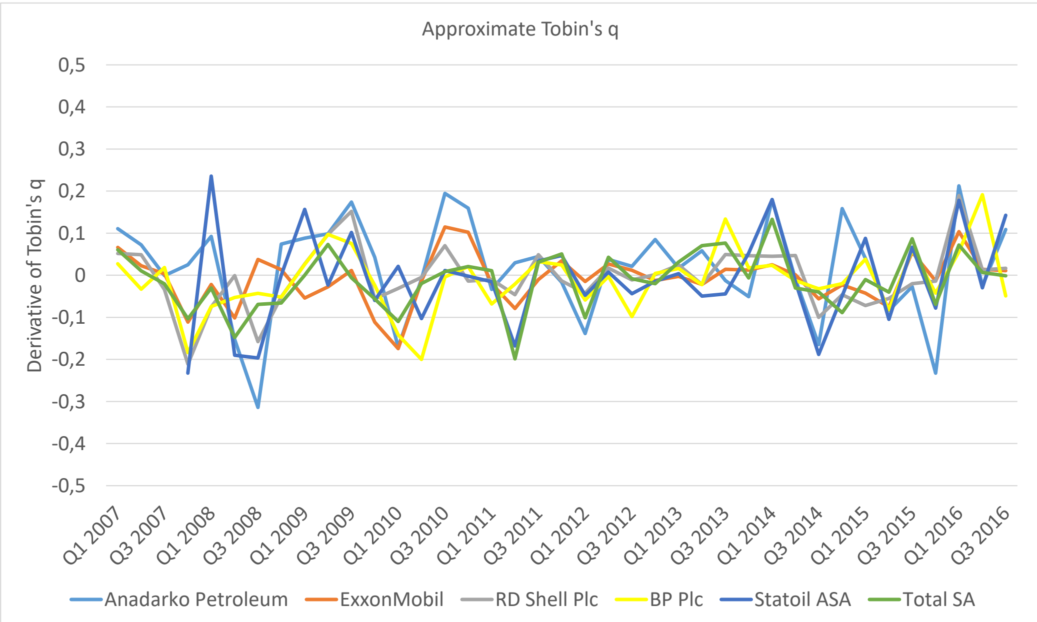

Figure 26: Figure showing change in Tobin's q for quarterly time series.

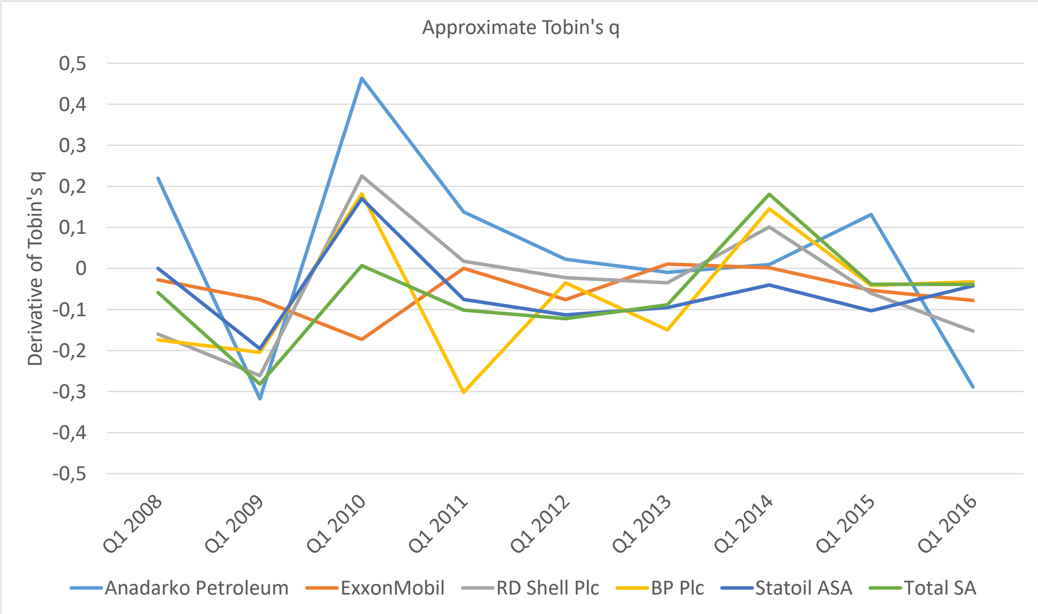

Figure 27: Figure showing change in Tobin's q for yearly time series.

