Universitetet i Stavanger

FACULTY OF SOCIAL SCIENCES,

UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
Master of Science in Business Administration	**Applied Finance**
	IS THE ASSIGNMENT CONFIDENTIAL? **No**
	(**NB**! Use the red form for confidential theses)

TITLE**: The effect of energy transition on the financial performance of oil and gas companies**

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Abstract

We investigate the effect of transition towards low carbon energy on the financial performance of European and US oil and gas companies in the years 2010-2018. This is important, as a major participant in the global energy market, oil and gas companies have been affected by the increase in the global interest in investments into low carbon energy. The research question is approached from both perspectives of individual company transition and global transition. We find that, first, individual company transition has a negative effect on European oil and gas companies for low levels of transition, and it has a positive effect for higher levels of transition. For US oil and gas companies, the opposite effect is true. Second, global transition to low carbon energy has a positive effect on the financial performance of European and the US companies and this effect is increasing when the magnitude of transition increases. Third, this positive effect decreases when the oil price increases. In the future, global transition to low carbon energy is expected to increase further, which will amplify the positive effect in both markets, especially when the oil price is low. Therefore, we recommend oil and gas companies to further their transition to a higher level, as it positively affects their financial status.

Keywords: Low-carbon transition, Oil and gas company, Energy transition, Renewable energy

Content

Preface

This thesis concludes our Master of Science degree in Business Administration with specialization Applied Finance at the University of Stavanger Business School. The topic of the thesis is suggested by our supervisor and motivated by the increase in global interest towards a world with cleaner energy.

We would like to thank our supervisor, Niaz Bashiri Behmiri for priceless guidance and support throughout the process.

We would also like to thank each other for a great partnership along the way. Lastly, we would like to express our gratitude to our family for their patience and support.

University of Stavanger

Stavanger, June 2020

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1 Introduction

Energy transition towards low-carbon, cleaner energy systems laid the foundation of the "new energy era". To alleviate environmental problems, such as global warming and climate change, the global energy landscape has been changing: the share of fossil fuels is gradually diminishing, and the proportion of renewable energy is rapidly rising (Lu et al., 2019). Controlling and reducing greenhouse gas (GHG) emissions is an essential factor for stabilizing the global climate. IRENA[1] reports that renewable energy sources and energy efficiency can successfully implement a 90% reduction of energy-related CO_2 by 2050 (IRENA, 2019). Therefore, energy transition is an indispensable solution to mitigate GHG emissions to prevent climate change, to achieve decarbonization of the energy system, and to develop a sustainable development of socio-economic systems.

The Kyoto Protocol and Paris Agreement under the United Nations Framework Convention on Climate Change were signed for dealing with the threat of GHG emissions to limit global warming. These agreements have incited both countries and oil and gas companies (O&G companies, henceforth) to join the transformational process and to accelerate energy transition. As a major producer of fossil fuels and GHG, O&G companies play a crucial role in the global energy system and the energy transition. Alongside these agreements, the changing nature, economy, and social environment boosted activity of O&G companies in the energy transformation. As a result, most of international O&G companies have started to diversify their business to thrive in energy transition and contribute to the decarbonization process. The extent of adaptation to the fast-changing environment and the response to energy transition by O&G companies vary among companies. For instance, many of them are stepping in to become energy companies rather than O&G companies by investing huge amounts in renewable-green technologies. Nevertheless, many of them are still focusing on fossil fuels and try to increase energy efficiency and invest in low-carbon technologies.

However, according to the International Energy Agency (IEA) renewable energy will be the global major energy source by taking a 40% share of total power generation in 2040 (IEA, 2017). IEA

[1]International Renewable Energy Agency

claims that, the rapid penetration of renewable energy into the energy mix caused an increase in the global interest and investments for the renewable energy (IEA, 2020). This tendency shows that there is a notable crescendo in the magnitude of the global energy transition. Therefore, if O&G companies decide to stand aside in the energy transition process, it might have a negative impact on the oil and gas industry. Moreover, uncertainties in the oil and gas industry, such as decreasing oil demands and highly volatile oil prices might affect financial stability of O&G companies. Thus, all these factors entail some modifications in the core business of such companies. Some O&G companies, specially, oil majors have already taken steps for active involvement in the fast-growing new energy sector. However, the other factors, such as lower investment returns for the low carbon activities and unclear future financial outcomes of energy transition, make this process undesirable for some O&G companies. Particularly, uncertainty in the transformation process raises the question how energy transition would affect the financial performance of O&G companies.

Considering the lack in the literature regarding this question, we want to shed a new light on the issue of energy transition and its effect on the financial performance of O&G companies. Hence, our research aims to uncover whether there are any possible impacts of low carbon activities on the financial performance of O&G companies. Finding the answer to this question could be helpful for the companies, which are willing to make a move towards low-carbon energy. In the literature, there are several papers, which comprise different aspects of the energy transition in O&G companies. For instance, Pickl (2019) considers energy transition strategies and the renewable investments of eight oil majors, Lu et al. (2019) analyse the low carbon transformation process and its components (such as carbon emission targets, investment priorities, the magnitude of high-tech technologies, opportunities and challenges) in the nine major O&G companies, Shojaeddini et al. (2019) study the strategies of international and national oil companies (IOC and NOC) in the energy transition process, Fattouh & West (2019) investigate the challenges of energy transition and new investment opportunities for international O&G companies, Fattouh et al. (2019) question which adaption strategy should be chosen by oil companies and oil-exporting countries in the energy transition, Zhong & Bazilian (2018) consider the role of seven international oil companies (IOC) in energy transition, explores their business strategies and integration startup services into new renewable operations, Chaiyapa et al. (2018) examine the renewable investment of Thai state-owned O&G company and two associates in last 15 years and conduct a discourse analysis about the legitimization of their new businesses, lastly Danielsen, (2017) researches the effect of exposure to renewable energy on the valuation of O&G companies. Most of these studies investigate energy transition pathways, i.e. the transformation process, its opportunities, challenges, the companies' resilient strategies, investment activities et cetera.

Unlike the abovementioned studies, this study focuses on the quantitative effect of transition towards low carbon on the financial performance of oil and gas companies. We consider both transition of the individual company and global transition. Due to data availability, we limit our study to the European and the US market. The data used in this study consists of 17 European and 27 US oil and gas companies for the years 2010-2018. The models are estimated using the two panels separately. Financial performance is defined as return on assets. Effects of company size, leverage, oil price and the oil crash in 2014-2015 are controlled for. The emission reduction score is applied as indicator of company transition towards low carbon energy production. It measures the company's commitment to reducing emission in the production process. Global transition is defined as global renewable energy generated and global share of renewable energy consumed. The study also explores the presence of non-linear relationships between transition and financial performance and of a moderating effect between the oil price and the transition indicators. The models are estimated by applying a fixed effect transformation to control for omitted variable bias relating to time and company effects.

The results of our empirical analysis for individual company transition show that the effect of transition on financial performance depends on the magnitude of transition. For European oil and gas companies, the initial effect is negative, but turns positive when transition reaches a higher level. For the average European oil and gas company in the panel, an increase in transition to low carbon production favorably affects financial performance. However, for US oil and gas companies, the initial effect is positive, but turns negative when transition reaches a higher level. For the average US oil and gas company in the panel, an increase in transition to low carbon production unfavorably affects financial performance. This effect is opposite from what is observed in the European market. We believe the difference in results between both markets has to do with a difference between policies of the EU and the US. The US announced in 2017 they will withdraw from the Paris Agreement and will focus on producing low cost fossil fuel energy (Hersher, 2019; Vakhshouri, 2017). Meanwhile, Europe has a strong focus on production of renewable energy, as Europe tries to meet its Paris Agreement goals of mitigating its GHG emissions by at least 40% before 2030 (European Parliament, 2019). Moreover, in the US certain oil majors have a strong lobby to prevent utility companies from switching to renewables (Csomós, 2014).

The results of our empirical analysis for global transition show an initial negative effect on financial performance of European oil and gas companies for low levels of transition, which turns positive when transition reaches a higher level. These results are the same for both global renewable energy consumed and global renewable energy generated. In case of US oil and gas companies, global transition shows a different effect on financial performance. When applying global renewable energy generated as transition indicator, the results are the same as European companies, with an initial negative effect on financial performance, but the effect turns positive as renewable energy generated increases. However, the results for global share of renewable energy consumed show that the effect of renewable energy consumption is positive and increasing. This means that even at low levels of global renewable energy the effect of transition on financial performance is positive. The positive effect of an increase in absolute value of global renewable energy generated is likely prescribed to the global increase of energy demand due to the rising population, which simultaneously increases absolute demand of oil and gas (Csomós, 2014). The positive effect on financial performance of an increase in the share of renewable energy consumption can be explained through oil and gas companies diversifying into renewable energy. Moreover, we find a negative moderating effect from oil price on the effect of transition variables. This implies a high oil price reduces this positive effect of transition. Therefore, it can be argued that a high oil price reduces oil and gas companies' incentive to invest in low carbon technologies. This means a high oil price halts oil and gas company's investments into renewables, slowing the low carbon transition process.

