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Stranded Assets in Oil and Gas Companies?

An Empirical Study of How Reserves and Investments in Renewable Energy Affect Firm Value in the Transition to a Low-Carbon Economy.

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Abstract

To reduce the level of a global warming in the time to come, a large part of the world´s fossil fuel reserves may have to be left unburned. Since oil and gas companies own a large part of these reserves, it has been suggested that these firms risk that substantial parts of their assets could become stranded in the transition to a low-carbon economy. A few of these firms have diversified into renewable energy and clean tech, and are expected to become broader energy companies in the future.

This study investigates the impact oil and gas reserves, as well as the investments in renewable energy and clean tech have on firm valuation. This is tested using a panel data model on a sample of 653 oil and gas companies listed on North American exchanges in the timeframe of 1999 to 2018. The main findings of this research suggest that developed oil reserves, as well as developed natural gas reserves are important factors for their valuation. Moreover, undeveloped natural gas reserves also seem to add value for these firms. It may be that investors are recognizing the future value for these reserves in a low-carbon economy, as it is the cleanest type of fossil fuel. However, as this effect is only present in one model, caution should be taken when concluding on this finding. On the other hand, undeveloped oil reserves and the growth in such reserves do not seem to have any effect on firm value. This is partly contrary to Atanasova & Schwartz (2019), who find a negative effect from the growth in undeveloped oil reserves on firm value. They believe this to be evidence that financial markets recently have recognized that reserves are at risk of being stranded. Alternatively, the insignificant effect from undeveloped oil reserves in this study may be explained by investors not attaching any value to them due to their future uncertainty. If this is the case, the risk of stranded assets for oil and gas companies may be minimal, as only developed oil and natural gas reserves seem to matter for their valuations. The last finding of this research is that investments in renewables and/or clean tech does not seem to have any effect on these firms valuation. An explanation for this could be that these investments makes up a relatively small amount of oil and gas companies' capital expenditures and, therefore, its effect is difficult to measure with the methodology used.

Keywords: asset pricing, hydrocarbon resources, renewable energy, stranded assets, climate finance

JEL Classification: G12, Q35, Q42, Q54

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1. Introduction

During the last decade there has been increased focus on climate change and how much CO2 we can allow to enter the atmosphere while keeping global warming to an acceptable level. The debate seems no longer to be centered on whether climate change is real, but rather how much we can limit the severe consequences it poses to our environment. In 2015, the Paris agreement was signed by 195 nations in an attempt to limit the seemingly unavoidable global warm up to well below 2℃ by 2050. This development poses challenges for fossil fuel producers as well as nation states with large amounts of valuable fossil fuel reserves. According to Linquiti & Cogswell (2016), two thirds of these reserves may be left underground and it is furthermore speculated whether or not financial markets are carrying a carbon bubble (Carbon Tracker, 2011).

A climate effect has previously been documented in the coal industry (Byrd & Cooperman, 2016), as well as in the stock market (Griffin et al., 2015) and in the bond market for fossil fuel producers (Delis, Greiff & Ongena, 2020). More recently, Atanasova & Schwartz (2019) also claim to find evidence of stranded assets in oil companies. However, most of these producers also own large reserves of natural gas which have been considered by some to be a bridge fuel in the transition to a low-carbon economy under certain circumstances. Especially if methane leakage from production can be minimized and near-zero carbon alternatives are not available in the short term (Hausfather, 2015). A few oil and gas producers have also diversified into renewables and clean tech like carbon capturing systems, potentially allowing them to still produce their reserves or transiting into broader energy companies in the near future. Empirical studies that also includes natural gas and renewables, in an attempt to investigate stranded assets among oil and gas producers, are not known by the author to exist. In order to add to our knowledge on this topic, this thesis will therefore explore the following research question:

How do oil and gas reserves and investments in renewable energy and clean tech affect firm value for oil and gas producers in the transition to a low-carbon economy?

In an attempt to answer this question, data from 653 oil and gas producers listed on North American stock exchanges during the timeframe of 1999 to 2018 is used. For reasons of comparison and validation, the thesis builds on existing research on oil companies conducted by Atanasova & Schwartz (2019). Oil and natural gas reserves, as well as investments in renewables and clean tech are included into a panel regression model together with the standard financial control variables. Their effects on firm value is measured by Tobin's Q. Because of the nature of the dataset, particularly for high values of growth in oil and gas reserves, a choice is made to present the results before and after winsorizing variables for robustness. The outcome shows that outliers may drive some of the initial results.

The main findings of this thesis is that investors largely seem to take developed oil and natural gas reserves into account when they do their valuations and that higher amounts of reserves increases firm value. This is also confirmed by a positive and significant effect from the growth in developed oil reserves. Furthermore, a positive and significant effect from undeveloped natural gas reserves for some regression specifications is documented. This finding is consistent with the idea that natural gas may potentially come to operate as a bridge fuel in the time to come (Hausfather, 2015). Perhaps this is what investors also are recognizing. No negative effect from the growth in undeveloped oil reserves on firm value is found in this research. Such an effect has previously been documented by Atanasova & Schwartz (2019). Arguably, this finding can be interpreted in two ways. First, it brings doubt to whether stranded asset risk have actually been recognized by financial markets in the investigated timeframe. Second, the insignificant effect may be due to investors not taking undeveloped reserves into account when valuing oil and gas companies. If this is the case, stranded assets may already be accounted for, implicitly, as financial markets are not attaching any value to them. This line of reasoning is consistent with Yergin & Pravettoni (2016), who argues that the risk of stranded assets for oil and gas producers may be minimal as developed reserves makes up about 80% of their value and can be expected to be produced within five to ten years. The stranded asset risk for oil and gas companies may therefore be minimal. Lastly, the low-carbon transition strategies of oil and gas companies fail to show a significant effect on firm value. A reason for this may be that renewables and clean tech makes up a relatively small amount of oil and gas producers capital expenditures during the investigated timeframe. Additionally, the number of firms in the dataset with such strategies are relatively small. Perhaps in the near future, when this industry has matured to a greater extent, a positive effect can be found.

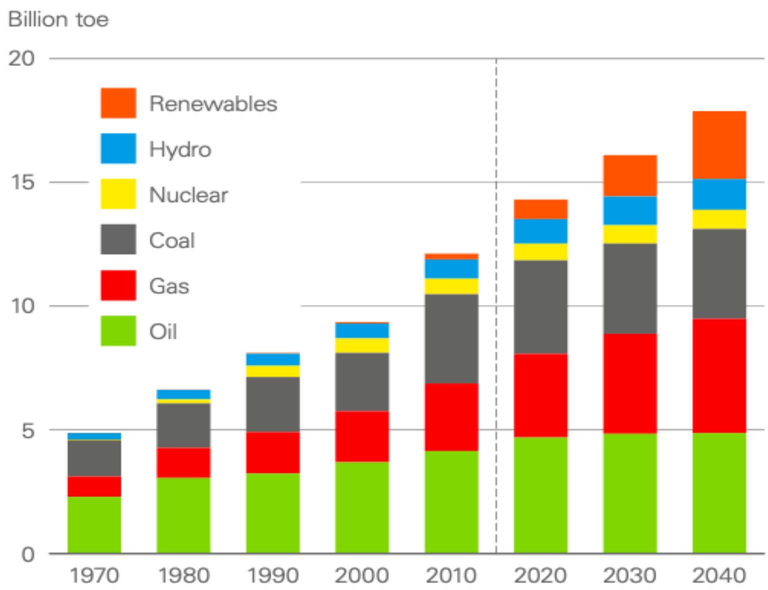
The paper is constructed in the following way. Section 2 starts by introducing the reader to the dilemma of climate challenges, rising energy demand and the proposed carbon bubble. After this, a review of research related to climate finance and stranded assets in the fossil fuel industry is presented. In Section 3, the research question and subsequent hypotheses are supported and formulated. Section 4 introduces the data sources and summary statistics for the research. The methodology is explained in Section 5 while the results are presented in Section 6. A conclusion is provided in Section 7 while limitations and recommendations can be found in section 8.

2. Background and Literature review

2.1 Climate challenges and increasing energy demand

To reduce the impact of global warming in the future, and the consequences that follows, it is likely that a large part of the world's fossil fuel reserves will have to remain underground and is left unburned. Although there has been an ongoing public debate for decades about whether CO2 emissions is connected to global warming, the more recent direction of this debate could largely be attributed to Meinhausen et al. (2009) and Allen et al. (2009). They showed how much CO2 could be emitted if we were not to exceed a rise in global temperatures of 2℃ by 2050, with respective probabilities. The probability of exceeding 2℃ increases rapidly with the amount of CO2 emitted over 1000 Giga tons (Meinhausen et al. 2009). In 2015, 195 nations made a strong commitment to mitigate global warming by signing the Paris agreement. Thus, they agreed to reduce emissions such that the world temperature would not rise above 2℃ pre-industrial levels by 2050. The nations would also pursue efforts to limit the increase to 1.5℃ (Linquiti & Cogswell, 2016). The EU has later committed even stronger to a low-carbon future by introducing The European Green Deal in 2019. This plan has set a goal of carbon neutrality for the union by 2050. To achieve this, divestment of fossil fuel resources and investments in greener energy sources are necessary (COM, 2019). Following these events, Carbon Tracker (2020b) has claimed that the peak demand for oil, gas and coal has already been reached in 2019. They furthermore argue that this eventually will lead to lower rents for petrostates and lower profits for fossil fuel producers. On the other hand, the world's energy demand still seems to grow strongly and fossil fuels are still regarded as an important energy source. According to BP's Energy Outlook (2019), fossil fuels will still be a part of the energy mix and will likely continue to grow in the near future. Figure 1 shows the projected increase in demand for the various types of energy sources. Oil demand is expected to increase until 2030, while natural gas takes a larger part of the energy mix up until 2040. Coal demand is rather expected to contract.

Figure 1: Primary Energy Demand By Fuel Source

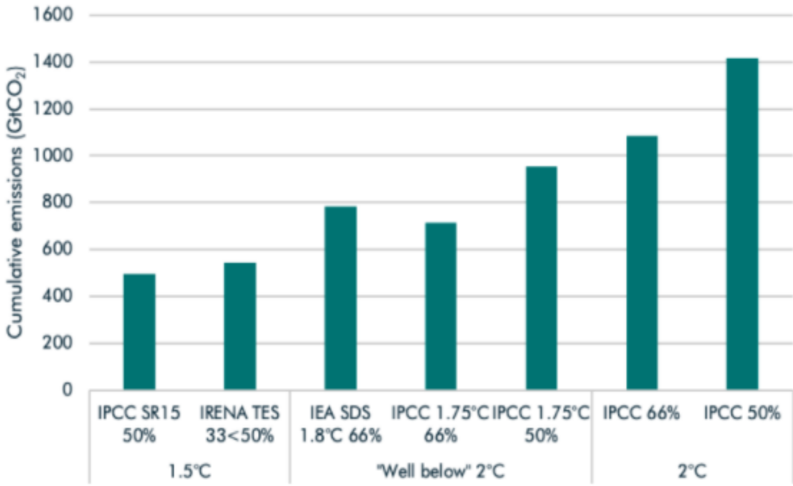


Source: BP Energy Outlook 2019.

2.2 The global carbon budget and fossil fuel reserves

The global carbon budget is the amount of CO2 we can emit in the atmosphere over the next 30 years, and still reach the world's climate goals. Figure 2 shows the Global Carbon budget, or what we can possibly emit under the different climate goals. Gigaton of CO2 (GtCO2) is a measure of cumulative emissions. The columns shows us the estimated emission limits by different models. As of May 2020, what was left of the global carbon budget if we are to not surpass the "well below" 2℃ limit, were at best a little less than 1000 GtCO2 (Carbon Tracker, 2020a). To put this into perspective, it is even less than the world´s listed oil and gas companies had in combined prospective reserves in 2013. According to Carbon Tracker (2013), this was estimated to be about 1540 GtCO2. Moreover, if the world were to pursue the 1.5℃ goal, even the proven reserves of the same companies, equivalent to 762 GtCO2, will be far more than we ever can allow to be emitted. This is at the core of the issue. If fossil fuel reserves have to be left unburned, this could potentially have severe consequences for the value of oil and gas companies (Carbon Tracker, 2013).

Figure 2: The Global Carbon Budget



Source: Carbon Tracker (2020a)

2.3 Stranded assets and the carbon bubble

The term *stranded assets* was first popularized by the NGO Carbon Tracker (2011). A general definition for a stranded asset may be "an asset which loses significant economic value well ahead of its anticipated useful life, as a result of changes in legislation, regulation, market forces, disruptive innovation, societal norms, or environmental shocks" (Generation Foundation, 2013, p.1). The term *carbon bubble* has later been used to describe the risks financial markets are potentially carrying if a large part of the world's current reserves is left in the ground to reach the world´s climate goals (Carbon Tracker, 2011).

There are at least four main drivers of stranded assets (van der Ploeg & Rezai, 2020). The first is policy makers trying to cap emissions by introducing carbon taxes, subsidies for renewables or emission trading schemes. Such policies can stimulate development of cleaner energy sources or energy efficiency, while the less clean energy sources are penalized. Also, policy makers can more directly intervene by buying up fossil fuel reserves, preventing them from being used. The second driver is extraction cost. The more expensive fossil fuel reserves becomes to extract, the more sensitive it becomes to price changes and cheaper substitutes. For example if oil prices were to fall below a certain threshold indefinitely, some projects may never be developed and thus become stranded. The third is significant drops in costs for renewables, hydrogen fuels or battery technology. For instance, over the last four decades, the price of solar panels have decreased over 99%, while its efficiency has been increased dramatically (Chandler, 2018). The final force is positive feedback effects which means that green behavior is contagious between agents. Not only among consumers, but also between governments, firms and even investors. For instance if some countries switch to more ambitious climate policies, it may be cheaper for other countries in the same region to do the same (van der Ploeg & Rezai, 2020).

According to Linquiti & Cogswell (2016), the total world´s fossil fuel reserves have an estimated value of around $295 trillion in a business-as-usual case. Under a strict world climate policy, they claim that 63% or $185 trillion of these reserves must be left underground. This is a substantial amount and is equivalent to 2.4 years of global GDP. As of 2011, the combined market value of the 100 largest fossil fuel producers listed on the world's stock exchanges was also more than $7 trillion (Linquiti & Cogswell, 2016). According to Carbon Tracker (2013), roughly two thirds of this value can be classified as stranded in a Paris-compliant world. This has furthermore lead them to believe that financial markets are potentially carrying a carbon bubble.