5.1 Panel Data Analysis

First, using a general model, we estimated simple cross-sectional regressions of Tobin's q against the measurement for renewable exposure for each year in the study, see table 1. The model coefficients represents the absolute change in Tobin's q by one unit change the renewable measure, MW/Kboepd. The number of observations is stable at 6 per year, which corresponds to the number of companies included in the analysis. The statistical fit of the model is not very good. The R^2 varies between 0.177 and 0.67, with varying significance. The average R^2 for the dataset for the 10 years of the analysis is 0.44. The coefficients are all negative, implying that investments in renewables is reducing the valuation of the company, as measured by Tobin's q. Although coefficients are varying over time, there appears to be a declining trend, see figure 28, indicating that the negative impact of investments in renewable is weakening. However, with the limited number of observations, the relevance of the cross-sectional analysis seems minimal.

To make full use of the dataset, a panel-data regression was performed, and we add multiple explanatory variables to try and improve the model fit. As mentioned before, the Dickey-Fuller test to check for stochastic trends implied some stationarity issues, in addition wooldridge's first-difference test for serial correlation also led us to reject the null hypothesis that there were no serial correlation in the original errors [17]. As a result, the analysis was performed using a first difference model for the panel data regression, with confirmation that serial correlation and stationarity issues was removed, see appendix B for R script. By utilizing the full

Year	MW/Kboepd Coefficient	P-value	R^2	Observations
2007	-3.69	0.382	0.194	6
2008	-2.12	0.406	0.177	6
2009	-1.39	0.341	0.226	6
2010	-1.44*	0.099	0.533	6
2011	-1.13**	0.046	0.67	6
2012	-1.163*	0.059	0.632	6
2013	-0.995*	0.092	0.548	6
2014	-0.86*	0.1	0.519	6
2015	-0.914*	0.097	0.538	6
2016	-1.059	0.151	0.439	6

* Significant at 90% confidence level
**Significant at 95% confidence level
***Significant at 99% confidence level

Table 1: Cross-sectional regressions of Tobin's q against MW/Kboepd

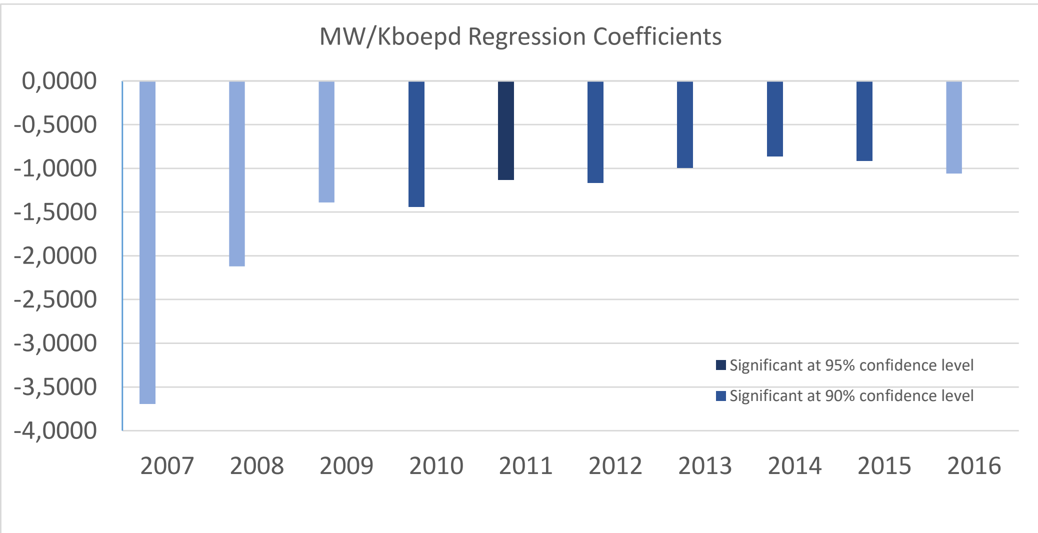

Figure 28: Estimated coefficient for MW/Kboepd from the cross-sectional regressions.