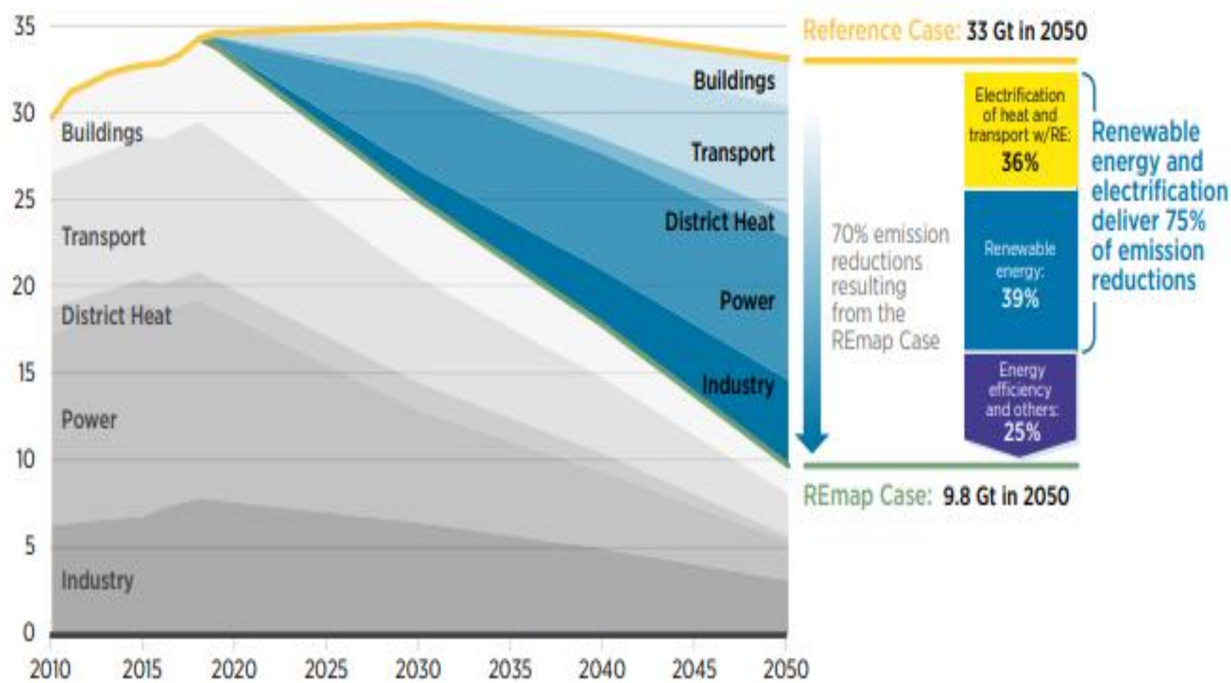
The remainder of our thesis is organized as follows; chapter 2 provides an overview of global energy transition, chapter 3 provides a theoretical background and hypotheses, chapter 4 provides the literature review, chapter 5 describes the data used in this study, chapter 6 describes the methodology and econometric models, chapter 7 presents the results and answers our hypotheses, and lastly chapter 8 offers the conclusion.

2 Overview of global energy transition

2.1 Energy transition definition

Energy transition is defined as a long-term modification in the structure of the global energy system (Hauff et al., 2014). It refers to a shift from an energy system based on one type of energy source to another type of energy resource (Fouquet & Pearson, 2012). The occurrence of energy transition is entailed by several inevitable global factors. The first major energy transition was a change from biomass (wood) energy to fossil fuels and this transformation process lasted from the 17^{th} century to the end of the 19^{th} century. The discovery of new fossil fuel reserves, progress of technology and urbanization stipulated and accelerated the transition process (Solomon & Krishna, 2011). As a result, fossil fuels have become the main source of the global energy supply. Currently, the world is facing the second great energy transition, which relies on transformation from fossil fuels, such as oil, gas, and coal, to renewable energy sources, such as, solar, bioenergy and geothermal energy. Transformation to renewable energy aims to reduce detrimental consequences of exploitation of fossil fuels. These detrimental effects, such as climate change and air pollution perform as key drivers of the global energy transition. Hence, energy transition is an indispensable solution to mitigate GHG emissions, prevent climate change, achieve decarbonization of the energy system and to develop a sustainable socio-economic system. Controlling and reducing GHG emissions is an essential factor for stabilizing the global climate. Thus, in 2016, the Paris Agreement under the United Nations Framework Convention on Climate Change was signed to deal with the threat of GHG emissions. It brought attention to the global climate change challenge and exerts global effort for responding to this problem. A total of 197 countries have agreed to sign the convention in order to cope with climate change (Denchak, 2018). The main goal of The Paris Agreement is to keep the increment in global average temperature well below 2°C pre-industrial levels and to continue efforts to limit temperature rise to 1.5 °C (UN Climate Change, 2016). IRENA claims that, for not exceeding 2°C increment in global temperature, decarbonization of the energy system must be expedited over the next 35 years (IRENA & IEA, 2017). According to the report of IRENA shown in *figure 1*, renewable energy sources and energy efficiency, enhanced by significant electrification can successfully implement the 90% reduction of energy-related CO_2 by 2050 (IRENA, 2019).

Figure 1. Annual energy-related CO_2 emissions in the Reference Case and reductions in the REmap Case, with the contribution by sector, 2010-2050 (Gigatonnes per year).

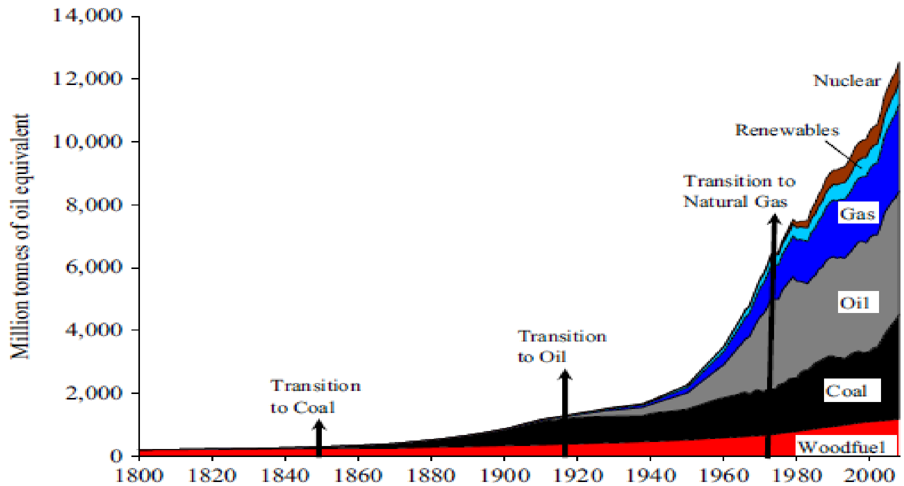


Source: IRENA, "Global energy transformation: A roadmap to 2050. 2019 (IRENA, 2019)

To achieve these results, the proportion of renewables in the energy production should be increased. IRENA's REmap analysis claims that, this portion would rise about 60% by 2030 and 85% by 2050. Hence, there would be significant alteration in energy supply mix (IRENA, 2019). Nevertheless, even if this decarbonization plan is achieved, fossil fuel will continue being a major part of the energy supply due to increasing energy consumption.

History shows that energy transitions have entailed to substantial increases in the energy consumption (Grubler, 2004). *Figure 2* demonstrates how the overall global energy consumption has been rising after energy transitions. Therefore, it is anticipated that the transformation towards renewable energy will also increase global energy consumption, but it does not ensure that fossil fuel use will decrease substantially in the near future (Fouquet, 2009). However, IRENA claims that the overall global fossil fuel consumption would be a third of today's consumption level in 2050. According to their estimation, the significant fall would be in the coal consumption, but oil demand would be at roughly half of today's level (IRENA & IEA, 2017).

Figure 2. Global energy consumption and transitions, 1800–2010.

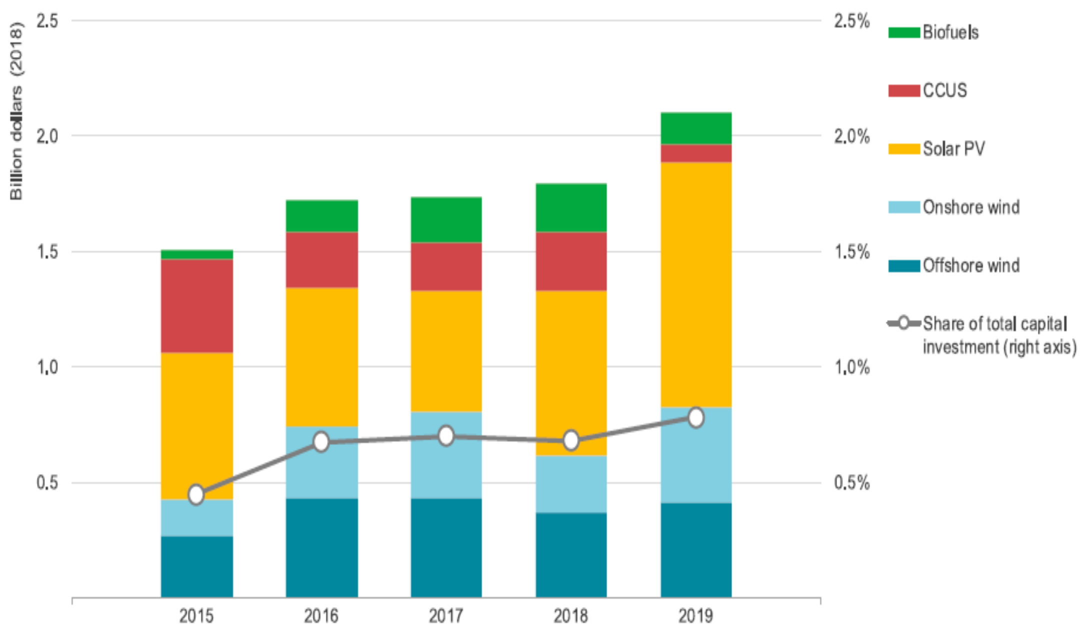


Source: R. Fouquet, "A Brief History of Energy,"2009.