There are also reasons to believe that some types of fossil fuels should be less stranded than others. For instance, McGlade and Ekins (2015) estimate that more than 80% of coal reserves, 50% of gas reserves but only about 30% of oil reserves should remain unburned from 2010 to 2050, to comply with the 2°C target. In this scenario, we could perhaps expect gas reserves to be more stranded than oil reserves. However, in countries with a stricter climate policy or a CO2 trading scheme, natural gas is likely to replace coal for energy production as it is a far cleaner source of energy. According to IEA (2019), a coal-to-gas switch could reduce emissions by 50% for electricity production and 33% reduction for heat generation. This analysis takes both CO2 and methane into account. Natural gas also could have the potential to help reduce emissions by a substantial amount if used in combination with renewable sources[1] like wind and solar (Forbes, 2019). It has also been proposed as a way of reducing emissions by producing hydrogen ("blue hydrogen"), where the carbon is removed from the natural gas (The Oxford Institute for Energy Studies, 2020). Following this line of reasoning, we could perhaps see the demand for natural gas increase where coal is being more or less retired as an energy resource. Especially in regions with stricter climate policies such as in the EU. Due to its properties of

[1] Renewables like wind and solar have great potential, but currently, challenges with energy storage makes it problematic to operate in large scale without intermittent energy production from either coal or natural gas.

lower emissions, natural gas could have a brighter future than other fossil fuels, and therefore makes it more questionable if these reserves actually are stranded after all. According to Generation Foundation (2013), a potential problem could be leakage of the far more potent climate gas methane in the production of natural gas[2], but to this date it is unclear how big of a concern this is as little data is gathered on this matter. However, if this is the case, one could perhaps see more aggressive regulation in the future. This clearly could make the business case problematic for natural gas as well.

Stranded assets could also be related to production cost and carbon intensity in production. Kepler Cheuvreux (2014) argues that the higher cost oil producers are also the most carbon intensive and therefore, the ones with the highest exposure to the risk of stranded assets. For instance, Canadian oil sands are about three times as carbon intense in production as Saudi oil, but it is also much more expensive to produce. In an environment with constant lower oil prices, its production is therefore likely to be reduced (HSBC, 2015). A lower oil price may therefore be favorable for the climate as the most carbon intense oil production generally requires a higher break-even point. But this also means that some types of producers, like Canadian oil sands, could face a higher stranded risk than others. McGlade & Ekins (2014) estimate that 500 billion barrels of existing oil reserves must remain unused before 2035 in an effort to limit the average temperature increase to 2℃. This number increases to 600 billion if Carbon capture systems (CCS) are unavailable. Furthermore, they argue that arctic and tight oil is mostly un-burnable with the climate constraint, and an estimated 40% of uncovered Deepwater oil must remain underground. This is even with CCS available. The estimate increases to 55% without. HSBC (2015) argues that disruptive forces in renewables and battery technology can potentially ruin the business case for fossil fuels. With a close-to zero marginal cost, renewables have the potential to outcompete more expensive and less clean energy sources such as fossil fuels. However, they still regard regulation as the most important driver for change. As such, a stricter climate policy and lower oil prices may force some projects to be left undeveloped. Disruptions in CCS technology have the potential to reduce the amount of reserves that are of risk of being stranded, while disruptions in battery technology and renewables work in the opposite direction and undermines the business case for fossil fuels.

[2] For every gram, Methane is 72 times more efficient climate gas than Co2 is.

However, there are also studies that do not agree with the negative projections for fossil fuels by for instance Carbon Tracker (2013) and Linquiti & Cogswell (2016). For instance, Yergin & Pravettoni (2016) largely disproves the existence of a carbon bubble and is criticizing Carbon Tracker for not distinguishing between the different types of reserves. They argue that 80% of firm value for oil and gas companies are based on proven reserves, which are expected to be produced within the next five to ten years. Therefore, the stranded asset risk may be minimal. Furthermore, Newell et al. (2016), combines projections from various agencies and energy companies[3]. They find that the demand for fossil fuels will most likely increase beyond 2040. On the other hand, this projection also entails that global the temperature increases above 3℃, unless more stringent policies are adopted. Likewise, oil companies themselves find it very unlikely that demand for especially oil and gas will decline during the next 20 years. It is rather expected to increase as the world population is growing (Exxon Mobil, 2019). BP (2019) projects that oil production will grow further than today's levels before plateauing in 2035. Natural Gas and Renewable energy is furthermore projected to grow more rapidly, while coal is expected to contract sharply. In BP´s (2019) most climate-optimistic scenario, oil and gas is expected to account for nearly half of the energy mix. On the bright side, emissions are reduced with 45% in this scenario, where energy efficiency and switch from coal to natural gas and renewables being the largest contributor to the reduction. In both these scenarios, fossil fuels will still have a dominant role in the worlds energy mix in the next 30 years to come and thereby it should, to a lesser degree be stranded.

2.4 Stranded assets in securities markets

Some investors are also beginning to recognize the long-term risks of climate change and that a large part of the oil and gas company's assets could potentially be subject to impairment. The Norwegian Sovereign Wealth Fund is one large investor that is not mandated to invest in pure fossil fuels anymore (The Guardian, 2019). Other large private investors like BlackRock, which is one of the world´s largest investors in fossil fuels, have also announced divestment of some of these holdings (Financial Times, 2020). Krueger, Sautner & Starks (2019) conducted a survey and found that particularly institutional investors already account for climate risks in their portfolios. The majority of these investors also expected global temperatures to rise significantly by the next hundred years and they believe that this risk was not fully reflected in financial markets yet. Regulatory risk was believed to be the greatest risk. The overvaluation

[3] International Energy Agency, Shell Exxon Mobil and OPEC

in equities, however, was not considered to be particularly large, but greatest for oil companies. Moreover, larger investors oriented towards longer-term investments considered directly influencing the management rather than divestment. Through the option market, Ilhan, Sautner & Vilkov (2020) estimated that carbon tail-risk protection was more expensive for carbon-intense firms, and that these prices fluctuated by the political climate. Especially, the cost of protection decreased after the climate sceptic Donald Trump was elected into the White House. Engle et al. (2019) created a dynamic hedging approach for climate risk. They constructed portfolios that could hedge market reactions to climate change news from the media. This shows that climate risk may already have materialized in financial markets.

Most of the research that are currently available on stranded assets are forward looking, meaning that it is trying to project the amount of stranded assets in a future scenario. Research that falls into this category are for instance Carbon Tracker (2013) and Linquiti & Cogswell (2016). The disadvantage about this literature is that it is largely dependent on some carbon constraint and uncertainty about demand for fossil fuels in the future (Curtin et al. 2019). Therefore, empirical studies could give us useful insight to whether or not this relation holds in reality. Up until now, there has been fewer attempts to actually find evidence for this in securities markets but a few should be mentioned.

HSBC (2013) was one of the first to investigate stranded assets for oil and gas producers. They estimated stranded risk by using a value-at-risk (VAR) model for six of the largest oil companies with headquarters in Europe[4]. Using cost data from Wood Mackenzie, they calculated the VAR for each producer by adding up the total values of projects that could be unburnable. They found that a modest reduction in oil and gas demand could decrease the firm´s equity values by 40% to 60% for stranded oil projects, but only 6% to 9% for stranded natural gas. Atanasova & Schwartz (2019) supports the claim that stranded assets are already being priced in financial markets. By applying a panel regression model to American oil producers, they found that growth in undeveloped oil reserves has a negative effect on firm value, which is measured by Tobin´s Q. They also find that the negative effect from undeveloped reserves are stronger in countries with stricter climate policies. Overall, the effect was also stronger after the Paris agreement was signed in 2015. This was proposed by the authors as evidence that participants in financial markets increasingly believe that a larger part of the oil reserves will

[4] BP, Shell, Total, Statoil (Equinor), BG and ENI

have to be left in the ground. Thus, it shows that investors already price in the stranded asset risk. Griffin et al (2015) evaluated the unburnable carbon among 63 publicly listed oil and gas companies through an event study. They found that stock prices only declined by 1.5% and 2.0% over a two days event window when media popularized the Meinshausen et al. (2009) 2°C target carbon constraint. Less so for new media announcements after this event. They furthermore argue that the modest decline in stock prices may be due to optimism towards future CCS technology, anticipation of tax reductions following hard government policies, expectations about increased demand for oil and gas in the future or that informed investors already have priced in the "unburnable carbon".

Regarding coal, Byrd & Cooperman (2016) show through an event study in the timeframe 2011 to 2015, that news about breakthroughs and progress in carbon capture systems (CCS) were associated with positive abnormal returns for coal producers. On the other hand, setbacks in CCS did not yield any significant reaction, leading the authors to believe that a risk premium were already imbedded into the prices. On the flipside, the results from their study suggests that the existence of a carbon bubble could be exaggerated as the negative news already is priced into financial markets. Heede and Oreskes (2016) concluded that stranding risk for 70 private fossil fuel producers were minimal as long as they did not continue to invest in new reserves. The risk was higher for the eight government-run producers in the sample, due to their far higher amounts of estimated reserves. They furthermore advice investors and consumers to focus on phasing out projects with high extraction cost and carbon intensive production. Caldecott (2013) examined stranded asset risk among Australian coal mining firms and found that the current coal price was unlikely to be sustained due to shifting demand from China and thereby could make several projects unprofitable. They furthermore concluded that Chinas shifting coal demand was likely related to rising concerns about air pollution, greenhouse gas emission and massive non-fossil energy deployment in China. Therefore, they warn investors that more coal assets in Australia are at risk of becoming stranded as China is an important export market for their coal.

For corporate loans, Delis, Greiff & Ongena (2020) investigated the corporate loan market and found that potentially stranded fossil fuels are already priced into the spreads. Especially, they show that banks had increased their loan spreads to fossil fuel producers after the Paris agreement was signed in 2015. Moreover, "Green" banks charged higher loan rates for fossil fuel producers. These results were solid after controlling for the steep decline in oil prices of

2014 to 2015. Using the carbon intensity for every unit of GDP, The Global Footprint Network (2016) investigated carbon exposure in sovereign debt. They argued that investors to a lesser degree considered climate risks for sovereign bonds. Moreover, they found that particularly China could face higher carbon risk due to its high carbon footprint and government emissions. On the bright side, they were also by far the most promising issuer of Green Bonds[5]. Carbon Tracker and S&P (2013) also announced that firms with exposure to Canadian Oil sands or other unconventional production could see their pressure on their credit worthiness increase in a stressed, low oil price scenario. This was mostly the case for high cost producers but also more diversified players could be affected.

To summarize, there has been a few successful attempts which show that investors are in fact accounting for stranded asset risk, but it is unclear whether the carbon bubble proposed by Carbon Tracker (2013) is actually present in financial markets. The amount of stranded assets, among fossil fuel producers, also depends on how investors value these assets. If most of their value comes from developed reserves, the stranded risk may not be particularly large as these reserves will be produced within 5 to 10 years (Yergin & Pravettoni, 2016). However, as more reserves are being developed, the stranded risk could potentially increase in the future, but it is unclear if this holds for all types of fossil fuels. The demand for oil and natural gas is rather projected to increase in the near future (Newell et al., 2016; Exxon Mobil, 2019; BP, 2019). This suggests that a carbon bubble may be exaggerated. At least for oil and natural gas. On the other hand, unexpected developments in alternative energy sources, as well as government regulation, could perhaps alter this scenario and potentially pose a larger threat to fossil fuel reserves than is accounted for today (HSBC, 2015).

2.5 Transition into greener energy companies

Due to the current situation for oil and gas producers with price volatility and uncertainty about future climate policies, diversification strategies into greener energy projects may be necessary. According to Lu et al. (2019), the path to low-carbon transformation can be divided into three types: "(1) the petroleum business turns to the natural gas business; (2) reduces carbon emissions in production and operation; (3) develop and utilize renewable energy", all of which can be carried out in parallel. The transition from oil to natural gas can therefore also be considered as a low-carbon transition strategy, but investing in renewables is the most thorough

[5] Green Bonds are meant to offer investors fixed income while investing in low-carbon projects.

one (Lu et al. 2019). In this paper we exclude (1) natural gas as a transition strategy. This is because we already account for this in the fossil fuel reserves. In the remainder of this paper we shall define a transition strategy as investment in renewable energy (includes solar photovoltaics, wind, biofuels and “green hydrogen”) and/or investments in carbon capture systems or “blue hydrogen” facilities which can potentially enable them to still produce their reserves in a low-carbon economy.

Several of the world’s largest oil and gas companies have been investing in alternative energy sources such as solar photovoltaics, wind and biofuels for many years already. According to Pickl. (2019), five of the eight major oil producers[6] are potentially transiting into broader energy companies in the near future. For example, the CEO of Europe’s largest oil producer, Royal Dutch Shell, recently insisted that he is not running a pure oil company anymore, but an energy transition company (Bloomberg, 2019). The remainder of the oil majors, all of which are American oil and gas companies[7], are rather focusing their resources on technologies like carbon capture systems (CCS). Potentially, this could enable them to still produce their large developed reserves. The reason for this is according to Lu et al. (2019) “An America First Energy Plan” released by the United states in 2017 which strongly supports the traditional oil and gas industry, but positively, the plan also embraces responsible environmental stewardship in production, protecting air, water and conserving natural habitats (The Heartland Institute, 2018). Furthermore, Pickl (2019) argues that there seem to be a strong linkage between their amount of proved oil reserves and their renewable energy activity among oil majors, where the companies with the largest reserves[8] are the least active in this type of business. Companies with smaller amount of reserves[9] are moving faster into renewable energy. Nonetheless, the world's oil giants seem to want to be a part of the world's energy transition.