dataset we increase the number of observations to 231. In model 1, using only the measure for renewable exposure, the coefficient is now positive, indicating that investments in renewable are increasing value of companies. However, the results is statistically insignificant, and the R^2 value is negligible. Introducing oil price as an explanatory variable in model 2 reveals a highly significant relationship between oil price and Tobin's q. The coefficient for oil price indicates that increasing oil price has a positive impact on valuation measured by Tobin's q. The coefficient for MW/Kboepd is still positive but with a higher p-value, it is even more insignificant. The model predictability increased and a F-test for joint significance gives a test statistic of 13.2318 with a p-value of $3 * 10^{-6}$. The R^2 for model 2 is 0.096, so although is is highly significant, it can still only explain about 10% of the variance, hence its explanatory power is not very good. In model 3, the explanatory variable production was introduced. As Osmundsen et al. [39] notes, it is a proxy for size. It has a positive and highly significant coefficient, indicating that larger companies have higher value, maybe due to factors explained in section 4.3.3, and it increases the explanatory power of the model. The coefficient for renewable is still positive and less insignificant with a p-value of 0.57. In model 4 and 5 we introduce reserve replacement ratio and debt/asset ratio respectively, as explanatory variables. None of them have statistically significant coefficients, but we note that both are negative. It is surprising that reserve replacement ratio should have a negative coefficient but its significance is very low so it will not be given much attention. As expected, debt/asset ratio has a negative coefficient, indicating that highly leveraged companies might face lower valuation, however, this explanatory variable is also insignificant with a p-value of 0.491. Adding reserve replacement ratio and debt/asset ratio does not improve the explanatory power of the model as indicated by lower R^2 values and F-test results.

	Model 1	Model 2	Model 3	Model 4	Model 5
Estimated Coefficiencts[a]					
MW/Kboepd	0.0823 (0.608)	0.003 (0.982)	0.083 (0.573)	0.078 (0.602)	0.066 (0.662)
Oil Price		0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)	0.002*** (0.000)
Production			0.001*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Reserves Replacement Ratio				-0.002 (0.742)	-0.002 (0.730)
Debt/Asset Ratio					-0.224 (0.491)
Diagnostics					
R^2	0.001	0.096	0.167	0.163	0.161
Joint Significance	F(1,230) = 0.2637 p = 0.608	F(2,229) = 13.2318 p = 0.000	F(3,228) = 16.344 p = 0.000	F(4,227) = 12.24 p = 0.000	F(5,226) = 9.86 p = 0.000
Observations	231	231	231	231	231

* Significant at 90% confidence level
**Significant at 95% confidence level
***Significant at 99% confidence level

[a] p-values in parenthesis

Table 2: Estimated Panel Data Models for MW/Kboepd.

5.2 Time Series Analysis

After the panel data regression in the previous section, we also decided to do a company specific analysis to test if the renewable measure could be significant in a time-series regression for the respective companies. Thereby assessing if investors in one company exposed to renewable might value the renewable investments more than for other companies.

Statoil The average Tobin's q for Statoil over the period analyzed was 0.76. As we can see in table 3, Statoil has a negative coefficient for renewable exposure, however the result is insignificant. The significant variables are oil price and production at 99% and 95% confidence levels respectively. Note that production has a negative sign here, indicating that increasing production results in lower valuation. This is counterintuitive, but we note that when looking only at one company, production as a proxy for size loses some of its meaning, as the numbers are fairly stable. Reserve replacement ratio is highly insignificant and with a negative sign in its coefficient. Debt/asset ratio is also insignificant but with a positive coefficient. The R^2 of model 5 on Statoil is 0.354, indicating that the model can explain 35.4% of the variance in Tobin's q by use of the 5 explanatory variables.

	Statoil	RDS	Total	BP	Anadarko	XOM
Estimated Coefficiencts[a]						
MW/Kboepd	-2.032 (0.274)	-1.12** (0.028)	0.100 (0.658)	-0.513* (0.096)		
Oil Price	0.004*** (0.000)	0.001** (0.039)	0.001 (0.105)	0.001 (0.429)	0.004*** (0.000)	-0.001 (0.843)
Production	-0.001** (0.025)	0.0002* (0.073)	0.000 (0.997)	-0.0001 (0.294)	0.001 (0.482)	0.000 (0.822)
Reserves Replacement Ratio	-0.001 (0.991)	0.026 (0.139)	-0.058 (0.484)	-0.001 (0.431)	-0.061** (0.018)	-0.154*** (0.002)
Debt/Asset Ratio	1.400 (0.15)	0.419 (0.597)	0.073 (0.947)	0.860 (0.438)	1.824*** (0.003)	-3.620** (0.014)
Diagnostics						
R^2	0.354	0.1237	0.001	0.001	0.599	0.247
Joint Significance	F(5,31) = 4.947 p = 0.001	F(5,34) = 2.101 p = 0.089	F(5,34) = 0.898 p = 0.4935	F(5,34) = 0.770 p = 0.577	F(5,34) = 15.59 p = 0.000	F(5,34) = 4.197 p = 0.007
Observations	36	39	39	39	39	39

* Significant at 90% confidence level
**Significant at 95% confidence level
***Significant at 99% confidence level
[a] p-values in parenthesis

Table 3: Estimated time series for all companies using model 5 in table 2 for MW/Kboepd.