Realization of energy transition should be the main global aim, however, only having renewable energy recourses is not enough for such success. In addition to these resources, smart technologies, roadmaps, policy frameworks and governmental supports are required. Energy companies, particularly O&G, play a crucial role in developing these low carbon transformation technologies. As a major producer of fossil fuels and GHG, the effect of the decarbonization process on O&G companies has been inevitable. Facing pressure from both governments and stakeholders, increasing expenditures of hydrocarbon extraction and current global economic conditions urged them to reconsider their business strategy regarding diversification and energy transformation. Energy transition in O&G companies implies to choose business strategies towards transformation to a low carbon world, which entails investments to renewable resources, zero carbon or green technologies like electrification, as well as low carbon technologies, such as carbon capture and sequestration (CCS), and hydrogen fuels.

The rapid penetration of renewable energy into the energy mix caused an increase in the global interest and investments for the renewable energy. As for the oil and gas industry, investment amounts for the renewable energy sector is growing year by year (*Figure 3*). Nevertheless, IEA reports claim that, such "green" investment is still small part of whole capital expenditures (IEA, 2020).

Figure 3. Renewable energy investments of the oil and gas industry.



Source: International Energy Agency, "The Oil and Gas Industry in Energy Transitions – Analysis," 2020

2.2 Energy transition definition in oil and gas companies

The low-carbon energy transition will be a beginning of new "clean era". Pearson and Foxon (2012) mention this transition process as part of a potential Third Industrial Revolution because of its effect on social and economic transformation (Pearson & Foxon, 2012). Thus, energy transition will have to a great degree of impact on environment, global economy and the whole society. Clearly, O&G companies have been affected significantly throughout this process. First, greater renewable energy portions in the energy mix performs as an obstacle for the increase in the demand of oil and gas. Political decisions around oil and gas have an immediate impact on the prices, which directly influence the financial performance of O&G companies as well. Therefore, it is recommendable to diversify their business by investing in the renewable energy sector. Secondly, environmental actions of the Paris Agreement meant to mitigate global climate change can create a potential threat for the financial stability and existence of O&G companies. It is expected that implementation of the Agreement's requirements lead to a decline in the long-term demand of hydrocarbon energy, increase operation costs due to high taxes on CO_2 emission and impair O&G

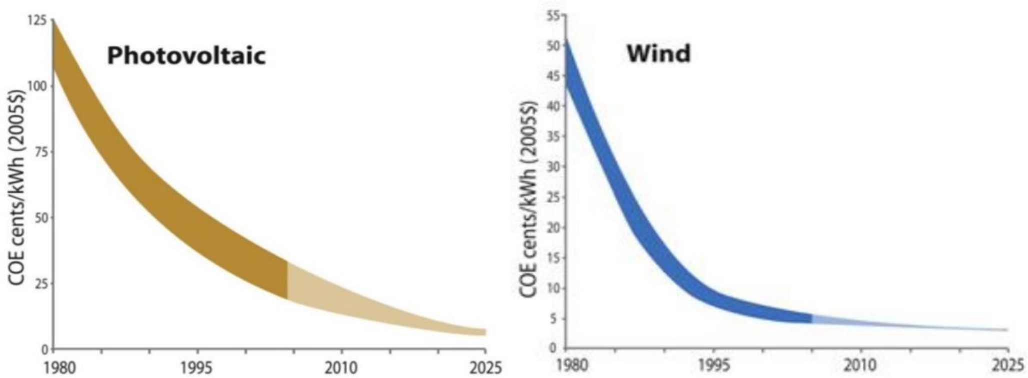
companies' public relations (Zhong & Bazilian, 2018). Hence, to maintain economic stability and stay in the energy market in the long run, O&G companies should participate in the energy transition process.

In addition to economic and environmental sides, the social aspect of energy transition is also a strong factor affecting governments and O&G companies' attitudes towards renewable energy. Crowe et al. (2019) show that social acceptance and public perception about renewable and nonrenewable energy sources can affect the energy transition in corresponding areas. Moreover, as an investor, employee, consumer or shareholder, society members' positive viewpoints about energy transition and concerns about climate change can put pressure on the decisions of O&G companies. Prioritization of environmental, social and governance (ESG) factors by investors also helps to increase the importance of the energy transition (S&P Global, 2020).

Nowadays, the increasing use of renewable energy sources, progress in energy storage technologies and the onset of electrification has accelerated the energy transition process as well. However, the roots of using renewable energy sources go back to several centuries. Waterwheels can be the first example of renewable energy, which was the base model for today's hydropower energy. The utilizing power of wind started with windmills five hundred years ago in Europe, particularly in the Netherlands. The working mechanism of modern wind turbines was influenced by these windmills. The invention of first solar energy system in the world happened in 1860 in France. The inventor, Augustin Mouchot, had doubts about depletion of coal sources, so he tried to create his "sun meter" (Project Solar UK, 2018). Although, the higher production cost of renewable energy caused to exploit fossil fuels as major energy sources in the latest centuries.

Recently, advanced technologies help to decrease the production costs for renewable energy sources. For example, the following graphs (*Figure 4)* show a significant decline in the cost of wind and solar energy production in US for last 40 years (Racz, 2018).

Figure 4. Production costs of wind and solar energy in US from 1980-2025.

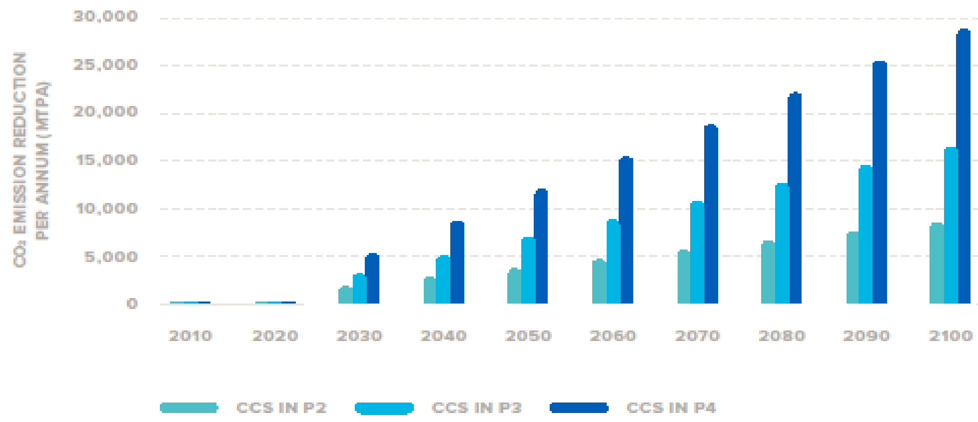


Source: C. Racz, “Renewable Energy: History, Innovation, and Potential,”

Thus, decline in production costs made renewable energy sources economically more attractive to the O&G companies. Alongside the climate change pressure, such a “cost-cutting” effect of new technologies has helped to accelerate the energy transition. Therefore, the development of smart, green technologies provides new efficient ways of utilizing renewable energy sources. Meanwhile, investing in energy storage technologies helps to reduce methane intensity, limit climate change and overall boost the decarbonization process (Shojaeddini et al., 2019). For instance, one of the storage technologies, Carbon Capture and Storage (CCS) is considered crucial for achieving long term climate change goals. According to The Global Status of CCS 2018 Report, there are 23 large-scale CCS facilities, which capture 43 million tonnes of CO_2 per annum. Moreover, Global CCS Institute data analysis (*Figure 5*) shows that, CCS can reduce up to 30.000 million tonnes of CO_2 per annum by 2100 in the best scenario (P4) [2] (Global CCS Institute, 2018). Thus, due to generating economic efficiency and limiting climate change, technology is considered as one of the key drivers of the energy transition in the O&G companies.

[2] P4: a resource-and energy-intensive scenario: emissions reductions are mainly achieved via technological means, making strong use of carbon dioxide removal through the deployment of bioenergy with ccs.

Figure 5. CCS contribution in the reduction of CO2 emission based on three different scenarios



Source: Global CCS Institute, "Global Status Report of CCS 2018", 2018.

To tackle climate change and increase the corporate social responsibility, several IOCs [3] are jointly working on some projects and organizations. The Oil and Gas Climate Initiative (OGCI) is an outstanding example for such collaborations. OGCI, an international industry-led organization, is established by 13 O&G companies from different countries in 2014 (OGCI, 2019). The OGCI members aim to:

1) Achieve zero routine flaring.
2) Lessen methane intensity in the production process to below 0.25% by 2025.
3) Enhance investment portfolios in regarding to reduce CO_2emissions and reuse (Oil&Gas UK, 2018).

Moreover, there are other organizations and projects, such as IPIECA[4], Global Gas Flaring Reduction Partnership, and Oil and Gas Methane Partnership, focus on helping to mitigate natural gas flaring, methane leakage and develop companies' environmental and social performance (Shojaeddini et al., 2019).