According to the director at the Centre for Climate finance and Investment at Imperial College, Charles Donovan, it is a conventional wisdom that investing in renewable energy is less profitable than fossil fuels (Forbes, 2020). In a report affiliated with the same author, they conclude that this consensus is wrong and that investing in renewables have offered a far higher rate of return than fossil fuels over the past 5 and 10 year period (CCF&A, 2020). Historically,

[6] BP, Eni, Total, Royal Dutch Shell and Equinor.
[7] Exxon Mobil, Chevron and Petrobras
[8] Chevron, Exxon Mobil and Petrobras. Apart from BP which is relatively active in the renewable space as well as also having large proved oil reserves.
[9] Equinor, Eni, Total, Shell.

renewables have also had a lower energy efficiency than oil and gas, but recently wind and solar technology has reached a mature level with further room for improvement. Biomass energy is still far more expensive and energy inefficient than traditional fossil fuels (Rana et al., 2020). Policy interventions may help spur more investments and developments to become even more competitive. Especially for oil producers located in areas with a stricter climate policy, such as in the EU. In some of these countries renewables are also subsidized by the government, such as in the Netherlands (Power Technology, 2020b). Moreover, the cost of renewable energy deployment has recently become much lower and is still decreasing (Forbes, 2018). These factors could potentially challenge the fossil fuel industry further, given that intermittency challenges[10] with the power grid are solved.

There seem to be benefits to being "green" and the transition strategies of oil and gas companies could be expected to increase shareholder value. One reason for this could be that investing in renewables positively affects their Environmental, Social and Governance (ESG) scores, and there is growing evidence from the literature that such focus is increasing shareholder value. According to Jagannathan, et al. (2017), asset managers which include ESG criteria in their strategies have increased from $13.3 in 2012 to $22.9 trillion in 2016. They furthermore conclude that investors also could reduce portfolio risk by using ESG scores to improve their portfolios, as these firms are better prepared for dealing with future regulation, technology disruptions and changes in consumer tastes. Moreover, Pastor et al. (2019) finds that high scoring ESG companies' stock performance is strong on average and a reason for this may that investors is trying to hedge climate risk. Furthermore, they also conclude that such investment preferences is forcing companies to become "greener". Blumenshine & Wunnava (2010) investigated the relationship between market capitalization and having a "green" profile or having a higher environmental score by using the Newsweek´s Top 500 Green Rankings 2009 as a proxy. They found that having a "green profile" increased market capitalization value over non-green companies by a staggering 86,3%. They are, however, cautious about concluding on their finding as they admit there may be several omitted factors in their study that also contribute to the value of a company. Nevertheless, the existence of a "green premium" has been supported by others like Chan & Walter (2014) which both find abnormal returns from environmentally

[10] Power generation from renewable sources, especially from solar power, does not produce a steady flow of energy. This can create overproduction during daytime and underproduction at nighttime in locations where solar generation is high (e.g. California). Therefore, it increases demand for other energy sources when solar production is low, and furthermore, increases the need for storage capacity when production is high (ABB, 2019)

friendly IPO´s and SEO´s in the long term and short term as well as that green stocks performs better in the long term. It is, however, unclear whether the oil and gas industry can benefit in the same way. Yoo et al. (2013) also found that renewable M&A´s during 2008 - 2010 created positive abnormal returns in general, but for the oil industry specifically, it destroyed value. Arguably there are limitations to this finding as it is only based 15 observations over 2-3 years. For the longer term, literature highlighting this relationship is lacking.

A stand-alone successful example of what the oil majors are trying to achieve is perhaps the previous oil and gas producer Ørsted[11]. By divesting nearly all of their oil and gas operations over the years and rather focusing strongly on offshore wind farms, Ørsted has successfully transitioned to becoming a "green" energy company (Power Technology, 2020a). As of June 2020, Ørsted had a market value close to that of the Norwegian oil and gas giant Equinor. According to Reuters (2020), it has also rebranded itself as a "renewable major".

3. Hypothesis development

To help answer the research question, a few key points can be taken from the literature review. First, at least in some parts of the world, there seem to be a public consensus that fossil fuels are harmful for the environment. This view is largely supported by academics such as Meinhausen et al. (2009) and Allen et al. (2009). Moreover, there have been several attempts to quantify the amount of fossil fuels that are at risk of being stranded in a low-carbon economy (Carbon Tracker, 2011; Linquiti & Cogswell, 2016; McGlade & Ekins, 2015). So far, a few successful attempts have also claimed to find evidence for this in securities markets (Atanasova & Schwartz, 2019; Griffin et al., 2015; Byrd & Cooperman, 2016; Delis, Greiff & Ongena, 2020). Second, the degree to which fossil fuels are stranded should depend on various factors such as demand in the future, carbon emissions and policy risk (Ploeg & Rezai, 2020). For instance, coal emits more CO2 than oil and far more than natural gas. Therefore, the risk of policy intervention or lower demand due a shift away from industries that harm the climate, can severely damage the coal industry and make natural gas look like a cleaner substitute for power generation. Thus, natural gas could have a lower risk of being stranded than oil, while coal has the largest risk of being stranded following this reasoning. Lastly, the transition strategies of oil and gas companies could be expected to yield a positive impact on their value if investors increasingly take ESG scores or having a "green profile" into account when making capital

[11] Previously Danish oil and gas (DONG)

allocations (Jagannathan, et al., 2017; Pastor et al., 2019; Blumenshine & Wunnava, 2010; Chan & Walter, 2014). Additionally, a report from CCF&A (2020) suggests that renewables actually have been more profitable than fossil fuels during the last 5 to 10 years. Out of these key points, nine hypotheses are developed to answer the research question.

3.1 Oil reserves

According to Yergin & Pravettoni (2016) proved reserves are expected to be produced within a timeframe of 5 to 10 years and accounts for about 80% percent of oil and gas companies' value. Oil and gas reserves are classified according to their certainty of recovery under current economic and operational conditions, where proved reserves require a 90% probability of recovery or greater (EIA, 2019). Proved reserves are furthermore divided into developed and undeveloped reserves where the former can be expected to be recovered using existing methods and equipment through existing wells. For the latter, it requires major expenditure and involves new, undrilled wells (SEC, 2010). According to Misund & Osmundsen (2017), investors do not consider information about probable reserves when forecasting future cash flows, but rather primarily use proved reserves in their estimations. Following this line of reasoning, focusing the study only on proved reserves should be sufficient to produce meaningful results[12]. Like in Atanasova & Schwartz (2019) a positive effect from developed oil reserves and a negative effect from the growth in undeveloped reserves is expected to be found. With oil demand on the rise, and following Yergin & Panettoni's (2016) line of reasoning, one could also argue that growth in developed reserves should have a positive effect on firm value since they can be expected to be produced within a short timeframe. The first four hypotheses are therefore as follows:

Hypothesis 1: Developed oil reserves are positively associated with firm value

Hypothesis 2: Undeveloped oil reserves are negatively associated with firm value

Hypothesis 3: Growth in Developed oil reserves is positively associated with firm value

Hypothesis 4: Growth in Undeveloped oil reserves is negatively associated with firm value

[12] Probable and Possible reserves are also not available in Compustat industry specific.

3.2 Natural gas reserves

To contribute further to the current research, natural gas reserves are also included into the analysis. The reason for this is that natural gas reserves also should be an important factor for oil and gas companies' assets. Some have also suggested that natural gas could have a brighter future than oil, as it is the cleanest source of fossil fuel and could potentially support renewable production (Forbes, 2019; Hunt, 2009). Additionally, it has been a popular belief that natural gas can serve as a bridge fuel by replacing coal for power generation. Its future potential for this increases if methane leakage from production are minimized, but even more if CCS are used (Hausfather, 2015). For these reasons, its stranded assets risk could also be lower. Like for oil, natural gas reserves are divided into developed and undeveloped reserves. The expectation is to find a positive effect of both developed and undeveloped natural gas reserves, as well as the growth in these reserves. Therefore, the fifth to the eight hypotheses are as follows:

Hypothesis 5: Developed gas reserves are positively associated with firm value

Hypothesis 6: Undeveloped gas reserves are positively associated with firm value

Hypothesis 7: Growth in developed gas reserves is positively associated with firm value

Hypothesis 8: Growth in undeveloped gas reserves is positively associated with firm value

3.3 Transition strategies of oil and gas producers

An attempt is also made to test if the oil and gas companies' transition strategies have added value. There are reasons to believe a "green" premium exists for oil and gas producers which have diversified into renewable energy or clean tech as this possibly improves ESG scores (Pastor et al., 2019; Blumenshine & Wunnava, 2010; Chan & Walter, 2014). On the other hand, renewable energy could also have the potential to become a profitable part of their businesses in the near future (CCF&A, 2020). Renewable energy is also expected to increase rapidly over the next years and reach 15% of the total energy consumption by 2040 (BP, 2019). Therefore, the last hypothesis is as follows:

Hypothesis 9: The transition strategies of oil and gas producers leads to a higher firm valuation than the control group on average.

4. Data

4.1 Data sources and selection

Oil and gas reserves are held by firms which operate under a handful of primary Standard Industrial Codes (SIC). To ensure the inclusion of enough firms that hold oil and gas reserves, we use the following SIC codes: 1311 (Crude Petroleum and Natural Gas), 2911 (Petroleum Refining) and 5172 (Petroleum and Petroleum Wholesalers, except Bulk Stations and Terminals). All of the oil majors can be found under SIC code 2911, while the small to medium producers operate under SIC code 1311 and 5172.

For accounting and market data Compustat is used. Data on oil and gas reserves is collected from the industry specific database on WRDS, while Datastream is used for oil and gas prices. Control variables are created from Compustat fundamentals. The full sample of oil and gas producers combined is 924 companies from 1999[13] to 2018[14], with more than 6400 firm-year observations. After excluding penny stocks[15], observations where total assets are zero, EBITDA is missing, and furthermore, observations where shares outstanding, stockholders equity or reserves are missing or negative, the final sample of firms is 653, with more than 4000 firm-year observations.

As no official database on renewable investments is known by the author to exist, a transition focus or a "green" dummy variable is hand collected from reading the firm's annual reports and/or official webpages. As large part of the sample has become inactive during the timeframe investigated, such information is not easily available for all firms. For these firms we use the EDGAR module in WRDS to find and scan their previous annual report filings to the SEC. Bloomberg is used as a support tool. Firms with investments in renewable energy or clean tech get 1 for the years they are active in this segment, 0 otherwise. While examining each company, only 11 companies[16] with a total of 160 firm-year observations, can clearly be said to have a transition focus. Most of these companies operate internationally under SIC code 2911 and most of them can be classified as international oil majors.

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[13] Before 1999, reserves coverage in Compustat is almost nonexistent.
[14] As of Aug 2020, oil and gas reserves from 2019 is not available yet.
[15] Stock price below 0.4. The reason for this threshold was to avoid leaving too many firms out of the sample.
[16] These firms are BP, Eni, Total, Royal Dutch Shell, Equinor, Exxon Mobil, Chevron, Petrobras, Repsol, Lukoil and Suncor Energy

4.2 Descriptive statistics

Summary statistics for the full sample of firms can be found in Table 1, while the firms with a transition strategy can be found in Table 2. The average (median) Tobin´s Q for the whole sample is 1.776 (1.334), while for the transition strategy group the average is 1.37 (1.27). This indicates that the market value exceeds its book value for most of the companies. The standard deviation for both the Tobin´s Q is much larger for the whole sample than the transition strategy group, indicating a much larger variation. This is expected since the full sample includes a lot of small companies. We can also see this from the average total assets where the full sample has more than $12,479 million while the median is quite small with only $486 million, supporting our previous statement that a lot of the firms in the sample are in fact small. Not surprisingly, the firms with a transition strategy are much larger with an average (median) total assets of $176,849 ($160,145) million. They are also more leveraged with a 42.28% leverage ratio while the full sample has a 36.3% on average. We can also see that they are much more profitable on average than the full sample with a mean (median) of 19.08% (17.55%). While in the full sample the mean (median) is -25.3% (15.72%), indicating that a lot of the firms are not profitable at all. This could be important to note as we are comparing them through a dummy variable later on. Kurtosis and skewness are also added to give the reader an understanding of the non-normality and outliers present in some of the variables. This is especially true for Capex and Profitability, as well as for the reserve variables. We will later address this issue in the methodology and robustness section of our results part.

Shown in Panel 2 in both Tables are the reserves variables for both oil and gas. All reserves are reported in their total amount divided by the dollar value of total assets. As we can see from the amount of observations, most of the companies’ own oil reserves, while a bit fewer own both oil and natural gas reserves. Kurtosis and skewness of quite some magnitude are also present for these variables. More so for the whole sample. How all the variables were created is covered in section 5.2.

Table 1: All Firms

Summary statistics for the full sample of 653 firms in the time frame 1999 to 2018. Panel 1 shows the firm financial variables, while Panel 2 shows the firms Oil and Gas reserve variables. The reserve variables for both oil and gas is calculated by dividing the reserves by the dollar value of assets. Table 3 shows how the financial variables were created.

Panel 1: Financial variables										
All Firms	Observations	Mean	Median	Std dev	Skewness	Kurtosis	5 %	25 %	75 %	95 %
Tobin´s Q	4,238	1.7764	1.334	2.857	15.183	308.327	0.668	1.020	1.799	3.581
Assets (million of US $)	4,252	$12,479	$486.08	$44,244.15	5.486	36.149	$13.51	$110.94	$3,079.95	$61,689
Leverage	4,250	36.3%	34.2%	21.4%	0.493	2.726	5.0%	20.0%	50.0%	76.5%
Capex	4,051	33.8%	21.8%	33.8%	56.11	3341.65	3.6%	11.8%	40.0%	102%
Profitability	4,076	-25.3%	15.72%	18.93%	-44.59	2048.66	-22.88%	5.3%	26.95%	47.3%
Dividends	4,039	0.037	0	0.814	54.15	45.16	0	0	0.013	0.106
Panel 2: Fossil Fuel Reserves										
Total Reserves (Oil)	4,252	0.0474	0.0253	0.104	10.022	151.876	0.0004	0.0098	0.0483	0.1498
Developed Reserves (Oil)	4,029	0.0251	0.0143	0.0528	12.215	223.609	0.0001	0.0057	0.0275	0.0788
Undeveloped Reserves (Oil)	4,029	0.0206	0.0068	0.0729	14.116	283.850	0	0.0013	0.0175	0.0672
Total Reserves (NG)	4,082	0.3360	0.1856	1.0048	17.687	404.401	0.0042	0.0830	0.3576	0.9140
Developed Reserves (NG)	3,894	0.1925	0.1166	0.6186	31.186	1189.962	0.0020	0.04702	0.2167	0.5230
Undeveloped Reserves (NG)	3,894	0.1388	0.0452	0.6649	23.229	713.680	0	0.0104	0.1187	0.3768

Table 2: Firms with a Transition Strategy

Summary statistics of the 11 firms in the full sample which has a transition strategy or a "green" profile. Panel 1 shows the firm financials while Panel 2 shows the Oil and Gas reserves. The reserve variables for both oil and gas is calculated by dividing the reserves by the dollar value of assets. Table 3 shows how the financial variables were created.