RDS Royal Dutch Shell has a negative coefficient for renewable exposure but at a significance level of 95%. This indicates that as RDS increases their exposure to renewable energy, their value decreases. Oil price has a positive coefficient at a 95% significance level as expected. Production has a positive effect on valuation at a 90% significance level, which is more in line with what we expected, Reserve replacement ratio and debt/asset ratio both have positive coefficients but at insignificant levels. The model has an R^2 of 0.1237, wich is fairly low in terms of explanatory power. The average Tobin's q for RDS was 0.67.

Total The average Tobin's q for Total was 0.69. As we can see from table 3 none of the explanatory variables for Total SA are statistically significant and this is also reflected in the low R^2 value of 0.001, which indicates that the model has no explanatory power at all. Although not significant, the measure for renewable does have a positive coefficient.

BP As for Total, model 5 does not have any particular explanatory power for BP, with an R^2 value of 0.001. However, the measure for renewable exposure is significant at a 90% confidence level, but the coefficient is negative, indicating that it has detrimental effect on valuation. The average Tobin's q for BP was 0.63.

Anadarko For Anadarko, the oil price has a positive coefficient, at a 99% significance level. However reserve replacement ratio and debt/asset ratio is affecting valuation negatively and positively respectively, which is counterintuitive. Note also that they are significant at the 95 and 99% level respectively. It may be that for smaller companies like Anadarko increasing debt leverage can be viewed positively by the market as it may give them more flexibility in terms of investments, but we have not found any particular evidence for this in the literature. The explanatory power of the model for Anadarko is very good with an R^2 of 0.599. The variance here is mostly explained by the oil price. As we discussed in section 4.3.1, independent companies like Anadarko are more dependent on oil price so this is as expected. The average Tobin's q for the period analysed was 0.88

ExxonMobil With Tobin's q of 1.33, ExxonMobil has the highest average over the period for the companies in the analysis. Oil price is somewhat surprisingly not significant for ExxonMobil during the time-series regression, altough this is true also for two of the other large integrated companies with a large downstream segment which provides them with a hedge towards oil price, as mentioned in section 4.3.1. What is unexpected for ExxonMobil is that reserve replacement ratio is significant at the 99% level but the coefficient is negative, indicating that increasing reserve replacement leads to decreasing value. It is also surprising that debt/asset ratio is significant at the 95% level, with a negative coefficient indicating that higher leveraging with debt is detrimental to company value. The R^2 for model 5 is 0.247 indicating that 24.7% of the variance in the valuation of ExxonMobil can be explained by the explanatory variables included in model 5. The fact that oil price did not affect the value for ExxonMobil, BP or Total will be discussed in the following section.

5.3 Market Capitalization as the Dependent Variable

As a sensitivity we chose to test the models using market capitalization as the dependent variable instead of Tobin's q. This was done to see if there where more correlation between renewable exposure and the price the company achieves in the market. As we can see from table 4, the model fit increased significantly for all companies, even Total and BP, where our model had close to zero explanatory power. The R^2 for the company specific models now range from 0.3 to 0.55. This is mostly attributed to the high correlation between market capitalization and oil price. The fact that regression model with Tobin's q as the dependent variable did not show any statistical significance of oil price on valuation for ExxonMobil,