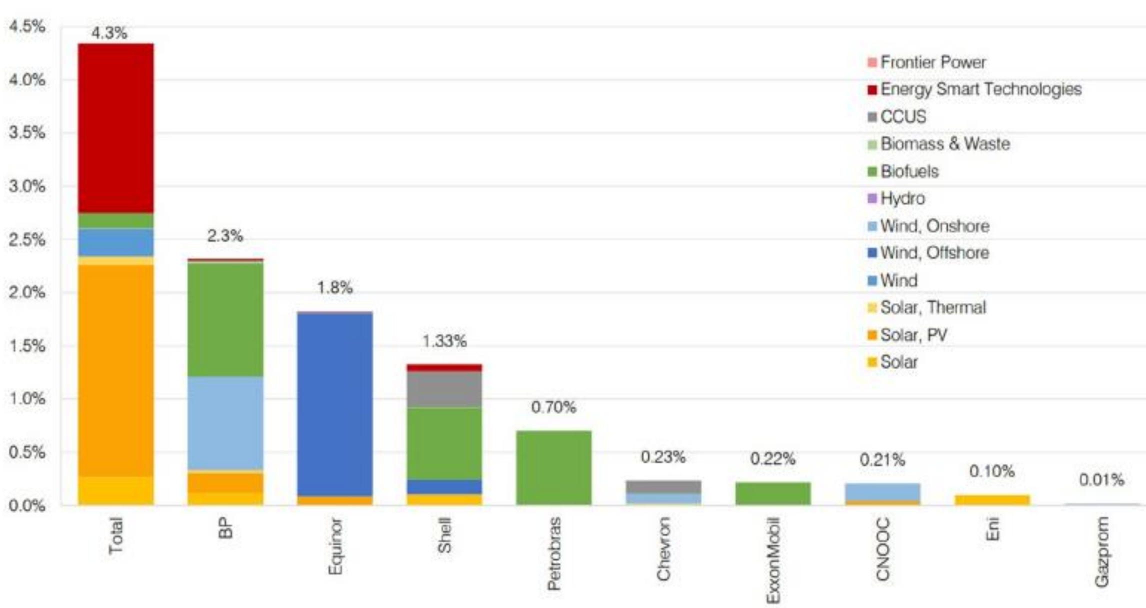
[3] International Oil Companies

[4] International Petroleum Industry Environmental Conservation Association.

2.3 Energy transition background in oil and gas companies

Energy transition implies three requirements (low carbon, secure, and low cost) of the 'energy trilemma', which must be met by new technologies for achieving Paris Agreement goals (Oil&Gas UK, 2018b). Alongside the Paris Agreement, the changing nature, economy and social environment has boosted activity of O&G companies in the energy transformation process. As a result, most of international O&G companies have started to diversify their business to thrive in energy transition and contribute to the decarbonization process. The extent of adaptation to the fast-changing environment and the response to energy transition by O&G companies are in different levels. For instance, many of them are stepping in to become energy companies rather than O&G companies, by investing huge amounts in renewable-green technologies and research and development for low carbon production. However, other O&G companies are still focusing on fossil fuels and try to increase energy efficiency and invest in the low-carbon technologies instead. *Figure 6* demonstrates the variety in the low carbon investment portions in CAPEX [5] for the different O&G companies, such as Total, BP, Equinor, Shell, Eni, Chevron.

Figure 6. Low-carbon investment (organic and inorganic) portions of total CAPEX (2010-Q3 2018)



Source: CDP Worldwide (Shojaeddini et al., 2019)

[5] Capital expenditure.

We look at the first four oil majors' activities regarding the energy transition and decarbonization process. One of the biggest liquefied natural gas operators and oil producers, Total, aims to become an energy major rather than oil and gas major. Total defined a climate-oriented strategy for developing the following four business areas: 1) natural gas, 2) low-carbon electricity 3) petroleum products and 4) carbon neutrality (Total, 2019). Total believes that natural gas is one of the crucial components of the energy transition and considers it the keystone of company's transition strategy. Leading to lower GHG emissions, natural gas can be the best alternative to coal because of flexibility, it performs as a desired partner for renewable energies. In 2018, the share of gas in Total's hydrocarbon production was 50% and they target to increase this portion up to 60% by 2035 (Total, 2019). Total sets goals of reducing methane intensity to 0.25% from 0.32% by 2025 and carbon dioxide emissions by 25-35% by 2040. In addition, the company targets to increase the capacity of power generations based on renewable sources up to 25GW in 2025 (Total, 2018).
Initially, Total's renewable strategy focused on solar energy and biofuels, whereas, recently Total enhanced investments in favor of storage technologies and power generation (Total, 2019). In 2011, Total invested $1.4 billion in buying 60% majority stake of US-based Sunpower (solar panel producer) and became a new worldwide leader in the solar industry (Herndon et al., 2011). In 2016, Total acquired battery manufacturer, Saft and Belgium's third-ranked natural gas and renewable power supplier, Lampiris (Fuelsave, 2016; Reuters, 2016). Total EREN was established in 2017 after acquisition of a share in the French Renewable Energy company EREN for expanding business in the renewable power generation sector. Total EREN possesses diversified assets in renewable energy sources, such as solar, wind and hydropower (Total, 2019). In the same year, it acquired another French company, energy efficiency leader Greenflex and spent more than $200 million on transforming its refinery (La Mède) into a biorefinery (Pickl, 2019; Total, 2017). In 2018, Total created an affiliate, Total Solar, for distributing solar panels to commercial and industrial customers (Total, 2019). In 2019, Total renamed its venture capital fund, Total Carbon Neutrality Ventures (formerly, Total Energy Ventures), which focuses on renewable and low-carbon projects and has spent around $200 million in over 20 renewable start-ups since 2008 (Pickl, 2019; Total, 2018).

BP was one of the first O&G companies, which has taken the initiative to invest towards renewable energy two decades ago (BP, 2018a). In 2001, BP spent $200 million for the rebranding campaign from “British Petroleum” into “Beyond Petroleum”, which is an envisioned step towards energy transition (Pickl, 2019). Initially, BP’s renewable energy activities were related to manufacturing components for solar energy and developing projects of wind and solar energy (Pickl, 2019). BP has increased its renewable activity year by year throughout the world. Nowadays BP possesses the most part of onshore wind assets in US, biofuels business, such as sugar cane processing, ethanol production in Brazil and a carbon capture and storage (CCS) joint venture with other companies, such as Suncor, Petrobras, and Chevron (Mackenzie, 2018; Pickl, 2019). Moreover, in 2016, BP spent a $200 million for investing in Lightsource, the biggest solar power developer in Europe (Ward & Thomas, 2017). In 2018, BP made noticeable investments through three different investment projects, such as FreeWire, StoreDot, Chargemaster, which aim to improve charging technologies (Pickl, 2019).

BP’s energy transition strategy focuses on creating a balance between oil and gas and renewable energy business (BP, 2018a). Because of the ongoing notable role of the oil and gas industry over the next 20 years, BP continues to take advantage of oil and gas resources. Meanwhile, according to their strategy, BP created a “reduce, improve, create” approach for contributing to the decarbonization process. This framework targets to reduce CO_2 emission, improve their products and create low carbon business. The “reduce” targets aim to mitigate 3.5 Mte[6] of GHG emissions, achieve 0.2% methane intensity and zero net growth in operational emissions by 2025 (BP, 2018c, 2018b). The “Creating” part of this framework entails to extend renewable and low carbon activities by investing $500 million in these businesses each year, collaborating and contributing to OGCI’s “1+billion” fund for technology and research (BP, 2018a).

In order to be compatible with the Paris Agreement’s targets, Shell has created a new business strategy, which focuses on business and geographical diversification (Shell, 2018b). Shell’s transition strategy aims to provide more and cleaner energy to the whole society and helps the company thrive in the energy transition (Shell, 2018). In 2016, Shell formed New Energies Business division for focusing on energy transition in the long run. New Energies Business covers power and new fuel (advanced biofuels and hydrogen) activities (Shell, 2018b). According to the Shell Energy Transition Report, the company targets to lessen the current level of the Net Carbon Footprint (83 g CO_2e/megajoule) by 20% by 2035. (Shell, 2018b). In 2018, Shell’s CEO told the

[6] Million tonnes (Agarwal, 2008)

investors that Shell has become an "energy transition company" rather than an O&G company, which shows that Shell already has strategic roadmaps for resilience (Sheppard & Raval, 2018). Shell has made noteworthy organic and inorganic investments in low carbon and the renewable sector in recent years. For instance, in 2014 the oil major invested funds in GlassPoint Solar (solar steam generators manufacturer), in 2017, Shell acquired First Utility (electricity and gas supplier), and NewMotion (electric vehicle charging company) and in 2018 invested $200 million in to the US-based solar developer company, Silicon Ranch, $20 million in to Husk Power Systems, an India-based company, which supplied off-grid installations. Furthermore, Royal Dutch Shell invests in energy storage companies like Axiom Energy, GI Energy, and Sonnen (Deign, 2018; Financial Times, 2018b; Mackenzie, 2018; Wesoff, 2014). Statoil, the Norwegian international energy company, announced in 2018 it will be rebranding Statoil to Equinor, to reflect the company's energy transition strategy. To be in line with the transition roadmap, the former oil major established New Energy Solutions (NES) as a new business division in 2015. NES aims to support the company's activity in profitable low carbon and renewable energy areas (Equinor, 2015). Moreover, in 2016, the corporate venture fund, Equinor Energy Ventures (EEV) was founded as part of Equinor's business within NES (Equinor, 2016). EEV's goal is to develop the renewable energy sector as investing in new and ambitious renewable energy companies. According to Sustainable Development Goals, Equinor achieved one of the least CO_2 intensity indicators among oil and gas producers (operated 100%, 9kg CO_2/boe[7]), invested nearly $0.5 billion in new energy solutions, spent around 21% of total R&D funding for low-carbon areas development in 2018 (Equinor, 2019). Equinor targets to devote 25% of R&D expenditure to renewable energy by 2025, achieve 8kg CO_2/boe carbon emission intensity and increases new energy investments' portion in the total CAPEX up to 15-20% by 2030 (Equinor, 2018b; Financial Times, 2018a).