Panel 1: Financial Variables										
Variables	Observations	Mean	Median	Std dev	Skewness	Kurtosis	5%	25%	75%	95%
Tobin´s Q	160	1.3721	1.2730	0.4402	1.1163	4.2590	0.8196	1.0797	1.6187	2.3833
Assets	160	$176,849	$160,145	$101,518	0.3323	2.0282	$36,577	$89,321	$253,835	$347,750
Leverage	160	42.28%	42.41%	13.19%	0.3778	2.8982	20.73%	32.88%	51.62%	63.09%
Capex	159	10.50%	9.44%	4.90%	1.9101	7.2880	5.15%	7.27%	12.00%	23.03%
Profitability	160	19.08%	17.55%	9.60%	1.2890	6.3167	7.00%	11.86%	23.61%	36.72%
Dividends	153	0.0267	0.0321	0.0166	1.7802	13.067	0.0047	0.0194	0.0372	0.0478
Panel 2: Fossil Fuel Reserves										
Total Reserves (Oil)	160	0.0491	0.0374	0.0357	1.5151	4.7367	0.0144	0.0243	0.0577	0.1318
Developed Reserves (Oil)	149	0.0272	0.0215	0.0196	1.7385	5.6950	0.0095	0.0140	0.0317	0.0756
Undeveloped Reserves (Oil)	149	0.0179	0.0141	0.0134	1.9337	7.9807	0.0042	0.0090	0.0226	0.0477
Total Reserves (NG)	150	0.1834	0.1583	0.0973	0.8754	4.2993	0.0363	0.1253	0.2373	0.3650
Developed Reserves (NG)	144	0.1101	0.0907	0.0664	1.2663	5.0832	0.0222	0.0758	0.1354	0.2339
Undeveloped Reserves (NG)	144	0.0697	0.0652	0.0377	0.5405	2.9298	0.01415	0.0436	0.0911	0.1392

5. Methodology

5.1 Research design

Similar to Atanasova & Schwartz (2019), fossil fuel reserves are included into a panel regression model with Tobin's Q as the dependent variable to answer the hypotheses and research question. In addition to oil and gas reserves, a dummy variable is included to capture the effect of investments in renewables or clean tech (CCS) on firm valuation. A number of standard control variables such as size, leverage, profitability and dividends as well as oil and gas prices are added for robustness.

Panel data regression

The advantage of panel data models is that we can study observations from companies over time. Since there are 653 firms in the dataset, with more than 4000 firm-year observations, firm specific variation needs to be accounted for. This can be done in a fixed effects or random effects regression model with clustered standard errors on each firm[17].

According to Verbeek (2004), fixed effects models have the advantage of mitigating potential bias that can occur due to time-invariant unobservable factors (α_i), by holding these constant over time. Mathematically, the model can be written as

(1) $$y_{it} = \alpha_i + x'_{it}\beta + \varepsilon_{it}$$

where α_i is each firms individual effect and x'_{it} is a K-dimensional vector of explanatory variables, assumed to be an average for all firms and periods. α_i can furthermore, vary between firms. ε_{it} is the error term, as usually assumed to be independently and identically distributed over both time and individuals (Verbeek, 2004).

For most of the regression models, a fixed effects model can be applied. However, a problem arises when including the transition dummy variable. In lack of variation, a fixed effects regression model omits the variable. A way around this is therefore to apply a random effects

[17] STATA is used with the xtreg, re (fe) vce(cluster firm) command.

regressions for these regression specifications. According to Verbeek (2004), the Random effects model has a different way of encountering the issue with the time-invariant factor. It assumes that the individual intercept (α_i) is drawn from a distribution with a mean of μ and a variance of $\sigma^2_\propto$, which is furthermore independent of the explanatory variables $x'_{it}\beta$. The individual effect (α_i) is thus treated as random with a mean of zero. α_i is furthermore a part of the error term together with a component ε_{it}, which is assumed to be uncorrelated over time (Verbeek, 2004). Mathematically, the random effects model can be written as follows:

$$y_{it} = \mu + x'_{it}\beta + \alpha_i + \varepsilon_{it} \quad (2)$$

Both fixed effects and random effects models are applied for the regression models as to see if the results change[18]. The results do not change dramatically from the change of model. The results from the fixed effects regressions are reported in the majority of the results section, but with random effects for the regression specifications with the transition strategy "green" dummy.

5.2 Variable creation

Dependent variable

Tobin´s Q can be defined as the ratio of the firm´s market value to the book value of its total assets (Sandner & Block, 2011). In this paper, Tobin´s Q is calculated by adding up the market capitalization, the book value of preferred stock and the book value of total liabilities[19] [20] and then dividing it by the total assets. The logarithm of Tobins´s Q is furthermore used. There are advantages by doing so. First, taking the log of a dependent variable increases its normality, which is a necessity for a regression model´s assumptions. Also, Amihud, Schmid & Solomon (2017) argues that the log of Tobin´s Q makes the regression model fit the data better. In addition, it has been widely used in financial research prior to this study (Sandner & Block, 2011; Bebchuk & Cohen, 2005; Griliches. 1981).

[18] We apply a Hausman test to figure out if a random effects regression or a fixed effects regression is more appropriate. The test concludes that a fixed effects is more appropriate. Test results can be found in Table A3 in the Appendix.

[19] We also try to calculate Tobin´s Q using total debt as done by Sandner & Block (2011) and Atanasova & Schwartz (2019). The regression results for this data are shown in table 9.

[20] Some researchers use the market value of debt, but since this is not easily available, we use the book value of liabilities. Similar to Sandner & Block (2011).

Reserve variables

Reserve variables is calculated in the same way as in Atanasova & Schwartz (2019). *Oil reserves* is calculated as the barrels of oil equivalent divided by the firm's dollar value of total assets, while *NG reserves* is calculated as the cubic feet of natural gas divided by the firm's dollar value of total assets. The *Reserves Growth* variables are the change in both Oil and NG reserves ($\frac{Reserves_{it} - Reserves_{it-1}}{Reserves_{it-1}}$). Like in Atanasova & Schwartz (2019), reserves are furthermore split into developed and undeveloped reserves to separate their effects. We end up with a number of different reserve variables which are run in various regression specifications to see their independent and combined effects. All variables used can be found in Table 3.

Control variables

The control variables chosen for this research are quite standard and have been used by other researchers in the past. Table 3 provides a full overview of all variables used in the study.

(a) *Size* could be an important control variable to take into account. It is created by taking the logarithm of total assets. For instance, Hirdinis (2019) find that size has an significant effect on firm value.

(b) *Leverage* is used to account for the firm's capital structure. It is calculated as the total liabilities divided by market capitalization plus liabilities. In theory it should not matter[21], but higher leverage can also increase financial distress. Several researchers have found that it has an impact on firm value (See for instance Cheng & Tzeng, 2011 and Fosu et al., 2015)

(c) *Capital expenditures (Capex)* is the firm's capital expenditures divided by the lagged total assets. Trueman (1986) shows that the invested amount in a firm can be a signal of the true value of the firm. Meaning that the greater amount that is invested, the greater the value of the firm.

[21] See Modigliani & Miller (1958) for their influential theory about capital structure.

(d) *Profitability* is the Earnings before taxes and depreciation and amortization (EBITDA) divided by the lagged total assets. As profitable firms are more likely be traded at a premium, higher profitability can therefore be expected to have a positive impact on firm value (Allaynnis & Weston, 2001). Contrary to this, Hirdinis (2019) find that profitability has no effect on firm value.

(f) *Dividends* is the total dividends divided by the lagged total assets. According to Eades (1986) the role of dividends on firm value has been a puzzle. On the one hand, it should not matter in a perfect capital market. On the other hand, paying dividends may convey a signal to investors of the true value of the firm. Some institutional investors, like for instance insurance companies, seek out dividend paying stocks (Eades, 1986). There are varying empirical evidence for how much dividends affect firm value and this may change depending on the country. For instance, Budagaga (2017) find that dividends positively affect firm value, while Ismawati (2018) find that it has no effect.

(g) *Oil and Gas Prices*. For commodity producers, their value could be highly dependent on the underlying commodity price. For this reason, at least yearly oil prices should be included. Historically, oil and gas prices have been strongly correlated, but recently this correlation seem to have been partially decoupled[22] (CME Group, 2018). Thus, we should look at the variation in gas prices as well, but it is only included in the regression models with natural gas exclusively. For the remainder, the logarithm of oil prices is use

[22]It is likely that the shale revolution of 2008-2009 is responsible for this partial decoupling (Misund & Osmundsen, 2017)

Table 3: Variables

Financial Variables	
Tobin´s Q	Market capitalization, liquidation value of preferred stock and total liabilities divided by total assets
ln_Size	The logarithm of Total assets
Leverage	Total liabilities divided by lagged total assets
Capex	Capital expenditure divided by lagged total assets
Profitability	EBITDA divided by lagged total assets
Dividends	Total dividends divided by lagged total assets
Exploration cost	Exploration cost divided by current years oil production
ln_price_Oil	Logarithm of end of year oil price
ln_price_NG	Logarithm of end of year natural gas price
Reserve variables	
Total Reserves (Oil)	Total proved reserves (Oil) divided by the dollar value of total assets
Developed Reserves (Oil)	Proved developed (Oil) reserves divided by the dollar value of total assets
Undeveloped Reserves (Oil)	Proved undeveloped Oil reserves divided by the dollar value of total assets
Total Reserves (NG)	Total proved developed NG reserves divided by the dollar value of total assets
Developed Reserves (NG)	Proved developed (NG) reserves divided by the dollar value of total assets
Undeveloped Reserves (NG)	Proved undeveloped (NG) reserves divided by the dollar value of total assets
Transition focus (Green) dummy	Hand collected from firms annual reports (takes the number 1 if investment in renewables and/or clean tech, 0 otherwise)

Note: In the regression models Res is short for reserves and Growth in reserves is the year to year change in the reserve variables as calculated in the table above.

5.3 Panel data model assumptions

According to Verbeek (2004), there are important assumptions for a panel regression model. For both the random effects and fixed effects model, it is assumed that the correlation between unobserved variation in different time periods is captured by the individual effects α_i. It is furthermore assumed that X_{it} is strictly exogenous (Meaning X_{it} is not correlated with the error term ϵ_{it}) and there is no autocorrelation and heteroscedasticity in the error terms. Moreover, there should be no perfect multicollinearity (Meaning no independent variable is perfectly correlated to each other, but also high collinearity can be a problem as it can affect the standard errors). Finally, according to Bramati & Croux (2007), the presence of large outliers can strongly bias the panel data estimators.

Multicollinearity can bias the standard errors of the coefficients and should be investigated in detail. By testing for multicollinearity visually in a correlation table (Tables A5.1 to A5.3 in the Appendix), it is confirmed that no prefect collinearity is present between any of the independent variables. However, high correlation between many of the variables are present at the 1% significance level. For the most part this concerns the reserve variables, where total reserves (Oil) is strongly correlated with both developed and undeveloped reserves (Oil). Between 0.7403 and 0.8771 respectively. The relationship is also similar for natural gas reserves. The correlation between total reserves (NG) and developed reserves (NG) is 0.7692, while for total reserves (NG) and undeveloped reserves (NG), it is 0.8041. All significant at the 1% level. Logically this should be expected since developed and undeveloped reserves together makes up total reserves. Growth in total reserves is also strongly correlated with the growth in developed reserves for both oil and natural gas. The correlation is 0.8744 and 0.8866 respectively and significant at the 1% level. There is furthermore no correlation between growth in developed and growth in undeveloped oil reserves, but between Growth in developed and growth in undeveloped natural gas reserves, the correlation is 0.1638 at the 1% significance level. For most of the control variables, the correlation is low, but for profitability and dividends the correlation is -0.7233 at the 1% significance level. This could also be a problem for the regression models and should be tested further.

By using the variance inflation factor (VIF) module in STATA, the degree of multicollinearity is investigated. These results are presented in Table A4 in the appendix. The VIF module confirms moderate collinearity between the growth in total reserves (NG) and growth in developed reserves (NG) (5.07 and 4.92 respectively). The values for developed reserves (Oil) and developed reserves (NG), when run together with total reserves, could not be obtained as developed reserves was omitted by the regression model for both oil and natural gas. This is most likely due to high collinearity between these variables. There is furthermore no issues with collinearity when combining the same type of variables for oil and natural gas, or any control variables. Because of issues with collinearity between developed reserves and total reserves, a choice is made to run the regressions with total reserves separately from developed and undeveloped reserves, for both oil and natural gas. Growth in total reserve variables are also run separately with growth in developed and undeveloped reserves, because of moderate collinearity.

Heteroscedasticity and autocorrelation will furthermore make the estimators inefficient. All models are tested for autocorrelation using the Breusch-Godfrey/Woolridge method. Heteroscedasticity is tested using Brush-Pagan´s method. The tests conclude that all our models do in fact suffer from autocorrelation and heteroscedasticity at the 1% significance level. This problem is mitigated by using clustered standard errors is all regression specifications[23]. Test results is provided in Table A3 in the Appendix.

Of greater concern are the normality and the outliers in some of the variables. In panel data, the presence of outliers can strongly bias the model estimates (Bramati & Croux, 2007). For the dependent variable and the size variable, the logarithm is used, so this is should be less of an issue. Extreme observations, such as particularly large growth in oil or gas reserves, account for most of the outliers in the dataset. Adams et al (2018) argues that the problem with winsorizing[24], trimming or removing outliers is that it can create new limitations by fundamentally changing the data. They propose that every extreme observation is studied in detail before deciding what to do with it. We conclude that all outliers are in fact correct and not due to some calculation error. In this paper a choice is made not to simply drop observations or alter them in any way at first, but do our analysis with and without winsorizing. In the robustness section, all variables are winsorized at the 1% and 99% level, as well as using different methods for calculating Tobin´s Q and leverage to see if the results change. A full table of the winsorized variables can be found in Table A8 in the Appendix.