	Statoil	RDS	Total	BP	Anadarko	XOM
Estimated Coefficiencts[a]						
MW/KBOE	141.8 (0.875)	-137.2 (0.358)	15.894 (0.695)	-54.68 (0.443)		
Oil Price	2.592*** (0.000)	0.965*** (0.000)	0.716*** (0.000)	0.753*** (0.000)	0.262*** (0.000)	0.866*** (0.000)
Production	-0.223 (0.158)	0.038 (0.324)	0.006 (0.874)	-0.025 (0.427)	0.084 (0.302)	-0.002 (0.960)
Reserves Replacement Ratio	-29.07 (0.492)	4.052 (0.426)	-9.880 (0.509)	-0.100 (0.402)	-1.150 (0.424)	-3.061 (0.026)
Debt/Asset Ratio	227.9 (0.564)	-120.5 (0.625)	-19.50 (0.922)	199.6 (0.477)	33.26 (0.320)	-20.88 (0.609)
Diagnostics						
R^2	0.469	0.486	0.547	0.367	0.501	0.309
Joint Significance	F(5,31) = 7.195 p = 0.000	F(5,34) = 8.204 p = 0.000	F(5,34) = 10.19 p = 0.000	F(5,34) = 5.420 p = 0.000	F(5,34) = 10.55 p = 0.000	F(5,34) = 5.253 p = 0.002
Observations	36	39	39	39	39	39

* Significant at 90% confidence level
**Significant at 95% confidence level
***Significant at 99% confidence level

[a] p-values in parenthesis

Table 4: Regression results using market capitalization as the dependent variable.

BP or Total, while the model using market capitalization shows a highly significant relationship, is an indication that the different accounting practices of the companies can impact the analysis quite significantly.

For our explanatory variable MW/Kboepd, the coefficients are changing signs depending on company, indicating that renewable exposure has a positive effect on Statoil and Total, but a negative on RDS and BP. For the panel data the coefficient for renewable exposure was also positive. The variable is however statistically insignificant for all models. The other explanatory variables, reserve replacement ratio, debt/asset ratio and production where statistically insignificant for all companies except for ExxonMobil where reserve replacement ratio was significant at the 95% level. The coefficient indicates that reserve replacement ratio affect the market capitalization negatively.

For the panel data set regressing against market capitalization improved the explanatory power of the panel data model from 0.161 to 0.2335, as seen in figure 29, indicating that our model is better at explaining the variance in market capitalization than in Tobin's q. As expected, oil price was statistically significant at 99% level with a positive coefficient. Production was significant at 90% level, indicating that company size has a positive effect on market capitalization.

	Model 5
Estimated Coefficiencts [a]	
MW/Kboepd	21.094 (0.705)
Oil Price	1.117*** (0.000)
Production	0.0285* (0.100)
Reserves Replacement Ratio	0.051 (0.852)
Debt/Asset Ratio	576.0 (0.760)
Diagnostics	
R^2	0.2335
Joint Significance	F(5,226) = 15.016 p = 0.000
Observations	231

* Significant at 90% confidence level
**Significant at 95% confidence level
***Significant at 99% confidence level

[a] p-values in parenthesis

Figure 29: Regression results using market capitalization as the dependent variable for the panel data set.

5.4 Discussion

There is no indication in all the models that we have tested that there is any significant relationship between the valuation of an oil and gas company and its exposure towards renewable energy measured in terms of MW installed capacity of renewable energy per thousand barrel of oil equivalent produced per day. The relevance of simple cross-sectional regression of Tobin's q on MW/Kboepd seems unjustified given the small dataset we examined. In the panel data regression the coefficients remained positive for all the models, but not at a statistically significant level. In the company specific time series analysis, the coefficients where positive for three of the companies and negative for one. One somewhat interesting thing to note is that it was statistically significant at the 90% and 95% level for two of the companies, both with negative coefficients. This can indicate that investments in renewable might affect value negatively. However, when testing these two companies using only renewable exposure as the explanatory variable, it became apparent that there was no explanatory power left in the model.

Of the control variables included, only oil price and production where statistically significant in the panel data regression, and with positive coefficients, suggesting that higher oil price - and higher production (as a proxy for company size), leads to higher valuation. This is as we would expect. Reserve replacement ratio and debt/asset ratio, although higly insignificant both implied a negative impact on Tobin's q. The sign is unexpected but with such low significance, little trust should be placed in the coefficients. Of the models we tested, model 3 appears to be the best in terms of explanatory power, with an R^2 value of 0.167, adding reserve replacement ratio and debt/asset ratio to this model only reduced the adjusted R^2, indicating that these explanatory variables are not needed in the model. When performing the analysis on a company-by-company basis, we noticed that both BP and ExxonMobil's valuation was not affected by oil price in a statistically significant manner. These are also the two biggest company's in the analysis (RDS overtook BP in terms of production with the BG aquisistion in 2015), and both have fairly large downstream businesses which makes them less exposed to oil price, as we mentioned in section 4.3.1. Anadarko, which is the only independent company in the analysis (i.e. no downstream business segment), is highly dependent on oil price and the model has very high explanatory power, with an R^2 of 0.599. This is more in line with what we would expect. Some of the unexpected results from the company analysis is that both the american companies were significantly affected by debt/asset ratio and reserve replacement ratio, but in a negative way. We also note that the model was fairly good for Statoil, Anadarko and ExxonMobil with R^2 values of 0.345, 0.599 and 0.247 respectively. The model was not as good for RDS with an R^2 value of 0.12. For Total and BP the model was very poor, with no explanatory power at all. What is interesting to note is that out of the 4 companies with a stated interest in renewable energy, 3 have reduced their absolute exposure measured in megawatt installed capacity over the last year, as can be seen in figure 14.