Equinor has made outstanding investments in new energies in the latest years. In 2016-2018, the company invested Convergent Energy and Power (energy storage developer company), acquired 40% shares of Scatec Solar (integrator photovoltaics systems), 50% shares of two offshore wind development companies in Poland and has agreed to spend €400 million for acquiring Danske Commodities (power and gas trading company) (Financial Times, 2018a; Inc, 2016; Mackenzie,

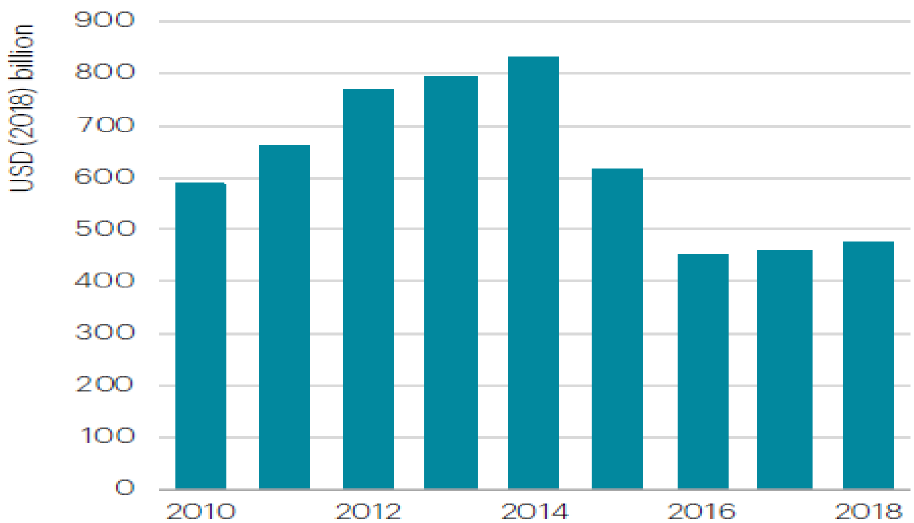
[7] Barrel of oil equivalent

2018). Moreover, after establishing EEV, Equinor invested $200 million venture capital in renewables start-ups and technologies (Equinor, 2016).

3 Theoretical background and hypotheses

The renewable energy sources most invested in are solar and wind energy. IEA reports that the renewable energy sources, particularly solar and wind energies, are gradually capturing a crucial part of the overall energy sector and that renewable energy will be the global major energy source as taking 40% share of total power generation in the next 20 years (IEA, 2017). It is doubtless that such upward tendency in renewable energy supply will affect the oil and gas industry. This impact has already been seen in the global energy investment trends. *Figure 7* demonstrates that there is a prominent decrease in the investment for upstream oil and gas after 2014.

Figure 7. Global investment in upstream oil and gas

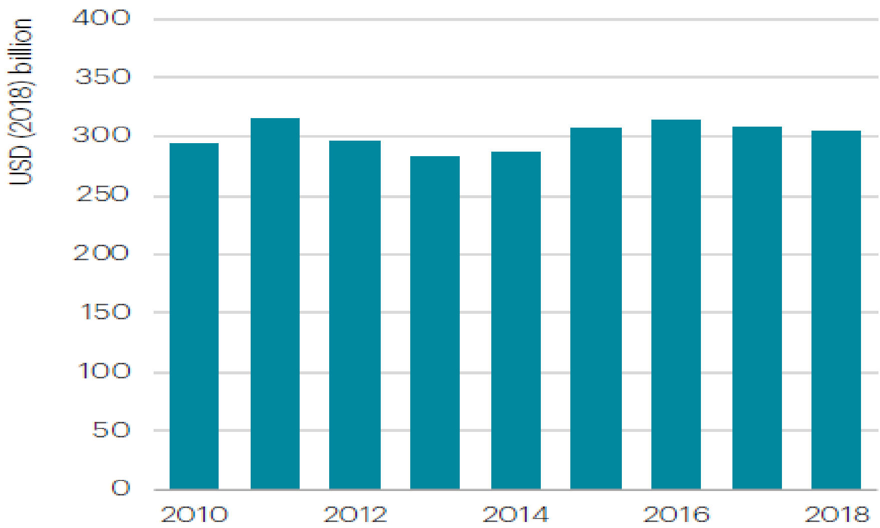


Source: International Energy Agency, World Energy Investment 2019.

However, *Figure 8* shows a gradual increase in renewable power investments after 2012. Moreover, as seen from the figures, the oil and gas sector tends to be more volatile, whereas the renewable energy sector is more stable, which shows the risk extent of these sectors.

World Energy Investment claims that the power sector has become the largest investment sector by exceeding the sector of oil and gas supply since 2016 (IEA, 2019).

Figure 8. Global investment in renewable power



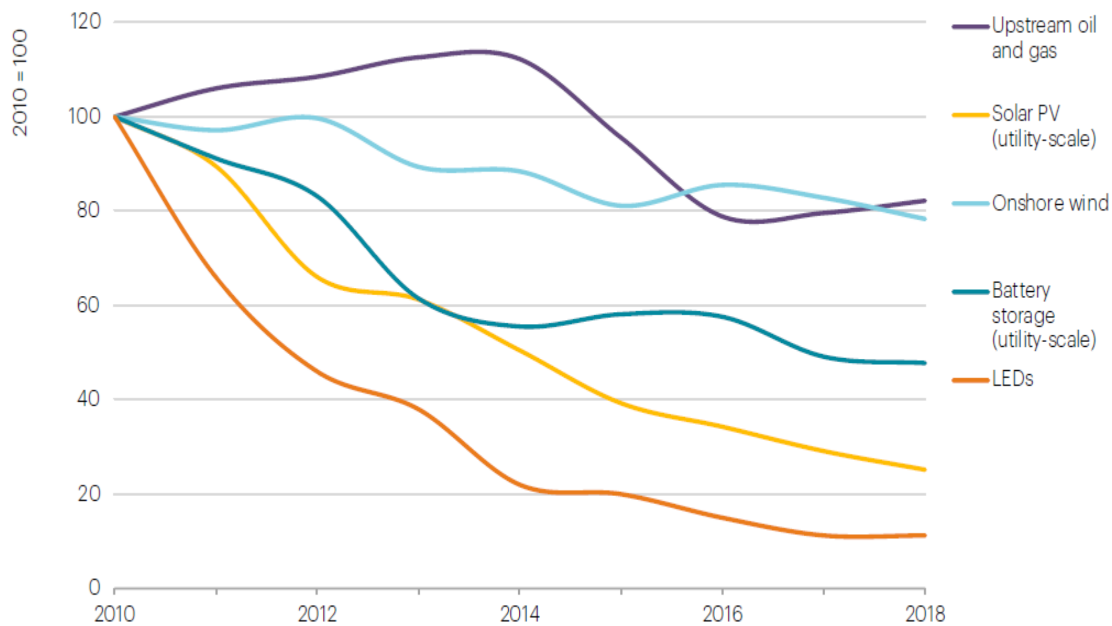
Source: International Energy Agency, World Energy Investment 2019.

This shows that the global interest towards renewable energy has been increasing. Meanwhile the oil and gas sector might gradually lose its dominance. Therefore, to stand aside in the decarbonization process might have a negative impact on the oil and gas industry. Moreover, ignoring the transition in the energy system can disrupt companies' business models and erode their profits (Fattouh et al., 2019). Therefore, rapid changes in the energy landscape, huge uncertainty in oil and gas industry and politics, and highly volatile oil prices entail O&G companies to undertake a move towards becoming an energy company rather than being an oil and gas company.

On the other hand, some O&G companies are reluctant to take such a step due to uncertainty in the global energy transition and particularly, lower returns on investment in the low carbon activities (Fattouh et al., 2019; Zhong & Bazilian, 2018).

Figure 9 demonstrates that despite of a sharp decline in 2016, the capital cost of upstream oil and gas sector is higher than the other energy-related sectors, which makes oil and gas sector still more attractive for investors.

Figure 9. Capital costs in selected energy related sectors.



Source: International Energy Agency, World Energy Investment 2019.

Thus, it is vital to find a successful transition strategy in this changing environment. However, this proves to be a challenging process for O&G companies. There is no one size strategy, that fits all companies (Fattouh et al., 2019).