There may also arise concerns about whether the dependent variable Tobin's Q as well as the independent variables are in fact stationary, as this is an important assumption for panel data regressions. Since the panel is unbalanced, a Fisher-type test based on Phillip-Perron is used. The test concludes that all variables are in fact stationary. A table with unit root tests for all variables is provided in Table A1 in the Appendix.

5.4 Regression models

To answer the hypotheses, several panel regression models are applied with different specifications for both oil and natural gas reserves, as well as combined. The transition strategy

[23] According to Bertrand et al. (2002) a generalized White-formula on which clustered standard errors is based on does a fairly good job on dealing with the autocorrelation. Additionally, Cameron and Miller (2015) finds that ignoring clustering understates the standard errors.

[24] Winsorizing is a method commonly used in financial research and pushes outliers further towards the mean which increases the normality of the data.

dummy is added in the last regressions. For all specifications, the standard control variables are included to avoid omitted variable bias. Additionally, the log of natural gas prices is also applied to see if this improves the regression models ran exclusively with NG reserves.

Model for hypothesis 1, 2, 3 and 4:

$$ln\,Tobins\,Q_{it} = \alpha_{it} + \beta_1\,Oil\,Reserves_{it} + \beta_2 Oil\,Res\,Growth_{it} + \beta_3 Size_{it} + \beta_4 Capex_{it} + \beta_5 Leverage_{it} + \beta_6 Profitability_{it} + \beta_7 Dividends_{it} + \beta_8 \text{ln\_}Crude\,Oil_{\,it} + \epsilon_{it}$$

Model for hypothesis 5, 6, 7 and 8:

$$ln\,Tobins\,Q_{it} = \alpha_{it} + \beta_1\,NG\,Reserves_{it} + \beta_2 NG\,Res\,Growth_{it} + \beta_3 Size_{it} + \beta_4 Capex_{it} + \beta_5 Leverage_{it} + \beta_6 Profitability_{it} + \beta_7 Dividends_{it} + \beta_8 \text{ln\_}NG\,Price_{\,it} + \epsilon_{it}$$

Model added for robustness (oil and gas reserves combined):

$$ln\,Tobins\,Q_{it} = \alpha_{it} + \beta_1\,Oil\,Reserves_{it} + \beta_2\,NG\,Reserves_{it} + \beta_3 Oil\,Res\,Growth_{it} + \beta_4 NG\,Res\,Growth_{it} + \beta_5 Size_{it} + \beta_6 Capex_{it} + \beta_7 Leverage_{it} + \beta_8 Profitability_{it} + \beta_9 Dividends_{it} + \beta_{10} \text{ln\_}Crude\,Oil_{\,it} + \epsilon_{it}$$

Model for hypothesis 9 (Oil and NG reserves together with transition dummy):

$$ln\,Tobins\,Q_{it} = \alpha_{it} + \beta_1\,Oil\,Reserves_{it} + \beta_2\,NG\,Reserves_{it} + \beta_3 Oil\,Res\,Growth_{it} + \beta_4 NG\,Res\,Growth_{it} + \beta_5 Size_{it} + \beta_6 Capex_{it} + \beta_7 Leverage_{it} + \beta_8 Profitability_{it} + \beta_9 Dividends_{it} + \beta_{10} \text{ln\_}Crude\,Oil_{\,it} + \beta_{11} \text{Transition Focus (Green)Dummy}_{it} + \epsilon_{it}$$

6. Regression results

6.1 Oil reserves

Table 4 shows our results from the regression specifications with oil reserves only. As we can see, the effect from developed oil reserves in model specification (4), is large and significant at the 1% level. One percentage point higher the amount of developed oil reserves (developed reserves of the dollar value of assets) leads to a 1.06% higher firm value, measured by Tobin´s Q. The effect is somewhat larger when including growth in reserve variables in (6) and is significant at the 5% level. Growth in developed oil reserves seem to increase firm value by a small amount (less than 0.01% increase in firm value for every year to year percentage point increase in developed reserves), but is only significant at the 10% level for both specifications (5) and (6). On the other hand, growth in undeveloped oil reserves seem to decrease firm value by about 0.002%, significant at the 5% level for both specification (5) and (6). Although both effects are economically small, this could work in favor of hypotheses 3 and 4. It seems like growth in undeveloped reserves slightly decreases firm value, while growth in developed reserves works in the opposite direction. This is partly in line with Atanasova & Schwartz (2019) who find that growth in undeveloped reserves have a negative effect on firm value, but in contrast, they find no effect from growth in developed reserves, like specification (5) and (6) shows. Strangely, no significant effect from total reserves or growth in total reserves from any of the specifications are present either. This is contrary to Atanasova & Schwartz (2019) who finds that also total reserves should have a positive effect on firm value while growth in total reserves has a negative effect. As total oil reserves should be a an important factor for oil companies valuation, it is sensible to expect this to be positive and significant. It seems, however, that the model is only capturing the effect from developed reserves.

Furthermore, the control variables yields economically sensible results. First, firm size decreases firm value by a small amount and is significant at the 1% level. On average, Tobin´s Q is decreasing by about 0.06% for every 1% increase in size. One reason for this could for instance be that larger firms in the oil industry have lower growth opportunities. Second, leverage is decreasing firm value by a substantial amount (about 1.5% decrease in Tobin´s Q for an increase in the proportion of debt of total assets). It seems like financial markets are penalizing firms with higher leverage by attaching a lower value to them. Third, profitability and dividends have a small negative effect on firm value, but this only holds for specification (1) and (4). This is contrary to what was expected since previous research has documented a positive effect or no effect from these variables (Allaynnis & Weston, 2001; Hirdinis, 2019; Budagaga, 2017; Ismawati, 2018). In line with Trueman (1986), capital expenditures seem to have a positive effect on firm value, but this is only significant for specification (5) and (6) at the 10% and the 5% level, respectively. Lastly, the logarithm if oil prices has a positive and significant effect on firm value. A one percentage point increase in oil prices increases firm value by about 0.10 % and is significant on the 1% level for all specifications. Overall, the control variables size and leverage shows similar results as in Atanasova & Schwartz (2019), but the effect they found the price of oil to have on firm value is much higher (about 0.7% to 1.0% increase in firm value for every percentage point increase in the oil price).

Table 4: Oil Reserves on Firm Value

Results from the Oil reserves variables on firm value. The dependent variable is the logarithm of Tobin´s Q. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications used. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Total Res (Oil)	0.1185		0.1894			
	(0.529)		(0.569)			
Growth Total Res (Oil)		0.000019	0.000017			
		(0.932)	(0.939)			
Developed Res (Oil)				1.0598***		1.3753**
				(0.005)		(0.011)
Undeveloped Res (Oil)				-0.2524		-0.2373
				(0.249)		(0.489)
Growth Developed Res (Oil)					0.00899*	0.0082*
					(0.072)	(0.089)
Growth Undeveloped Res (Oil)					-0.00223**	-0.00225**
					(0.025)	(0.018)
ln_Size	-0.0648***	-0.0581***	-0.0551***	-0.0617***	-0.0546***	-0.0454***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Leverage	-1.4722***	-1.4943***	-1.4947***	-1.4694***	-1.4461***	-1.4346***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capex	0.0001	0.0191	0.0218	0.0002	0.0539*	0.0663**
	(0.513)	(0.477)	(0.431)	(0.225)	(0.085)	(0.040)
Profitability	-0.0073**	0.0118	0.0101	-0.0085***	-0.0101	-0.0188
	(0.040)	(0.829)	(0.852)	(0.010)	(0.850)	(0.720)
Dividends	-0.0214**	0.1343	0.1251	-0.0226***	0.0184	0.0209
	(0.024)	(0.298)	(0.322)	(0.005)	(0.894)	(0.868)
ln_price_Oil	0.1037***	0.0944***	0.0981***	0.1108***	0.0875***	0.1024***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	4008	3493	3493	3810	2909	2909
Firms	622	544	544	594	474	474
R-sq						
Overall	0.3217	0.3493	0.3547	0.3235	0.3229	0.3319

6.2 Natural gas reserves

For the regression models with natural gas, the results can be found in Table 5. The effect from developed reserves of natural gas on firm value is positive and significant. A 1% increase in the proportion of developed reserves to total assets increases firm value by about 0.15% for specification (4) and 0.17% for (5), significant at the 5% and 1% level respectively. Similar to the model with oil reserves, undeveloped natural gas reserves does not seem to have any effect on firm value. On the other hand, the growth in undeveloped natural gas reserves increases firm value by a miniscule amount (0.00003% increase in Tobin´s Q for every year to year percentage change in reserves). This is significant at the 1% level for both specification (5) and (6). This

Table 5: Natural Gas Reserves on Firm Value

Results from the natural gas reserves variables on firm value. The dependent variable is the logarithm of Tobin´s Q. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications used. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and NG price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Total Res (NG)	0.01245		0.01756			
	(0.497)		(0.585)			
Growth Total Res (NG)		-0.00001	-0.00002			
		(0.694)	(0.510)			
Developed Res (NG)				0.1485**		0.16654***
				(0.028)		(0.004)
Undeveloped Res (NG)				0.01712		0.0273
				(0.244)		(0.226)
Growth Developed Res (NG)					0.000104	0.000097
					(0.242)	(0.429)
Growth Undeveloped Res (NG)					0.0000321***	0.000032***
					(0.000)	(0.000)
ln_Size	-0.0331***	-0.0195	-0.0181	-0.0275**	-0.0183	-0.0076
	(0.001)	(0.125)	(0.176)	(0.014)	(0.105)	(0.537)
Leverage	-1.5074***	-1.5247***	-1.5255***	-1.5126***	-1.4863***	-1.4945***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capex	0.00022	0.0532*	0.0535*	0.0003	0.0656**	0.0733***
	(0.395)	(0.057)	(0.056)	(0.284)	(0.014)	(0.007)
Profitability	-0.0060	-0.0307	-0.0304	-0.0067	-0.0102	-0.01536
	(0.188)	(0.596)	(0.598)	(0.157)	(0.856)	(0.783)
Dividends	-0.0101	0.0504	0.0542	-0.0083	-0.0119	-0.0077
	(0.385)	(0.724)	(0.705)	(0.459)	(0.930)	(0.956)
ln_price_NG	0.0956***	0.0949***	0.0960***	0.0997***	0.0959***	0.0976***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3847	3345	3345	3683	3857	2857
Firms	602	524	524	574	459	459
R-sq						
Overall	0.3894	0.4139	0.4170	0.3827	0.4403	0.4321

works against hypothesis 6, but in favor of hypothesis 8. It is not completely clear why the growth in undeveloped reserves increases value, while undeveloped reserves shows no effect, but one explanation could be that large outliers in the growth variables drives these results. This will also be tested further in the robustness section. There is furthermore no effect from total reserves, growth in total reserves or growth in developed natural gas reserves. The control variables mostly show similar results as for the oil reserves model. Size and leverage seems to decrease firm value, but contrary to the oil reserves model, there is no effect from size on specification (2), (3), (5) and (6). Capital expenditures has a positive effect on firm value for

(5) and (6), while there is no effect from profitability or dividends on any specifications. Natural gas prices also have a positive significant effect, where 1% increase in gas prices increase firm value by about 0.10% at the 1% significance level for all specifications. The results suggests that developed natural gas reserves are an important factor for firm valuation, while undeveloped natural gas reserves do not seem to add any value in this model.

6.3 Oil and natural gas reserves combined

For oil and gas reserves combined, a choice is made to report only developed and undeveloped reserves, as only these variables have shown to have an effect on firm value. The results are reported in Table 6. For all specifications, the effect from developed oil reserves is positive and significant at the 5% level, where one percentage point increase in the proportion of developed oil reserves, increases firm value by 1.06% and 1.16%. For specification (1), the effect from undeveloped oil reserves is actually negative, but this is only significant at the 10% level. For the model with reserve variables and growth variables combined, there is no effect from undeveloped oil reserves. The effect from developed natural gas reserves is similar to before, where one percentage point increase in the proportion of natural gas reserves of total assets increases Tobin´s Q by about 0.17%. It is significant at the 5% level for (1) and the 10% level for (3). Additionally, undeveloped natural gas reserves also seem to increase firm value by a small amount (about 0.03% for 1% increase in the proportion of reserves to total assets), but it is only significant at the 10% level for specification (1). Similar to previous regressions, the growth in undeveloped oil reserves decreases firm value and the growth in undeveloped natural gas reserves increases firm value. Surprisingly, the growth in developed natural gas reserves decreases firm value, while the growth in developed oil reserves shows no effect from any specifications in these models. The control variables are mostly the same as before, but the effect from capital expenditures is only significant at the 10% level for specification (3).

So far, the results are in line with hypotheses 1, 4, 5 and 8. Developed oil and gas reserves and the growth in undeveloped natural gas reserves seem to increase firm value, while the growth in undeveloped oil reserves is decreasing firm value. The negative effect from the growth in undeveloped oil reserves is in line with previous research conducted by Atanasova & Schwartz (2019), suggesting that financial markets are recognizing the stranded asset risk it poses, as it may be left unburned in the future. It´s effect is, however, very small. As we fail to find an effect from the more important undeveloped oil reserves on all specifications, it also suggests that financial markets have already recognized that these reserves may not add any future value.