Models 2-5 suggest that the valuation of the oil companies, by measure of Tobin's q, included in the analysis is strongly influenced by oil price. This is as expected and gives us more confidence in the proposed model. However, the statistical significance of reserve replacement ratio and capital structure seems minimal except for in the company specific analysis of Anadarko and ExxonMobil.

When performing the regressions with market capitalization as the dependent variable instead of Tobin's q, one observation that really stands out was the dependency on oil price. Oil price had positive coefficients for all companies at 99% significance level, and the explanatory power of the model increased quite dramatically for some of the companies, with R^2 values ranging from 0.301 to 0.547. This is an indication that while oil price has a positive effect on market capitalization, companies are doing a good job in reflecting the current oil price in their assets so that both the nominator and denominator in Tobin's q increase with increasing oil price, thus reducing sensitivity. This aligns with what was noted in section 2.3. It also suggest that different accounting practices between the companies can have a large impact on the results of the analysis. The measure for renewable exposure was still insignificant for all companies and in the panel data regression, but the coefficient changed signs for Statoil, indicating that increased exposure to renewable had a positive effect on valuation.

For the companies analyzed, the cash generated from renewable energy might be very low compared to their income from the sale of oil and gas or refined products. It has been impossible to read from the financial statements from the companies how much cash flow is actually generated from their renewable investments. Another thing to note is, as we mentioned in section 2.2, that if the expected returns from investments in renewable energy is lower than expected returns from investments in the oil or gas business segments, this might actually have a negative effect on valuation according to e.g. DCA theory. Our hypothesis that higher exposure to renewable energy leads to higher company valuation is, in part, based on a belief that the increasing popularity of renewable energy should actually increase the value of these investments more than the theoretical value. One example of this is Tesla, Inc. which trades at a Tobin's q of above 2, see figure 30. Our belief was that the majority of companies exposed towards renewable energy might trade at high Tobin's q values, but performing a quick sensitivity and calculating Tobin's q for SunPower as well, showed a value of less than 1. However, this was only a quick analysis of two companies, and it is difficult to come to any conclusions based on such small sample.

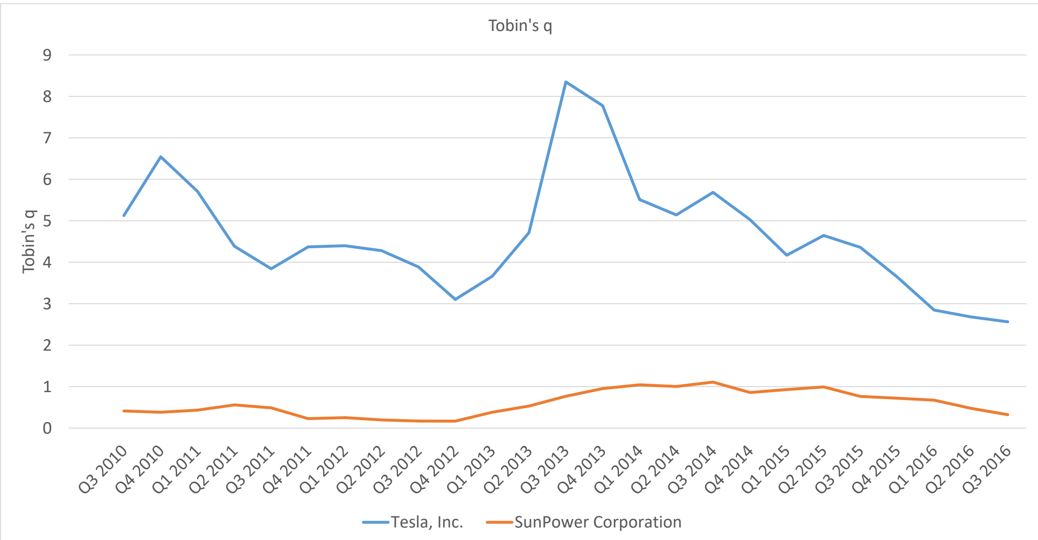

Figure 30: Tobin's q for Tesla, Inc. and SunPower Corporation.