The global importance of energy transition is rising, and the question occurs how this will affect the financial performance of oil and gas companies. There has been a lot of research on renewable energy in recent years, and it has become an extremely important topic in the energy market. Oil and gas companies could have major opportunities by diversifying into these markets, but no research has yet been done on the effects on financial performance when transitioning to renewable energy. In light of the fast-moving energy transition worldwide, and oil and gas companies' shown interest in diversifying into cleaner energy markets, it is essential to fill this gap in the literature by investigating the effect on financial performance of oil and gas companies when they move towards cleaner energy solutions. Thus, we think, it is noteworthy and advantageous to investigate the possibility of existence of such effect. Therefore, in our study we want to investigate whether there is any effect on the financial performance of oil and gas companies due to the transformation towards low-carbon energy. On one hand, we look at the effect of individual transition of oil and gas companies towards low-carbon energy, and on the other hand, we look at the effect of global transition towards renewables on the oil and gas companies' financial performance. We limit our study to the European and the US market. Therefore, we define the first hypotheses as:

Hypothesis 1. *Individual transition towards low carbon investments affects the financial performance of European and US oil and gas companies.*

The second main hypothesis concerns the effect of global transition towards renewable energies on oil and gas companies' financial performance:

Hypothesis 2. *Global transition towards low carbon energy affects the financial performance of European and US oil and gas companies.*

However, it is possible that the relationship between transition and financial performance to be non-linear in nature. It could be that initial steps towards transition will not be profitable due to high costs of entering a new market, but it may become profitable as a higher level of transition is reached (Csomós, 2014). Therefore, our third hypothesis is as follows:

Hypothesis 3. *Individual transition towards low carbon investments has a non-linear effect on the financial performance of European and US oil and gas companies.*

Moreover, in case of global transition, oil and gas companies will adapt to the new market and learn to take it to their advantage. Therefore, our fourth hypothesis is as follows:

Hypothesis 4. *Global transition towards low carbon energy has a non-linear effect on the financial performance of European and US oil and gas companies.*

Another possible factor influencing the effect of transition could be the oil price. Financial performance of oil and gas companies is influenced heavily by the oil price (Bagirov & Mateus, 2019; Danielsen, 2017; Guillermet & Manikom, 2014). We suspect a low oil price could be incentive for oil and gas companies to diversify into the renewable energy market. Likewise, when the oil price is high, investments into oil and gas sector could be preferred. Therefore, our fifth and sixth hypotheses are as follows:

Hypothesis 5. *The effect of individual transition towards low carbon investments on the financial performance of European and US oil and gas companies depends on the oil price.*

Hypothesis 6. *The effect of global transition towards low carbon energy on the financial performance of European and US oil and gas companies depends on the oil price.*

4 Literature Review

This chapter includes previous works relevant to the research question. Subchapter 4.1 covers the literature of energy transition in O&G companies. It includes the definition of energy transition in existing literature, and previous research on energy transition in O&G companies. Subchapter 4.2 covers the literature of financial performance. Special attention will be given to the measurement of financial performance in the oil and gas sector.

4.1 Energy transition in oil and gas companies

Several papers have written about the energy transition in O&G companies. Pickl (2019) considers the renewable investments and renewable energy transition strategies of eight oil majors.[8] This paper argues that investments in the renewable energy sector comprise investments to green technology regarding solar, wind, hydro and geothermal energy; and investments to low-carbon technology, such as carbon capture, biofuel and energy storage (battery). The author uncovers that only five oil majors have an explicit renewable energy strategy and they are more active in several sectors of renewable energy than the other three companies. The final finding shows that the oil majors with more proven oil reserves are less active in the renewable energy strategies and vice versa; less proven reserves lead to more active energy transition.

Lu et al. (2019) analyze the low carbon transformation process of nine major O&G companies. The article examines different aspects of this process, such as carbon emission targets, investment priorities, the magnitude of high-tech technologies, transition paths, and lastly opportunities and challenges of the O&G companies. Nine O&G companies' low-carbon actions, in terms of energy utilization, were examined. It is found that multiple oil majors (BP, Equinor and Shell) prefer to heavily invest in renewable energy development. However, other companies (Exxon Mobile and Chevron) are focused on energy efficiency instead. The findings of the analysis show that the first step of the low carbon transformation process is to improve natural gas business strategies. Second, to transform the O&G companies to integrated energy companies, it is necessary to increase the proportion of renewable investments in the long run. Third, the O&G companies should increase their activity in geothermal energy sector. Due to the affluent exploration technology and

[8] Shell, ExxonMobil, BP, Total, Chevron. Eni. Petrobras, Equinor

experience already present in O&G companies, geothermal energy is a type of renewable energy with high potential for profitability.

Chaiyapa et al. (2018) focus on a Thai state-owned O&G company and two associates, Bangchak Petroleum and Thai Oil Group. The main purpose of the paper is to survey the investment of these companies into the renewable energy sector in the last 15 years and to conduct a discourse analysis about the legitimization of their new businesses. The findings show that since the 2000s, the main part of three companies' investment portfolio belongs to biofuels (gasohol and biodiesel). However, solar energy also attracted the attention of Bangchak Petroleum and PTT in recent years. Their discourse analysis reveals that socio-political factors have been effective for legitimation issues of unconventional energy products. Moreover, the paper recommends the media and government should refer to O&G companies as "energy companies" instead of "oil and gas companies" in order to accelerate the transformation into low carbon energy.

Shojaeddini et al. (2019) study the strategies of international and national oil companies (IOC and NOC) in their analysis in the energy transformation process. The paper argues that, IOC's directly invest in renewable energies, whereas NOC's do not tend to directly invest in renewable energy. As the result, NOC does not get direct ownership of the renewable assets, instead, investing in renewable energy through electricity companies is a widespread trend among them. Furthermore, their findings imply that major IOCs, such as Total, Equinor, BP and Dutch Shell, have made huge investments for the development of carbon capture and storage technology, while only a few NOC have started to invest in such low carbon technologies.

Fattouh & West (2019) investigate the challenges of energy transition and new investment opportunities for international O&G companies. The authors argue that these companies' current technologies and business models cannot accomplish the goal to obtain full decarbonization. To face this challenge, the authors define two categories of investment opportunities. The first category comprises investments into new renewable energy technologies, such as, electrification, next generation solar and wind technologies. The second category entails to invest in "mixed" technologies, which enables the continued use of fossil fuels while reducing CO_2 emission, for example, CCS, blue hydrogen, and digitization. Moreover, the paper considers that for completing full decarbonatization, the international O&G companies should improve non-electric zero carbon technologies, which provide a connection between the electricity and decarbonized fossil fuels.

Ultimately, the authors suggest that there should be new regulation, policy, and business models in order to adapt to the transition process.

Fattouh et al. (2019) question which adaption strategy should be chosen by oil companies and oil-exporting countries in the energy transition. The authors state that energy transition leads to structural modifications in the global energy market and its members, such as oil companies and oil-exporting countries. The authors discuss that oil companies need a gradual extension in their business model instead of radical changes, and extension of the business model requires several changes in the investment strategies, technology, and operations. Moreover, Fattouh et al. (2019) argue that the multidimensional uncertainty in the transition process also affects the oil-exporting countries with big proven oil reserves. They are facing the threat to lose the potential income from exports and breakdown in socio-economic wellbeing, due to dependence on oil revenues. The authors suggest that the adaptation strategy for the oil-exporting countries should consist of diversification of their economies in the long term, which can help to mitigate the side effects of the energy transition.

Abovementioned papers have defined two different definitions for the energy transition in O&G companies. The first one implies a transition in energy production from fossil fuels to a renewable energy resource. The second meaning comprises a transition towards less polluting technologies, such as carbon capture technologies.

4.2 Determinants of companies' financial performance

Szeless et al. (2003) investigate the relationship between a company's line of business and its financial performance by using the multiple linear regression method. Panel data was gathered for 33 manufacturing companies of 3 years. The regression model was first analyzed cross-sectionally for each individual year, and afterwards analyzed using the pooled data. Financial performance is defined as both accounting-based performance and market-based performance. The accounting-based performance measures used were return on capital employed (ROCE) and return on sales (ROS). The market-based performance measures used were the Treynor ratio and the Sharpe ratio. The study confirms a positive relationship between industry profitability and financial performance for German, Swiss and Austrian companies.

Al-ahdal et al. (2020) analyze the impact of corporate governance mechanisms on the financial performance of Indian and Gulf Corporation Council (GCC) listed companies. In this study, financial performance is defined as return on equity (ROE) and Tobin's Q. They apply an eight-year panel data of 106 non-financial listed companies. The study applies the Generalized Method of Moment for the analysis. Variables used in this study were corporate governance indicators, leverage, industry dummy and country dummy. The study concludes that board accountability, audit committee, transparency and disclosure have insignificant impact on financial performance.

Lin et al. (2019) determine the correlation between Green Innovation Strategy and corporate financial performance in the automotive industry. Data of 163 international automotive companies were gathered for the years 2011-2017. Financial performance was measured using the performance ratio's return on assets, return on equity and return on sales. The regression was estimated using a two-step Dynamic System Generalized Method of Moments (GMM) method. Financial performance was regressed on, among others, green innovation indicators, size, moderating effect of size and indicators, R&D and advertisement intensity, leverage and free cash. The study concluded that Green Innovation Strategy positively affected financial performance.

So far, the companies of interest have been across different industries. In this study, we are interested in the financial performance of oil and gas companies specifically. Guillermet & Manikom (2014) analyze the effect of crude oil prices in the Eurozone from 2004 to 2013 on the financial performance of O&G producers. The study uses a multiple regression model using a 10-year panel. Financial performance is defined as return on assets (ROA), return on equity (ROE) and profit margin. The conclusion of the study is that the crude oil price has a negative effect on the financial performance of O&G companies in the Eurozone from 2004 to 2013.

Bagirov & Mateus (2019) also look specifically at the performance of O&G companies. They examine the relationship between crude oil prices changes and financial performance of O&G companies from the Western European region for the period 2005-2014. In the model, the regression was estimated using one-step difference generalised method of moments (GMM), two-step difference GMM, one-step system GMM and two-step system GMM. Financial performance is defined as return on equity. The study concluded crude oil price changes positively impact the financial performance of O&G companies in Western Europe.