Table 6: Oil and Natural Gas Reserves Combined on Firm Value

Results from the Oil reserves and Natural gas reserves variables on firm value combined. The dependent variable is the logarithm of Tobin´s Q. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications used. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as $(e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)
Developed Res (Oil)	1.0553**		1.1604**
	(0.033)		(0.029)
Undeveloped Res (Oil)	-0.6119*		-0.4564
	(0.092)		(0.306)
Developed Res (NG)	0.1688**		0.1732*
	(0.019)		(0.067)
Undeveloped Res (NG)	0.02973*		0.06004
	(0.076)		(0.488)
Growth Developed Res (Oil)		0.0107	0.01004
		(0.153)	(0.154)
Growth Undeveloped Res (Oil)		-0.00242**	-0.0024***
		(0.013)	(0.010)
Growth Developed Res (NG)		-0.0000394**	-0.0000294
		(0.039)	(0.145)
Growth Undeveloped Res (NG)		0.0000386***	0.0000347***
		(0.000)	(0.000)
ln_Size	-0.0548***	-0.0514***	-0.0393**
	(0.000)	(0.000)	(0.014)
Leverage	-1.4643***	-1.4382***	-1.4175***
	(0.000)	(0.000)	(0.000)
Capex	0.0002	0.0493	0.0613*
	(0.499)	(0.122)	(0.063)
Profitability	-0.0066	-0.0009	-0.0088
	(0.111)	(0.988)	(0.877)
Dividends	-0.01437	0.0110	0.0061
	(0.158)	(0.939)	(0.964)
ln_price_Oil	0.1224***	0.0771***	0.1018***
	(0.000)	(0.001)	(0.000)
Observations	3672	2663	2663
Firms	574	438	438
R-sq			
Overall	0.3509	0.3273	0.3332

Therefore, the stranded asset risk may be minimal and it seems unlikely to pose a systemic risk such as a carbon bubble proposed by Carbon Tracker (2013). The results so far, shows that the most important factors for oil and gas companies' valuation, seems to be developed reserves. This is largely in line with Yergin & Pravettoni (2016) who states that developed reserves account for 80% of their valuation. Additionally, the results suggests that also the growth in undeveloped natural gas reserves should increase firm value. But this is only significant at the 10% level for specification (1). An explanation for this could be that undeveloped natural gas reserves are recognized by markets to have a larger future value in a low-carbon economy as it is a cleaner source of energy. On the other hand, it is puzzling why the model fails to capture an effect from undeveloped natural gas reserves while the growth variable is positive and significant. Even though natural gas prices are included in the model it could be that the valuation of natural gas reserves have been affected by the shale gas revolution that started a decade ago. To further explain, Misund & Osmundsen (2017) found that proved developed natural gas reserves had a negative impact on oil and gas companies' shareholder returns for the post shale-gas period, in the timeframe of 2009 to 2013. This will be tested further in the robustness section. Also, as previously mentioned, outliers in the reserves variables may also impact the initial results. We will, however see, that some of our initial results are changing when using winsorized variables in Section 6.5.

6.4 Oil and natural gas reserves with transition dummy

To test if financial markets are adding a value premium to producers that are diversifying into renewables and/or clean tech (CCS), a random effects regression is used. As reported in Table 7, the results from the reserve variables are mostly the same as in previous regressions, both in magnitude and significance, but the effect from developed natural gas reserves is not present anymore. Also, the effect from undeveloped natural gas reserves is positive and significant in specification (1). There is furthermore no effect from the growth in developed oil reserves. It could be that the fixed effects model is a better fit for this dataset and that the random effects fails to capture these effect. The coefficient for the dummy variable is, however, not significant on any specifications. Perhaps investors did not believe that these investments would generate a sufficient return in the timeframe investigated, and therefore, do not add any particular value to them. Another reason why the model fails to capture an effect, could be that renewables have had a very small part of these companies' investment portfolios, relative to oil and gas reserves historically. Pickl (2019) provides a summary of the oil majors activities in the renewable space. Even though these companies have been increasing the investments in renewable energy over time, it still makes up a very small part of their overall capital expenditures (less than 5% for most of them). An attempt is also made to only include the companies that are investing in renewables and not just clean tech, but the result remains the same. The low-carbon transition strategies of oil and gas producers, do not seem to add any measurable value in the timeframe investigated.

Table 7: Oil and Natural Gas Reserves with Transition Dummy

Results from the Oil reserves and Natural gas reserves variables together with a transition dummy on firm value combined. The dependent variable is the logarithm of Tobin´s Q. Res is short for reserves. A random effects regression model with clustered standard errors on firm is used for all specifications used. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)
Developed Res (Oil)	1.1355***		1.4367***
	(0.001)		(0.008)
Undeveloped Res (Oil)	-0.5314		-0.2939
	(0.119)		(0.497)
Developed Res (NG)	0.0329		0.0108
	(0.355)		(0.581)
Undeveloped Res (NG)	0.03247**		0.0829
	(0.047)		(0.151)
Growth Developed Res (Oil)		0.0108	0.0101
		(0.123)	(0.141)
Growth Undeveloped Res (Oil)		-0.00012***	-0.000111***
		(0.000)	(0.000)
Growth Developed Res (NG)		-0.000026*	0.000018
		(0.097)	(0.317)
Growth Undeveloped Res (NG)		0.000039***	0.000035***
		(0.000)	(0.000)
Transition focus (Green) Dummy	0.0291	-0.0079	0.0202
	(0.617)	(0.929)	(0.751)
ln_Size	-0.0461***	-0.0297***	-0.0258***
	(0.000)	(0.000)	(0.002)
Leverage	-1.4903***	-1.4637***	-1.4357***
	(0.000)	(0.000)	(0.000)
Capex	0.00008	0.0578*	0.0686**
	(0.369)	(0.055)	(0.024)
Profitability	-0.0017***	0.0172	0.0018
	(0.000)	(0.759)	(0.974)
Dividends	0.0065	0.0817	0.0378
	(0.685)	(0.545)	(0.759)
ln_price_Oil	0.0915***	0.0485**	0.0720***
	(0.000)	(0.012)	(0.000)
Observations	3672	2663	2663
Firms	574	438	438
R-sq			
Overall	0.3899	0.4405	0.4536

6.5 Robustness of results

Like previously mentioned in the data and methodology section, the normality and outliers in some of the variables may be of concern for the initial results. For robustness, outliers are therefore treated by winsorizing all variables at the 1% and 99%[25]. In Table 8 the results from oil and gas reserves combined with winsorized variables is presented. As we can see, a fair amount of the previous results disappears. Most dramatically for our reserves growth variables. The only growth variable that is still significant is the growth in developed oil reserves, which is positive and significant at the 1% level for both regression specification (5) and (6). In magnitude the effect is also larger. For every percentage change in developed oil reserves of total assets, firm value is increasing by about 0.026%. Like in previous regressions, developed oil reserves also has a positive effect on firm value. Specification (4) shows that for every 1% increase in the proportion of developed oil reserves of total assets, firm value increases by about 1.22% and is significant at the 5% level. For specification (6) this number is 1.66% and significant at the 1% level. It seems like financial markets are reacting positively to larger amounts of developed oil reserves as well as its year to year growth.

For natural gas, the effect from undeveloped reserves are no longer significant while the effect from developed reserves is. Specification (4) shows that for every 1% increase in the proportion of developed natural gas reserves to total assets, firm value increases by about 0.32% and is significant at the 1% level. For specification (6) the effect is 0.23% and significant at the 5% level. This is works in favor of hypothesis 5, but against hypothesis 6. It could be that outlying observations in the reserve variables biased our initial results, leading us not to find an effect on developed gas reserves. Interestingly, the growth in developed natural gas reserves have a negative effect in this model, indicating that a 1% growth in these reserves decreases firm value by 0.02%. However, this only holds for specification (6), where also developed natural gas reserves are positive and significant. It is not clear how this relationship holds, but so far the results from natural gas reserves has shown to produce various results. Like previously mentioned, this could be linked to the shale gas revolution, potentially being affected by price volatility this model fails to capture. Lastly, there is no effect from the growth in undeveloped natural gas reserves like the previous models showed. It seems also here that outliers in fact biased our initial results.

[25] Specifically, the winsor2 program in Stata is used for this purpose.

After winsorizing the data, the control variables also seem to work better. Size and leverage are both decreasing firm value, with more or less the same magnitude as previously found, but in this model capital expenditure also seems to have an effect. For specification (1), (3), (4), (5) and (6), a 1% increase in the proportion of capital expenditures to total assets, increases firm value by around 0.06% to 0.09%. All of which is significant at the 1% level. This is contrary to Atanasova & Schwartz (2019) who found capital expenditures to have no effect on firm value. For the most part, profitability and dividends have no effect on firm value apart from regression specification (4), where profitability actually has a small negative effect, but is only significant at the 10% level. The effect from the oil price is similar as previous results, where about 1% increase in the price of oil leads to an increase in firm value about 0.11% to 0.13%. It is significant at the 1% level for all specifications. The transition dummy is also tested using winsorized variables. There is no significant effect from any specifications. These results are presented in Table A6 in the Appendix.

In comparison to Atanasova & Schwartz (2019), it is puzzling that both growth variables for total oil reserves and undeveloped oil reserves fail to show a robust effect, as more or less the same data and timeframe is used for this study. However, there may still be differences in how we conduct our research. On the one hand, the dataset for this study is somewhat smaller (653 vs. 679), but this should not normally lead to particularly large differences in estimates. Another difference could be that this study also include SIC 2911 (Petroleum Refining) and SIC 5172 (Petroleum and Petroleum Wholesalers) to capture oil majors that have investment portfolios of renewable energy and clean tech. An attempt is made to only include SIC 1311 (Crude Petroleum and Natural Gas) in the analysis, but the growth variables still show no effect. Additionally, there may also be differences in how the independent variable Tobin´s Q and leverage is calculated. In a final model, an attempt will be made to replicate Atanasova & Schwartz´s (2019) documented negative effect from growth in undeveloped reserves. In this model, Tobin´s Q and leverage is calculated using total debt instead of total liabilities. Variables are furthermore winsorized at the 1% and 99% as before.

Table 9 shows the regression results from the final model. Like previous regression models, developed oil reserves seem to be an important factor for firm valuation. Specification (6) shows that an increase in the proportion of developed oil reserves to total assets, increases firm value (Tobin´s Q) by about 2.5% and is significant at the 1% level. For specification (4), the effect is 1.5%, but it is only significant at the 10% level. The effect is also supported by the

Table 8: Oil and Natural Gas Reserves After Winsorizing

Results from oil reserves and natural gas reserves variables on firm value combined. The dependent variable is the logarithm of Tobin´s Q. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications. All variables are winsorized at the 1% and 99% percentiles. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Total Res (Oil)	0.2465		0.5487			
	(0.487)		(0.203)			
Total Res (NG)	0.1546**		0.1874**			
	(0.026)		(0.020)			
Growth Total Res (Oil)		0.0021	0.0007			
		(0.754)	(0.919)			
Growth Total Res (NG)		-0.00003	-0.00704			
		(0.239)	(0.475)			
Developed Res (Oil)				1.2189**		1.6599***
				(0.062)		(0.006)
Undeveloped Res (Oil)				-0.1254		-0.6403
				(0.850)		(0.336)
Developed Res (NG)				0.3219***		0.2304**
				(0.004)		(0.028)
Undeveloped Res (NG)				0.0911		0.1201
				(0.377)		(0.281)
Growth Developed Res (Oil)					0.0265***	0.0262***
					(0.003)	(0.004)
Growth Undeveloped Res (Oil)					-0.0048	-0.0043
					(0.128)	(0.151)
Growth Developed Res (NG)					-0.0107	-0.0208**
					(0.242)	(0.023)
Growth Undeveloped Res (NG)					-0.00009	-0.00002
					(0.969)	(0.928)
ln_Size	-0.0382***	-0.0513***	-0.0290*	-0.0295**	-0.0492***	-0.0295*
	(0.010)	(0.000)	(0.062)	(0.049)	(0.000)	(0.060)
Leverage	-1.4900***	-1.4976***	-1.4938***	-1.4944***	-1.4549***	-1.4330***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capex	0.0632***	0.0290	0.0867***	0.0748***	0.0628**	0.0835***
	(0.005)	(0.298)	(0.004)	(0.002)	(0.041)	(0.009)
Profitability	-0.0383	0.0088	-0.0059	-0.0893*	-0.0270	-0.0469
	(0.480)	(0.879)	(0.924)	(0.082)	(0.598)	(0.348)
Dividends	0.2816	0.1178	0.2927	0.2010	0.2039	0.1654
	(0.171)	(0.381)	(0.188)	(0.286)	(0.422)	(0.484)
ln_price_Oil	0.1073***	0.1178***	0.1085***	0.1261***	0.0723***	0.1048***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
Observations	3847	3308	3308	3672	2663	2663
Firms	602	521	521	574	438	438
R-sq						
Overall	0.3935	0.3713	0.4219	0.4148	0.4125	0.4640

growth in this variable. For every year to year percentage point increase in developed oil reserves, firm value increases by about 0.04% and is significant at the 1% level for both specifications (5) and (6). This largely confirms hypotheses 1 and 3. There is furthermore no significant effect from total oil reserves, undeveloped oil reserves or the growth in undeveloped oil reserves for any specifications. Therefore, hypothesis 2 and 4 is finally rejected. The model fails to document Atanasova & Schwartz´s (2019) claimed negative effect from the growth in undeveloped oil reserves.

For natural gas, the final model documents a positive effect from total reserves, developed reserves and undeveloped reserves, but with various significance levels. The effect on firm value from total reserves of natural gas, is positive and significant at the 1% level for both specification (1) and (3). For specification (2), the growth in total reserves for natural gas is also positive and significant at the 5% level. When dividing up total reserves into developed and undeveloped reserves, we see that both types of reserves seem to increase firm value. A 1% increase in the proportion of developed natural gas reserves of total assets increases firm value by around 0.37% and is significant at the 1% level. For specification (6) this number is 0.36% and significant at the 5% level. The magnitude and significance level is somewhat weaker for undeveloped natural gas reserves. Specification (4) shows that the increase in firm value is 0.24%, significant at the 10% level, while in specification (6), the increase is 0.28% and significant at the 5% level. These results are largely in line with hypothesis 5 and 6. It could be that natural gas reserves have more potential in a low-carbon economy as it is a cleaner type of fossil fuel than oil is. The remainder of the growth variables for natural gas do not seem to have any effect on firm value.