As mentioned in section 4.4, all accounting information has been gathered from the companies reported quarterly and annual reports, which is the most reliable source of information. Having access to a financial database might have made the data gathering more effective, possibly leading to inclusion of more companies in the analysis. One can discuss the validity of using the approximate form of Tobin's q as proposed by Chung and Pruitt [27], but it was proven to be highly correlated with the Tobin's q proposed by Lindenberg and Ross, equation 6, as well as the simple Tobin's q from equation 3. One of the issues with Tobin's q calculated with both equation 7 and equation 3 is that the only variable in the denominator is Total Assets, which implies that different accounting practices between companies might manifest as considerable changes in the ratio. As discussed in section 2.2, the use of book value as a proxy for replacement cost might also be an issue, but literature indicates that book value of total assets is a relatively unbiased estimator of replacement cost [11, 27, 42].

6 Conclusion

In this thesis we have have created a measure for exposure to renewable energy for oil and gas companies, based on available data. By use of regression analysis we have tested the relationship between this metric for exposure against company value, measured by the valuation metric Tobin's q. Based on the analysis we have performed there does not seem to be any correlation between exposure to renewable energy and company value for oil and gas companies, and the expected relationships were not expressed through the regression. The results indicate that the valuation impact, as measured by Tobin's q, of the renewable exposure measure is negligible, and thus we reject our hypothesis.

Using only the exposure to renewable energy as an explanatory variable did not produce any statistically significant results, but by inclusion of control variables, the explanatory power of the model was significantly increased. Oil price did, not unexpectedly, appear to have the greatest impact on valuation. In the panel data regression, model fit increased R^2 from 0.01 with high p-values, to 0.096 with very low p-values by inclusion of oil price. Production, which can serve as a proxy for size, as discussed in section 4.3.3, did also appear to have positive impact on company valuation. This indicates that company size and reputation might affect the valuation of the companies. When looking at company-specific analysis, we note that there were big differences in the explanatory power of the models, indicating that the companies react differently to the different explanatory variables used in this thesis. The fact that the only company without a downstream business segment, Anadarko Petroleum, was much more affected by the oil price than the other integrated companies was as expected.

When performing the regression analysis using market capitalization as the dependent variable we observed that the explanatory power of the models increased, with generally higher R^2 values. This is as expected due to the reasons discussed in section 5.4 and since market capitalization, as opposed to Tobin's q, is an image of investestors perception of the business, it is not dependent on accounting practices applied by the companies. Noteably, a significant part of the market capitalization for the companies could be explained by oil price. The average R^2 for the 6 companies, using model 5, was 0.45, indicating that 45% of the variance could be explained by these variables.

We note that the sample size in our analysis was fairly small, with only six companies included. One could probably come to a more confident conclusion by increasing the sample size. The sample was chosen, in part, based on companies that had been frequently discussed in the media in a renewable energy context[4, 41].

The metric we created as a measure for exposure to renewable energy has some limitations, as mentioned in section 4.2. Because of these limitations, a better measurement could rather have been electricity generated (i.e MWh) over kboepd, since it says something about produced electricity over produced oil equivalents. By use of realized prices for electricity, oil and gas, one could then have calculuated relative revenue streams which would give more information about the value of exposure towards renewable energy. However there is limited data to be found in the published reports from the oil and gas companies regarding electricity generation. The metric we've proposed has in a part been chosen due to the fact that installed capacity was, in most cases, the only measurement available in terms of exposure towards renewable energy.

It may also be that this thesis is a bit premature. There is no doubt that the push towards renewable energy has accelerated in the recent years, as evident in figures 1, 2, 3, 7 and 8. As cost comes down and profitability increases for renewables we might see more oil and gas companies increasing investments in the renewable energy sources to diversify their portfolios, and as their exposure increases it might be easier to assess the valuation impact of these investments. However, it is evident from figure 14 that some of the companies included in this analysis have actually decreased their exposure to renewables in recent years, despite their expressed interest in positioning themselves for an energy mix with less carbon intensity [12, 13, 43, 44].