Danielsen (2017) investigates the effect of exposure to renewable energy on the valuation of O&G companies. The applied variables in the model include exposure to renewable energy which is defined as megawatt of installed capacity of renewable energy divided by thousand barrels of oil equivalents produced per day, oil price that is the historical Brent oil spot price, size is measured as production, the reserve replacement ratio, which is the ratio between the current reserves exploited and the discoveries of new reserves, and the debt/asset ratio. Six oil majors were included in the analysis and it was performed over the years 2007-2016.[9] Danielsen found no significant relationship between exposure to renewable energy and the valuation of O&G companies. The major shortcoming of the research is the small size of the dataset. The metric used was also limiting as it only used installed capacity of renewable energy. No research on a larger scale, and no more comprehensive transition metric has been found.

Most of these studies investigate energy transition pathways, i.e. the transformation process, its opportunities, challenges, the companies' resilient strategies, investment activities et cetera. Unlike such studies, we focus on the impact that the transition process can have on oil and gas companies' financial situation. More precisely, we investigate the effect of energy transition on the financial performance of O&G companies. Danielsen (2017) is the only one that has investigated the effect of energy transition towards renewable energy on oil and gas companies' financial performance. Differently from Danielsen (2017), we treat the energy transition in a broad sense and our data is real-market data. Thus, in our research we consider energy transition towards low carbon investments within oil and gas companies, as well as global transitions that is proxied by global renewable consumption and global renewable generation. We believe due to accurate and realistic results, our study can be a good source for the future studies in the literature.

[9] Anadarko Petroleum, ExxonMobil, RD Shell, BP, Statoil and Total.

5 Data

The data consists of two panel data sets for the years 2010-2018[10]. The first panel contains 17 European O&G companies and the second panel includes 27 US O&G companies. The companies were selected based on data availability of the dependent and explanatory variables during the time span of the study. Especially availability of company-specific transition data is limited. Appendix 10.1 lists the names of all O&G companies in each panel.

Subchapter 5.1 offers definitions of all variables used in this thesis, subchapter 5.2 describes the data, and subchapter 5.3 shows stationarity tests of the data.

5.1 Data definition

5.1.1 Dependent variable

Financial performance is measured as return on asset. It measures the return a company receives relative to its total assets employed. It is measured as a percentage. Return on assets is a ratio commonly used to measure a company's performance (Guillermet & Manikom, 2014; Lin et al., 2019; Szeless et al., 2003) and following Villafana (2015), is calculated as:

$$ROA\ (\%) = \frac{Net\ Income + \left((Interest\ Expense\ on\ Debt - Interest\ Capitalized) \times (1 - Tax\ Rate)\right)}{Average\ of\ Last\ Year's\ and\ Current\ Year's\ Total\ Assets} \times 100 \qquad (1)$$

Financial performance data is retrieved using DataStream.

5.1.2 Energy transition indicators

In this study, we investigate the effect of energy transition of oil and gas companies' financial performance from multiple angles. Three variables are used to indicate energy transition. The indicators include company level transition, global transition towards renewable energy generation and global transition towards renewable energy consumption. Next, we discuss the definition of each indicator in more detail.

[10] The years 2008 and 2009 are excluded from the data to prevent outliers caused by the financial crisis.

a) Emission reduction score

We apply the emission reduction score (EMISSION) as an indicator of O&G companies' transition towards low carbon energy. The emission reduction score is an ESG[11] score, which is defined as follows:

> *"Emissions reduction score measures a company's commitment to and effectiveness in reducing environmental emission in the production and operational processes"* (Refinitiv, 2019)

It is a company-specific variable, which measures the company's commitment to reducing emission. A higher score indicates the company is more committed to its transition towards cleaner energy production. The emission reduction score is retrieved using DataStream.

b) Global renewable energy generation

This variable measures the gross global renewable energy generation in terawatt hour (GENERATED). It does not account for cross-border electricity supply. It indicates the annual renewable energy generated worldwide. A higher value signals more energy is generated worldwide from a renewable source, in absolute terms.

An absolute increase in renewable energy generated can be caused by an increase in energy demand due to the rise of global population, or when large populations transitioning out of poverty and acquiring access to the power grid. Another reason global renewable energy generated could increase is due to increasing demand to transition from fossil fuels towards renewable energy. The effect of global renewable energy generated on the financial performance of O&G companies will depend on these underlying factors.

In this study, this variable will be used in its logarithmic form. The data was retrieved from BP Statistical Review of World Energy 2019 (BP, 2019b).

c) Global share of renewable energy consumption

This variable measures the global share of renewable energy consumption (CONSUMED). It is calculated as:

[11] Environmental, social, and governance. ESG scores aim to quantify a company`s progress towards sustainability.

$$CONSUMED = \frac{Total\ world\ renewable\ consumption}{Total\ world\ energy\ consumption} \times 100 \qquad (2)$$

The unit of measurement for this variable is share of million tonnes oil equivalent. Renewable consumption includes solar, wind, geothermal, biomass and other renewables. Total energy consumption includes energy consumed from oil, gas, coal and renewables. The global share of renewable energy consumption was retrieved from BP Statistical Review of World Energy 2019 (BP, 2019b).

5.1.3 Non-linear components

The study includes two variables to account for non-linearity of the effect of transition indicators on financial performance. In the following, we discuss them in more details.

a) Quadratic term of transition indicators

It is possible that the relationship between financial performance and the transition variables are non-linear in nature. Including the quadratic term of the transition indicators allows for identifying this potential non-linearity. In this regard, increasing energy transition indicators could initially have a negative effect on financial performance of O&G companies; however, as the level of transition increases further the effect could turn positive. This non-linear relationship can be identified by adding a quadratic term of the transition indicator.

b) Moderating effect of oil price on transition indicators

Another potential non-linear relationship could be an interaction effect between the oil price and the transition variables. Increasing the energy transition indicators could have a stronger or lower effect on the financial performance when the oil price is low. Transition to renewable energy increases diversification of an O&G company, so the revenue of renewables can offset the loss of a company facing a low oil price. Including an interaction term between the oil price and the transition indictors allows for finding an increasing or decreasing relationship between the indicators and the oil price[12]. The moderating effects are calculated as follows:

$$Moderating\ effect\ of\ oil\ on\ transition\ indicator = \log(OIL) \times Transition\ Indicator \quad (3)$$

[12] Moderating effect of size on transition indicators was also tested but proved insignificant.

5.1.4 Control variables

Both company size and leverage are expected to affect financial performance, and therefore need to be controlled for (Al-ahdal et al., 2020; Bagirov & Mateus, 2019; Danielsen, 2017; Guillermet & Manikom, 2014; Lin et al., 2019; Szeless et al., 2003). Size is measured as total assets in US dollar.

Leverage represents the share of debt a company has, relative to its total capital. Higher leverage means the company has a higher relative debt level. Following Villafana (2015), leverage is calculated as:

$$\text{Leverage}=\frac{Long\ term\ debt+short\ term\ debt\ \&\ current\ portion\ of\ long\ term\ debt}{Total\ capital+short\ term\ debt\ \&\ current\ portion\ of\ long\ term\ debt}\times 100 \qquad (4)$$

Another variable which has a strong effect on the performance of O&G companies is the oil price (Bagirov & Mateus, 2019; Danielsen, 2017; Guillermet & Manikom, 2014). The European model therefore includes the Brent crude oil spot price (USD) as a control variable, and the US model controls for the WTI spot price (USD). Lastly, we expect the 2014-2015 oil crash to influence the financial performance of O&G companies. To account for this effect, a dummy variable will be added to the model. This variable takes the value 1 for the years 2014-2015, and value 0 otherwise. It is common to apply the logarithmic form for variables which are measured in currencies, therefore total assets and the oil spot price will be used in their logarithmic form. The spot prices for the Brent and WTI oil were retrieved from the Energy Information Administration (IEA). All other data for the control variables is retrieved from DataStream (Villafana, 2015).

5.2 Data description

Table 1 provides descriptive statistics for all data used in the study. ROA has an average of 2.65% for European companies, and an average of 1.32% for US companies. Both markets have a large standard deviation (10.20% and 15.72% respectively). In the European market its value ranges from -41.69% to 62.70%, and in the US market it ranges from -119.83% to 59.53%. The average EMISSION score is higher in the European market than in the US market (71.18 and 53.61 respectively). The EMISSION score also has a higher standard deviation in the US market than in the European market (25.81 versus 20.65). Average company size is similar in both markets.

Table 1. Descriptive Statistics

	n	Mean	St. Dev.	Min	Max
Global Data					
Log(GENERATED)	243	7.24	0.38	6.63	7.82
CONSUMED (%)	243	2.59	0.85	1.41	4.05
Europe					
ROA (%)	153	2.65	10.20	-41.69	62.70
EMISSION	153	71.18	20.65	6.76	99.76
Log(SIZE)	153	16.49	2.09	12.19	19.87
LEV	153	32.28	21.66	0	114.11
Log(OIL)	153	4.34	0.34	3.78	4.72
US					
ROA (%)	243	1.32	15.72	-119.83	59.53
EMISSION	241	53.61	25.81	3.28	98.33
Log(SIZE)	243	16.49	1.36	13.45	19.67
LEV	243	45.37	64.60	0	851.62
Log(OIL)	243	4.26	0.31	3.77	4.58

Notes: ROA(%) is defined as the ratio of return to total assets, EMISSION is the emission reduction score, Log(GENERATED) is the logarithmic term of the global renewable energy generated, CONSUMED (%) is the global share of the renewable energy consumption, log(SIZE) is the logarithmic term of the total assets, LEV is the leverage ratio, log(OIL) is the logarithmic term of the Brent spot price (European panel) or the WTI spot price (US panel).