The control variables also seem to work better in this model. The effect from size and leverage on firm value, is negative and significant at the 1% level for all specifications. Capital expenditures seem to have a positive impact on firm value and is significant at the 1% level for specifications (1), (3), (4) and (6). 5% for (5). For the first time dividends also seem to have a positive effect on firm valuation. A 1% increase in the amount of dividends to total assets increases firm value by about 1.3% and is significant at the 1% level for all specifications apart from (2). Lastly, the effect from oil prices is higher for this model, where 1% increase in the price for oil leads to an increase in firm value (Tobin´s Q) by about 0.22% to 0.31%. Even though this model has a lower R-squared than previous models, the reserve variables, as well

Table 9: Oil and Natural Gas Reserves After Winsorizing

Results from the Oil reserves and Natural gas reserves variables on firm value combined. The dependent variable is the logarithm of Tobin´s Q which is calculated with total debt and not total liabilities like in previous regressions. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications. All variables are winsorized at the 1% and 99% percentiles. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)	(4)	(5)	(6)
Total Res (Oil)	0.2672		0.5966			
	(0.537)		(0.279)			
Total Res (NG)	0.2456***		0.2832***			
	(0.004)		(0.004)			
Growth Total Res (Oil)		0.0062	0.0029			
		(0.521)	(0.777)			
Growth Total Res (NG)		0.00007**	0.0040			
		(0.029)	(0.771)			
Developed Res (Oil)				1.4631*		2.4781***
				(0.058)		(0.000)
Undeveloped Res (Oil)				-0.2198		-0.2104
				(0.805)		(0.840)
Developed Res (NG)				0.3673***		0.3633**
				(0.007)		(0.016)
Undeveloped Res (NG)				0.2383*		0.2812**
				(0.070)		(0.063)
Growth Developed Res (Oil)					0.0421***	0.0408***
					(0.000)	(0.001)
Growth Undeveloped Res (Oil)					-0.0013	-0.0017
					(0.832)	(0.786)
Growth Developed Res (NG)					0.00176	-0.01447
					(0.911)	(0.374)
Growth Undeveloped Res (NG)					0.00043	0.00079
					(0.923)	(0.862)
ln_Size	-0.1358***	-0.1526***	-0.1178***	-0.1247***	-0.1282***	-0.0905***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	-0.7693***	-0.8094***	-0.8198***	-0.7850***	-0.8071***	-0.7901***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capex	0.0916***	0.0328	0.1320***	0.1010***	0.1142**	0.1523***
	(0.005)	(0.483)	(0.005)	(0.003)	(0.033)	(0.006)
Profitability	0.0496	0.1454*	0.1308	-0.0033	0.1198	0.0859
	(0.567)	(0.099)	(0.187)	(0.970)	(0.184)	(0.332)
Dividends	1.3373***	0.5817**	1.3210***	1.3265***	1.4500***	1.3911***
	(0.000)	(0.014)	(0.000)	(0.000)	(0.001)	(0.001)
ln_price_Oil	0.2807***	0.2498***	0.2723***	0.3079***	0.2198***	0.2733***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3847	3308	3308	3672	2663	2663
Firms	602	621	521	574	438	438
R-sq						
Overall	0.1345	0.0943	0.1423	0.1466	0.1248	0.1920

as the control variables, seem to work better. Like previously mentioned, the shale gas revolution of 2008 may also have impacted the valuation of natural gas reserves. Misund & Osmundsen (2017) documented a negative effect from undeveloped natural gas reserves on shareholders returns in the post shale-gas period of 2009 to 2013. To test if this also applies to the companies in this study, developed and undeveloped natural gas reserves are interacted with a dummy for the period 2009 to 2013. These results can be found in Table A7 in the Appendix. The shale gas revolution does not seem to impact the results on a large level. The results from developed and undeveloped natural gas reserves mostly shows similar results as before.

6.6 Answering the hypotheses and research question

In conclusion, hypotheses 1, 3, and 5 are accepted based on significance levels of 5% on almost all specifications. First, the effect from developed oil reserves on firm value, is large and significant, at the 1% and 5% in most models. In one specification, the significance level is only 10%, but arguably, this is not enough to reject the overall effect. It seems like developed oil reserves are most important for the valuation of oil and gas companies. Moreover, the growth in developed oil reserves also shows a significant effect on firm value in almost all models. This finding is contrary to Atanasova & Schwartz (2019), who find no effect from growth in developed reserves, but rather a small negative effect from the growth in undeveloped reserves on all regression specifications. The negative effect from growth in undeveloped reserves is only present before winsorizing the variables, which could mean that outliers are driving the initial results. As it fails the robustness test, hypothesis 4 is rejected. Second, developed natural gas reserves also seems to be an important factor for the valuation of oil and gas companies. This effect is positive and significant at the 1% and 5% level for all regression models estimated with fixed effects. In the last model (Table 9), undeveloped gas reserves also show a positive effect on firm valuation and is significant at the 5% and the 10% level. One explanation for this may be that investors are recognizing that natural gas could have a greater future potential than other types of fossil fuel, as it is a cleaner source of energy. However, since the effect from undeveloped natural gas reserves only is present in the last model, caution should be taken when concluding on this finding. Because of various significance levels and results, hypothesis 6 remains inconclusive. An attempt is also made to measure if the effect from natural gas reserves has been affected by the shale gas revolution like Misund & Osmundsen (2017) previously have documented. Interacting the natural gas variables with a dummy for the period 2009 to 2013, does not improve the significance levels or the size of the coefficients to any particular degree.

Hypotheses 2, 7, 8 and 9 are rejected due to insignificant results. There is no effect from undeveloped oil reserves, as well as the growth variables for developed and undeveloped natural gas reserves, on firm value. As undeveloped oil reserves do not seem to add any value, it leads us to question Carbon Tracker´s (2013) suggested carbon bubble for oil and gas producers. It may very well be that financial markets already have priced stranded assets by not attaching any value to them. In that case, perhaps stranded assets does not pose a significant threat to oil and gas producers, at least in the near future. Lastly, the transition dummy variable shows no significant results from any regression specifications. It may be that financial markets are adding a green premium for some oil and gas producers, but we fail to document such an effect for the firms in the timeframe investigated. After all, these investments are also relatively small compared to the investments in oil and gas for these firms. According to Pickl (2019), these investments usually makes up a small part of the total capital expenditures, and it could be the reason why we fail to find an effect from this variable. Additionally, a previous study of M&A activity in the oil and gas sector, between 2008 and 2010, found that investments in renewables generated negative abnormal returns (Yoo et al., 2013). Perhaps investors did not believe that these projects would generate a sufficient return within the timeframe investigated.

7. Conclusion

The objective of this research was to investigate how oil and gas reserves, as well as investments in renewables and clean tech impact firm value in the transition to a low-carbon economy. Inspired by Atanasova & Schwartz (2019), a panel data model with 653 oil and gas producers is used in an attempt to highlight this relationship. By including natural gas reserve variables, as well as a dummy variable for investments in renewable energy and clean tech (CCS), this thesis seeks to go beyond earlier research.

The main results from this research suggest that developed oil reserves as well as developed natural gas reserves are important factors for the valuation of oil and gas companies. Developed oil reserves are by far the most important factor, followed by developed natural gas reserves. These results are consistent with Yergin & Pravettoni (2016), who argues that developed reserves, which can be expected to be produced within five to ten years, account for 80% of their valuations. The results are furthermore supported by Misund & Osmundsen´s (2017), who present similar results for oil and gas reserves in a study analyzing cumulative abnormal returns, for Canadian oil and gas producers. Moreover, in a final model (Table 9), also undeveloped natural gas reserves seem to increase firm value. Perhaps investors do in fact recognize the future potential for these reserves in a low-carbon economy, as it is a cleaner source of fossil fuel than oil and especially coal is. However, as the effect from undeveloped natural gas reserves is only estimated in one model out of many, it is not entirely conclusive and should be taken with caution. Furthermore, Atanasova & Schwartz´s (2019) documented negative effect from the growth in undeveloped oil reserves, cannot be confirmed in this thesis. The negative effect is only present before winsorizing the dataset and could be explained by the presence of outliers in the dataset. On the other hand, the growth in developed oil reserves has a positive and significant effect on firm value in almost all regression specifications. This indicates that investors are reacting positively to the year to year growth in developed oil reserves. Interestingly, there is no significant effect on firm value from undeveloped oil reserves. The insignificant results from undeveloped oil reserves could be interpreted in two ways. First, as both undeveloped oil reserves and the growth variable for undeveloped oil reserves fails to show any effect, it could lead us to question the robustness of Atanasova & Schwartz´s (2019) finding that financial markets recognize stranded assets. Second, if undeveloped oil reserves do not add any value, it could be interpreted as the market already having accounted for the potential stranded asset risk proposed by Carbon Tracker (2013). If this is the case, the presence of a carbon bubble in securities markets could be exaggerated. The last finding of this research is that the transition strategies of oil and gas producers do not seem to add any value. Reasons for this may be that these investments make up a very small part of their total capital expenditures or that investors did not believe that these projects would generate sufficient returns in the timeframe investigated. Perhaps in the near future, when this industry has matured, an effect can be measured.

This thesis contributes to the field of climate finance and stranded assets. To the authors knowledge, it is the first research to investigate the effect from both developed and undeveloped oil and gas reserves, as well as renewables, on firm value. In times when oil and gas assets are believed by some to be stranded, it is important to understand which types of reserve classifications investors actually are considering when valuing these companies. The main findings from this thesis confirms that developed reserves are the most important factors for these firms valuation. For oil, developed reserves seems to be the only factor. As these reserves are expected to be produced within a short timeframe, together with demand on the rise, it is hard to support the presence of a carbon bubble in financial markets. That is, in the shorter timeframe at least. For the longer term, uncertainty from regulation, technological disruptions in cleaner energy and battery technology, could perhaps alter this scenario. Hopefully, this thesis sheds light on how oil and gas reserves are valued in times when assets are believed by some to be stranded.

8. Limitations and recommendations

8.1 Data limitations

The first limitation of this study is that it only focuses on firms listed on North American stock exchanges. In the universe of oil and gas producers, some are also private or listed on Over-the-counter (OTC) exchanges. It should also be noted that the exclusion of some samples due to poor financials such as negative book value or a low share price, further could limit the results to not be valid for the whole sample of firms. Another limitation may stem fundamentally to the dataset, where some of the independent variables are highly clustered, skewed or have some large outliers, which can affect the overall results. Moreover, as yearly data is used for the reserve variables[26], they do not capture the immediate effect from reserve growth on firm value. The data instead captures an aggregate effect at the end of the year. Daily or monthly stock returns could perhaps lead to more efficient estimators for the reserve variables, because it would capture the effect more or less right after it is announced. The data collection for the transition strategy dummy may also contain errors. For instance, some companies could have investments in renewables in the past or present without this information being easily available through the company's available annual reports. As a quite wide definition for a transition strategy is used, it may also fail to capture the desired effect. For instance, some types of renewables are also most likely more profitable than others. Additionally, the number of firms that with certainty have a transition strategy, are very small compared to the whole sample. Increasing the number of firms with this characteristic could have assured greater validity to the conclusion on this issue. And lastly, the size of fossil fuel companies' renewables investments relative to their oil and gas investment is currently miniscule. For instance, Equinor used only 3% to 5% of their capital expenditure on renewables in the years 2017 and 2018 (Pickl, 2019). As this part of their business is potentially increasing in the near future, it should also provide more opportunities to investigate its effect.

[26] Compustat offers limited data on monthly reserves.

8.2 Model limitations

There may also be limitations to the model that was chosen, as well as how the variables were created. Both autocorrelation and heteroscedasticity is present in the dataset which undermines some of the assumptions for the regression models. Although a methodology supposed to mitigate these problems is used, estimators completely free from errors cannot be guaranteed. The significance levels for some of the reserve variables also varies to some degree from the different models and specifications used. It should therefore be noted that there still may be some uncertainty to how precisely the models capture the effects from reserves on firm value.

8.3 Recommendations for future research

A recommendation could be test the effect from reserves on firm value with a different dataset and/or methodology. An interesting approach could be to look at reserve growth in daily or monthly stock returns to investigate whether a negative effect from the growth in undeveloped oil reserves can be observed. The effect from undeveloped natural gas reserves should also be tested further to verify its existence. It would also be interesting to explore different variables for renewable investments. This could be a level and/or growth variable for renewable energy investment, generation or sales, but to the author´s knowledge, such information is not easily available and might have to be collected by hand. Additionally, an event study could perhaps also capture the effect from investments in renewables for these companies' value.

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Appendix

Table A1: Test for Unit root

The test used is a Fisher-type unit root test as the panel is unbalanced. Since we also have both Heteroscedasticity and autocorrelation in our dataset, we use a test based on Phillip-Perron which uses the heteroscedasticity- and autocorrelation-consistent covariance matrix estimator. The null hypothesis is that there is a unit root in the variable while the alternative hypothesis is that at least one panel is stationary. Based on the p-values, we reject the null hypotheses for all variables at 2 lags. The test concludes that at least one panel is stationary.

Test based on Phillips-Perron	
Variable	**p-value**
Tobin´s Q	<0.001
Total reserves (Oil)	<0.001
Total reserves (NG)	<0.001
Developed Reserves (Oil)	<0.001
Undeveloped Reserves (Oil)	<0.001
Developed Reserves (NG)	<0.001
Undeveloped Reserves (NG)	<0.001
Growth Total Reserves (Oil)	<0.001
Growth Total Reserves (NG)	<0.001
Growth Developed Reserves (Oil)	<0.001
Growth Undeveloped Reserves (Oil)	<0.001
Growth Developed Reserves (NG)	<0.001
Growth Undeveloped Reserves (NG)	<0.001
ln_Size	<0.001
Leverage	<0.001
Capex	<0.001
Profitability	<0.001
Dividends	<0.001
ln_price_Oil	<0.001
ln_price_NG	<0.001

Table A2: Test for Autocorrelation and Heteroscedasticity

A Breusch-Godfrey/Woolridge test is used for autocorrelation while a Breusch-Pagan test is used for heteroscedasticity. The null hypothesis (H_0)for Breusch-Godfrey/Woolridge is that there is no correlation while for Breusch-Pagan the null hypothesis (H_0) is that there is homoscedasticity. *** indicating significance level <0.01. Test thereby confirms the presence of both autocorrelation and heteroscedasticity in all models.

	Autocorrelation	**Heteroscedasticity**
Test based on:	Breusch-Godfrey/Woolridge	Brush-Pagan
Oil Reserves Model	265.826***	372.44***
NG Reserves Model	310.366***	210.25***
Oil and NG combined	275.843***	233.47***
Oil and NG with Green Dummy	275.866***	237.18***

Table A3: Hausman test for Fixed or Random Effects model

Hausman test can be applied when a choice has to be made between a fixed effects model and random effects model. Test statistics are based on Chi squared and the null hypothesis (H_0) states that differences in coefficients are not systematic. By rejecting the null hypothesis (H_0), the test concludes that a fixed effects model is more appropriate. Otherwise a random effects regression is more appropriate. Since the p-values are <0.001, we reject H_0 for both models. We should use Fixed effects.

Oil Reserves Model		**NG Reserves Model**	
Test statistics	p-values	Test statistics	p-values
26.49	0.0017	26.49	0.0017

Table A4: Variance Inflation Factor (VIF)

Test confirms collinearity between Total Reserves and Developed and Undeveloped Reserves for both oil and gas. This also holds for Growth Total Reserves (Oil/NG) and Growth Developed Reserves (Oil/NG). As Developed Reserves (NG) was omitted by the model, no VIF value could be obtained. This is most likely because of high collinearity between Total Proved Reserves (NG) and Developed Reserves (NG). The VIF values obtained has consequences for which combinations of reserve variables we chose to run in the regression models.