In considering possibilities for further work it would be interesting to obtain data on electricity generation from renewable energy, instead of just installed capacity. This, together with investment costs and cash flows from the renewable energy segments for oil and gas companies would make us able to perform a more in-depth analysis on the effect of investments in renewable energy on the valuation of these companies. It would also be interesting to explore other variables that affect the valuation of oil and gas companies, e.g. finding and development costs and unit production costs, as assessed by Osmundsen et al. [40]. As mentioned in the beginning of chapter 5, the two american companies generally trade at higher Tobin's q than their European counterparts, a study looking into the reasons for this, or if it is simply coincidence, could be intriguing. Performing an analysis to see how Tobin's q of companies only exposed to renewable energy compares to the Tobin's q of oil and gas companies could possibly also give some insight on how investments in renewables should impact the company valuation. Using different proxies for company valuation when performing the analysis and comparing the results could also be interesting.

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A Correlation Panels

Correlations

		ApproxQ	MW_BOE	Size	RRR	DebtRatio
ApproxQ	Pearson Correlation	1	-,864**	,746**	,411**	-,732**
	Sig. (2-tailed)		,000	,000	,008	,000
	N	40	40	40	40	40
MW_BOE	Pearson Correlation	-,864**	1	-,935**	-,587**	,859**
	Sig. (2-tailed)	,000		,000	,000	,000
	N	40	40	40	40	40
Size	Pearson Correlation	,746**	-,935**	1	,608**	-,783**
	Sig. (2-tailed)	,000	,000		,000	,000
	N	40	40	40	40	40
RRR	Pearson Correlation	,411**	-,587**	,608**	1	-,507**
	Sig. (2-tailed)	,008	,000	,000		,001
	N	40	40	40	40	40
DebtRatio	Pearson Correlation	-,732**	,859**	-,783**	-,507**	1
	Sig. (2-tailed)	,000	,000	,000	,001	
	N	40	40	40	40	40

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 31: Figure showing correlation panel where our renewable exposure metric is significantly correlated with all variables, leading to spurious regression results. Panel created using SPSS.

B Diagnostic Script in R

#testing fixed and time effects

library(car) library(plm) library(ggplot2) library(readxl) library(tseries)

df <- read_excel("PanelDataforRData.xlsx")

Company <- df$Company aQ <- df$ApproxQ OP <- df$OilPrice Date <- df$Date sQ <- df$SimpleQ DebtR <- df$DebtRatio Prod <- df$Size RRR <- df$RRR MW <- df$MW MW_BOE <- df$MW_BOE

#df

plot(aQ,Date)

ols <-lm(aQ ~ MW_BOE, data=df) summary(ols) fixed <- plm(aQ~MW_BOE , data=df, index=c("Company","Date"), model="within") summary(fixed)

fixef(fixed)

pFtest(fixed,ols)

#P-value of pFtest < 0.05 so fixed is better than OLS

#Now testing against random model random <- plm(aQ~MW_BOE , data=df, index=c("Company","Date"), model="random") summary(random)

phtest(fixed,random)

#model result from Hausman Test is 0.3517, must be <0.05 to chose fixed over random

#testing for time-fixed effects fixed.time <- plm(aQ~MW_BOE + factor(Date) , data=df, index=c("Company","Date"), model="within") summary(fixed.time)

pFtest(fixed.time,fixed) plmtest(fixed, c("time"), type=("bp"))

#pFtest indicates that time effects is needed, plmtest p value 0.1275 indicating no time effects needed. #test for cross-sectional dependence pcdtest(fixed.time,test=c("lm")) pcdtest(fixed.time,test=c("cd"))

#both test indicates tendencies of cross-sectional dependence

#test for serial correlation pbgtest(fixed) #serial correlation does exist.

#testing for unit root using dickey fuller panel.set <- plm.data(df, index = c("Company", "Date")) library(tseries) adf.test(panel.set$ApproxQ, k=1) is.numeric(aQ)

#unit root present (which is the basis for doing first differences) Removed when using FD model.

#test heteroskedsticity library(lmtest) bptest(aQ~MW_BOE + factor(Company) , data=df, studentize=F) #No heteroskedacity

#test fd serial correlation

fd <- plm(aQ~MW_BOE , data=df, index=c("Company","Date"), model="fd")

pwfdtest(fd)

pwfdtest(fd, h0="fe")

#This shows clearly that there is no serial correlation in the fd model but there is in the "whitin" model