Oil Reserves Models		**NG Reserves Models**	
Variable	VIF	Variable	VIF
Total Proved Reserves (Oil)	3.24	Growth Total Reserves (NG)	5.07
Undeveloped Reserves (Oil)	3.16	Growth Developed Reserves (NG)	4.92
ln_Size	1.26	Undeveloped Reserves (NG)	2.93
Growth Total Reserves (Oil)	2.24	Total Proved Reserves (NG)	2.91
Capex	1.22	ln_Size	1.22
Growth Developed Reserves (Oil)	1.20	Capex	1.21
Leverage	1.16	Profitability	1.20
Profitability	1.16	ln_Price_NG	1.16
ln_Price_Oil	1.12	Leverage	1.16
Dividends	1.09	Dividends	1.09
Growth Undeveloped Reserves (Oil)	1.02	Growth Undeveloped Reserves (NG)	1.08
Developed Reserves (Oil)	(Omitted)	Developed Reserves (NG)	(Omitted)
Mean VIF	2.76	Mean VIF	2.18

Oil and NG Combined (Total reserves)		**Oil and NG Combined (dev. and undev. reserves)**	
ln_Size	1.27	Developed Reserves (Oil)	1.40
Capex	1.25	Developed Reserves (NG)	1.34
Profitability	1.21	Capex	1.26
Leverage	1.16	Undeveloped Reserves (Oil)	1.25
ln_Price_Oil	1.12	ln_Size	1.24
Total Proved Reserves (Oil)	1.06	Profitability	1.22
Dividends	1.05	ln_Price_Oil	1.17
Total Proved Reserves (NG)	1.02	Leverage	1.16
Growth Total Reserves (Oil)	1.01	Dividends	1.13
Growth Total Reserves (NG)	1.00	Growth Undeveloped Reserves (NG)	1.04
Mean VIF	1.12	Growth Developed Reserves (NG)	1.04
		Growth Developed Reserves (Oil)	1.04
		Growth Undeveloped Reserves (Oil)	1.00
		Mean VIF	1.19

Table A5.1: Pearson Correlation Matrix

Correlation Matrix	ln_tobin´s Q	Total reserves (Oil)	Total reserves (NG)	Developed Reserves (Oil)	Undeveloped Reserves (Oil)	Developed Reserves (NG)	Undeveloped Reserves (NG)	Growth Total Reserves (Oil)
ln_tobin´s Q	1.0000							
Total reserves (Oil)	0.0815***	1.0000						
Total reserves (NG)	0.0390**	0.2191***	1.0000					
Developed Reserves (Oil)	0.0404**	**0.7403*******	0.0827***	1.0000				
Undeveloped Reserves (Oil)	0.0909***	**0.8771*******	0.2582***	0.3265***	1.0000			
Developed Reserves (NG)	-0.0073	0.0001	**0.7692*******	0.0444***	-0.0280	1.0000		
Undeveloped Reserves (NG)	0.0607***	0.3243***	**0.8041*******	0.0229	0.4453***	0.2386***	1.0000	
Growth Total Reserves (Oil)	0.0701***	-0.0147	0.0004	-0.0176	-0.0050	-0.0031	0.0044	1.0000
Growth Total Reserves (NG)	0.0140	0.0053	0.0369*	-0.0003	0.0090	0.0300	0.0321	0.0009
Growth Developed Reserves (Oil)	0.0947***	-0.0138	-0.0057	-0.0162	-0.0063	-0.0039	-0.0070	0.8744***
Growth Undeveloped Reserves (Oil)	-0.0012	-0.0084	-0.0043	-0.0101	-0.0037	-0.0038	-0.0032	0.0717***
Growth Developed Reserves (NG)	0.0060	0.0007	-0.0061	-0.0057	0.0066	-0.0039	-0.0067	0.0007
Growth Undeveloped Reserves (NG)	0.0770***	0.0437**	-0.0052	0.0675***	0.0140	-0.0076	-0.0007	-0.0008
ln_Size	-0.2227***	-0.0692***	-0.0415***	-0.0305	-0.0847***	-0.0287	-0.0381**	-0.0358**
Leverage	-0.3017***	-0.0535***	-0.0380**	-0.0173	-0.0748***	0.0128	-0.0654***	-0.0212
Capex	0.0100	-0.0063	-0.0057	-0.0095	-0.0011	-0.0058	-0.0032	0.0170
Profitability	-0.0487***	0.0028	0.0049	0.0073	-0.0025	0.0128	0.0026	-0.0637***
Dividends	0.0110	0.0011	-0.0138	-0.0025	0.0040	-0.0108	-0.0106	-0.0098
ln_price_Oil	0.0354**	-0.1971***	-0.1409***	-0.2226***	-0.1074***	-0.1478***	-0.0799***	0.0002
ln_price_NG	0.0612***	0.0264	-0.0268	0.0347**	0.0158	-0.0239	-0.0160	0.0154

*, ** and *** indicating correlation significance at the 10%, 5% and 1% level respectively. Correlation between independent variables above 0.50 is highlighted I bold.

Table A5.2: Pearson Correlation Matrix

Correlation Matrix	Growth Total Reserves (NG)	Growth Developed Reserves (Oil)	Growth Undeveloped Reserves (Oil)	Growth Developed Reserves (NG)	Growth Undeveloped Reserves (NG)	ln_Size	Leverage	Capex
Growth Total Reserves (NG)	1.0000							
Growth Developed Reserves (Oil)	0.0017	1.0000						
Growth Undeveloped Reserves (Oil)	-0.0002	0.0084	1.0000					
Growth Developed Reserves (NG)	**0.8866*****	0.0026	-0.0004	1.0000				
Growth Undeveloped Reserves (NG)	0.2360***	-0.0021	-0.0002	0.1638***	1.0000			
ln_Size	-0.0088	-0.0484***	-0.0245	-0.0108	-0.0261	1.0000		
Leverage	-0.0311	-0.0332	-0.0278	-0.0154	-0.0387**	0.3311***	1.0000	
Capex	0.0175	0.0356**	-0.0055	0.0251	-0.0088	-0.0829***	-0.0350**	1.0000
Profitability	0.0008	-0.0699***	-0.0164	-0.0072	0.0013	0.0991***	0.0191	-0.1189***
Dividends	-0.0059	0.0010	-0.0069	-0.0048	0.0348	-0.0836***	-0.0242	0.2517***
ln_price_Oil	0.0305	0.0103	0.0211	0.0295	0.0019	0.1282***	-0.0969***	0.0014
ln_price_NG	-0.0174	0.0367**	-0.0041	-0.0213	-0.0185	-0.1339***	-0.2274***	-0.0043

*, ** and *** indicating correlation significance at the 10%, 5% and 1% level respectively. Correlation between independent variables above 0.50 is highlighted I bold.

Table A5.3: Pearson Correlation Matrix

Correlation Matrix	Profitability	Dividends	ln_price_Oil	ln_price_NG
Profitability	1.0000			
Dividends	**-0.7233*****	1.0000		
ln_price_Oil	-0.0236	0.0056	1.0000	
ln_price_NG	0.0162	-0.0133	0.1109***	1.0000

*, ** and *** indicating correlation significance at the 10%, 5% and 1% level respectively. Correlation between independent variables above 0.50 is highlighted in bold.

Table A6: Oil and Natural Gas Reserves with Transition Dummy After Winsorizing

Results from the Oil reserves and Natural gas reserves variables on firm value combined. The dependent variable is Tobin´s Q. Res is short for reserves. A random effects regression model with clustered standard errors on firm is used for all specifications. All variables are winsorized at the 1% and 99% percentiles. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)	(3)
Developed Res (Oil)	1.4656**		1.7856***
	(0.011)		(0.001)
Undeveloped Res (Oil)	0.0217		-0.1503
	(0.971)		(0.809)
Developed Res (NG)	0.3096***		0.2641***
	(0.001)		(0.002)
Undeveloped Res (NG)	0.0852		0.1140
	(0.330)		(0.227)
Growth Developed Res (Oil)		0.0274***	0.0249***
		(0.002)	(0.007)
Growth Undeveloped Res (Oil)		-0.0048	-0.0050*
		(0.123)	(0.092)
Growth Developed Res (NG)		-0.0098	-0.0196**
		(0.277)	(0.032)
Growth Undeveloped Res (NG)		-0.0004	-0.00006
		(0.842)	(0.979)
Transition focus (Green) Dummy	-0.0039	-0.0130	-0.0019
	(0.941)	(0.881)	(0.975)
ln_Size	-0.0233***	-0.0283***	-0.0169**
	(0.007)	(0.001)	(0.046)
Leverage	-1.5112***	-1.4750***	-1.4327***
	(0.000)	(0.000)	(0.000)
Capex	0.0880***	0.0706**	0.0930***
	(0.000)	(0.012)	(0.001)
Profitability	-0.1483***	0.0140	-0.0329
	(0.002)	(0.784)	(0.508)
Dividends	0.2511	0.2558	0.2072
	(0.163)	(0.266)	(0.322)
ln_price_Oil	0.1153***	0.0461**	0.0965***
	(0.000)	(0.017)	(0.000)
Observations	3672	2663	2663
Firms	574	438	438
R-sq			
Overall	0.4220	0.4405	0.4819

Table A7: Oil and Gas Reserves with Interaction Dummy for Shale Gas Revolution

Results from the Oil reserves and Natural gas reserves variables on firm value combined. The natural gas reserves are interacted with a dummy for the period 2009 to 2013 to capture the effect from the shale gas revolution. The dependent variable is Tobin´s Q. Res is short for reserves. A fixed effects regression model with clustered standard errors on firm is used for all specifications. All variables are winsorized at the 1% and 99% percentiles. Each number represents a different model specification. One unit change for the reserve variables as well as for Leverage, Capex, Profitability and Dividends is 0.01. The percentage change in the independent variable for a unit change in the dependent variable is therefore calculated as ($e^{0.01*\beta}$-1)*100. For size and oil price, the change in percentages is the same as the coefficient as this is a log-log relationship. The p-values are reported in parentheses while *,** and *** indicates a significance at the 10%, 5% and 1% level.

Model	(1)	(2)
Developed Res (Oil)	1.5087**	2.5634***
	(0.049)	(0.000)
Undeveloped Res (Oil)	-0.2011	-0.2212
	(0.821)	(0.830)
Developed Res (NG)	0.3904***	0.3678**
	(0.006)	(0.016)
Developed Res (NG)*2009-2013	-0.2153	-0.0568
	(0.243)	(0.822)
Undeveloped Res (NG)	0.2453*	0.3102**
	(0.083)	(0.043)
Undeveloped Res (NG)*2009-2013	-0.0017	-0.2756
	(0.993)	(0.289)
Growth Developed Res (Oil)		0.0412***
		(0.001)
Growth Undeveloped Res (Oil)		-0.0015
		(0.806)
Growth Developed Res (NG)		-0.0144
		(0.379)
Growth Undeveloped Res (NG)		0.00075
		(0.867)
ln_Size	-0.1246***	-0.0910***
	(0.000)	(0.000)
Leverage	-0.7809***	-0.7841***
	(0.000)	(0.000)
Capex	0.0999***	0.1493***
	(0.003)	(0.006)
Profitability	-0.0117	-0.0762
	(0.893)	(0.394)
Dividends	1.3180***	1.3718***
	(0.000)	(0.001)
ln_price_Oil	0.3302***	0.2993***
	(0.000)	(0.000)
Observations	3672	2663
Firms	574	438
R-sq		
Overall	0.1470	0.1898

Table A8: Variables After Winsorizing

Summary statistics for the full sample of 653 firms in the time frame 1999 to 2018. Panel 1 shows the firm financial variables, while Panel 2 shows the firms Oil and Gas reserve variables. Panel 3 provides a summary of the variables Tobin´s Q and Leverage used in Table 9. All variables apart from Tobin´s Q and Assets are winsorized at the 1% and 99%. The reserve variables for both oil and gas is calculated by dividing the reserves by the dollar value of assets.

Panel 1: Financial variables										
All Firms	Observations	Mean	Median	Std dev	Skewness	Kurtosis	5 %	25 %	75 %	95 %
Tobin´s Q	4,238	1.7764	1.334	2.857	15.183	308.327	0.668	1.020	1.799	3.581
Assets (million of US $)	4,252	$12,479	$486.08	$44,244.15	5.486	36.149	$13.51	$110.94	$3,079.95	$61,689
Leverage	4,250	36.2%	34.2%	21.2%	0.464	2.624	5.0%	20.0%	50.0%	76.5%
Capex	4,051	35.5%	21.8%	49.03%	4.49	28.11	3.6%	11.8%	40.0%	102%
Profitability	4,076	14.5%	15.72%	22.78%	-0.781	6.86	-22.88%	5.3%	25.95%	47.29%
Dividends	4,039	0.0182	0	0.045	3.72	17.92	0	0	0.013	0.106
Panel 2: Fossil Fuel Reserves										
Total Reserves (Oil)	4,252	0.0433	0.0253	0.0646	3.889	21.611	0.0005	0.0098	0.0483	0.1498
Developed Reserves (Oil)	4,029	0.0230	0.0143	0.0295	3.004	13.903	0.0001	0.0057	0.0275	0.0788
Undeveloped Reserves (Oil)	4,029	0.0169	0.0068	0.0330	4.154	22.613	0	0.0013	0.0175	0.0672
Total Reserves (NG)	4,082	0.2857	0.1856	0.3459	3.049	15.00	0.0042	0.0830	0.3576	0.9140
Developed Reserves (NG)	3,894	0.1705	0.1166	0.1897	2.381	10.00	0.0020	0.0470	0.2167	0.5230
Undeveloped Reserves (NG)	3,894	0.1073	0.0452	0.1972	4.235	24.239	0	0.0104	0.1187	0.3768
Panel 3: Tobin´s Q and Leverage in Table 9										
Tobin´s Q	4,238	1.5182	1.0608	2.8482	15.145	307.877	0.406	0.7577	1.5579	3.3495
Leverage	4,251	20.95%	15.62%	20.95%	1.112	3.679	0.0%	0.34%	31.43%	64.89%