The correlations between the variables for both the European and US panels are shown in *Table 2*. It should be noted that there is a very high correlation between transition factors global renewable energy generated and global share of renewable energy consumption. This makes sense as both transition indicators measure global transition from different angles. When creating the models for this analysis, there will not be multiple transition variables in one model, so the correlation between these variables will not cause problems. In the US market, company size and EMISSION also show a correlation on the higher side. This high correlation can cause multicollinearity in the model, which can lead to insignificant results for the EMISSION variable.

Table 2. Correlation matrix

		1	2	3	4	5	6	7
(a) Europe								
1	ROA (%)	1						
2	EMISSION	0.018	1					
3	Log(GENERATED)	-0.227***	0.088	1				
4	CONSUMED (%)	-0.188**	0.072	0.989***	1			
5	Log(SIZE)	0.151*	0.672***	-0.010	-0.013	1		
6	LEV	-0.119	0.117	0.199**	0.202**	0.122	1	
7	Log(OIL)	0.263***	-0.029	-0.632***	-0.646***	0.031	-0.225***	1
(b) US								
1	ROA (%)	1						
2	EMISSION	0.022	1					
3	Log(GENERATED)	-0.173***	0.192***	1				
4	CONSUMED (%)	-0.138**	0.197***	0.990***	1			
5	Log(SIZE))	0.163**	0.752***	-0.012	-0.023	1		
6	LEV	-0.508***	-0.133**	0.145**	0.132**	-0.344***	1	
7	Log(OIL)	0.385***	-0.142**	-0.668***	-0.680***	0.072	-0.206***	1

Note: *p<0.1, **p<0.05, ***p<0.01

5.3 Stationarity

To test for stationarity of data, we apply the Levin et al. (2002) and Breitung (2000) panel unit root tests. The null hypothesis for both tests indicates that the data contains unit root; therefore, if the test statistic is statistically significant, it means the null hypothesis can be rejected, and the data is stationary. The results are summarized in *Table 3*. Using these tests, we have enough evidence to conclude all variables are level stationary.

Table 3. Stationarity tests

	Levin-Lin-Chu	Breitung
(a) Europe		
ROA (%)	-6.304***	-3.726***
EMISSION	-12.068***	-1.047
Log(GENERATED)	-5.968***	-2.916***
CONSUMED (%)	29.793	-3.922***
Log(SIZE)	-4.187***	-1.361*
LEV	-7.042***	-0.357
Log(OIL)	-8.840***	-2.057**
(b) US		
ROA (%)	-7.289***	-3.754***
EMISSION	-1.691**	-0.428
Log(GENERATED)	-7.522***	-3.674***
CONSUMED (%)	37.556	-4.942***
Log(SIZE)	-3.938***	-0.923
LEV	-6.988***	-2.299**
Log(OIL)	-8.815***	-3.161***

Notes: 1. The Levin-Lin-Chu unit root test reports adjusted t-statistics. The Breitung test reports lambda statistics. 2. *p<0.1, **p<0.05, ***p<0.01.

6 Methodology and models

This chapter covers the models and methodology used to estimate our models. Subchapter 6.1 explains which methodology is used when estimating the regressions, and subchapter 6.2 lists all models that will be estimated.

6.1 Fixed effect method

In this study, we estimate the models by applying a fixed effects transformation (Wooldridge, 2014). It is a panel data technique that allows for control of time-invariant unobserved variables within a panel data.

Consider the following model:

$$y_{it} = \beta_1 x_{it} + a_i + u_{it}, \qquad t = 1,2,\dots,T \tag{5}$$

Where a_i is the time-invariant unobserved variable. For each i, the model is averaged over time:

$$\bar{y}_i = \beta_1 \bar{x}_i + a_i + \bar{u}_i \tag{6}$$

Notice how $\bar{a}_i = a_i$ because the effect is time-invariant so does not change over time.

By subtracting (6) by (5) we get:

$$y_{it} - \bar{y}_i = \beta_1 (x_{it} - \bar{x}_i) + u_{it} - \bar{u}_i, \qquad t = 1,2,\dots,T \tag{7}$$

Or:

$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it} + \ddot{u}_{it}, \qquad t = 1,2,\dots,T \tag{8}$$

By applying this fixed effect transformation, we control for omitted variable bias. Besides the fixed effect transformation, all regressions are estimated with robust standard errors. This controls for heteroskedasticity and serial correlation.

Alternative methods would be a random effect transformation, or simple panel OLS. However, when estimating the models, we find the random effect estimations are identical with the panel OLS estimations. This means for this study, the random effect model is not appropriate to use. Between OLS and the fixed effect method, the latter resulted in more significant estimations. Panel OLS estimations will be included in the appendix as a robustness check.

6.2 Models

In this study, we estimate five models to measure the effect of transition towards low carbon energy on the financial performance of O&G companies. The first model is a benchmark model, without any transition indicators. The four remaining models are estimated three times using the different transition indicators described in chapter 5. Each estimation includes only one of the three transition indicators. Lastly, each regression is estimated twice, once for the European market and once for the US market.

In all models, i represents the individual company and t represents the time-period. All models are estimated by applying the fixed effect transformation. Through this transformation, the variable a_i is the company fixed effect and δ_t indicates the year dummies. Log(SIZE) is the logarithm of total assets, LEVERAGE is the level of debt relative to the total capital, log(OIL) is the logarithm of the Brent Crude oil spot price (USD) for the European market, and the logarithm of the WTI spot price (USD) for the US market. DUMMY takes the value 1 for the years 2014-2015, and 0 otherwise, representing the oil crash. For TRANSITION, we apply one of the following three indicators described in chapter 5: EMISSION, GENERATED, CONSUMED.

The remainder of the chapter describes the five models.

a) Benchmark model

The benchmark model estimates the effect of control variables on financial performance of O&G companies without any transition indicators:

$$ROA_{it} = \beta_0 + \delta_t + \beta_1 \log(SIZE)_{it} + \beta_2 LEVERAGE_{it} + \beta_3 log(OIL)_{it} + \beta_4 DUMMY_{it} + a_i + \varepsilon_{it}$$

(Model 1)

b) Model with single transition variable

The model with a single transition variable estimates the linear relationship between transition towards low carbon energy, and O&G companies' financial performance. The regression that will be estimated is as follows:

$$ROA_{it} = \beta_0 + \delta_t + \beta_1 TRANSITION_{it} + \beta_2 \log(SIZE)_{it} + \beta_3 LEVERAGE_{it} + \beta_4 log(OIL)_{it} + a_i + \beta_5 DUMMY_{it} + \varepsilon_{it}$$

(Model 2)

c) Model with quadratic term

The model with a quadratic transition variable estimates the non-linear relationship between transition towards low carbon energy, and O&G companies' financial performance. The regression that will be estimated is as follows:

$$ROA_{it} = \beta_0 + \delta_t + \beta_1 TRANSITION_{it} + \beta_2 TRANSITION^2{}_{it} + \beta_3 \log(SIZE)_{it} + \beta_4 LEVERAGE_{it} + \beta_5 log(OIL)_{it} + \beta_6 DUMMY_{it} + a_i + \varepsilon_{it} \quad \text{(Model 3)}$$

d) Model with moderating effect of oil price

The model with a moderating effect of oil price estimates the interaction effect between the oil price and the transition variables. Increasing the energy transition indicators could have a stronger or lower effect on the financial performance when the oil price is low. The regression that will be estimated is as follows:

$$ROA_{it} = \beta_0 + \delta_t + \beta_1 TRANSITION_{it} + \beta_2 TRANSITION_{it} \times \log(OIL)_{it} + \beta_3 \log(SIZE)_{it} + \beta_4 LEVERAGE_{it} + \beta_5 log(OIL)_{it} + \beta_6 DUMMY_{it} + a_i + \varepsilon_{it} \quad \text{(Model 4)}$$

e) Model with quadratic term and moderating effect

This model contains both the quadratic term of the transition variable and the moderating effect of the oil price. It allows for identification of both effects occurring simultaneously. The regression is as follows:

$$ROA_{it} = \beta_0 + \delta_t + \beta_1 TRANSITION_{it} + \beta_2 TRANSITION^2{}_{it} + \beta_3 TRANSITION_{it} \times \log(OIL)_{it} + \beta_4 \log(SIZE)_{it} + \beta_5 LEVERAGE_{it} + \beta_6 log(OIL)_{it} + \beta_7 DUMMY_{it} + a_i + \varepsilon_{it}$$

(Model 5)

It should be noted that all regressions with the emission reduction score variable are estimated with its first lagged effects. Theoretically, a lagged effect is more suitable because emission reduction score reflects a company's commitment to and effectiveness in reducing its emission. It is likely that the decisions made to commit to a lower emission score will not be reflected on a company's financial performance until a year later. The other transition indicators are applied in their current time. In the next chapter, all models are estimated, and their results are discussed.

7 Empirical results

This chapter reports the empirical results of the models described in chapter 6. Subchapters 7.1 to 7.3 discuss the empirical findings per transition indicator, subchapter 7.4 discusses the results of the robustness checks, and finally subchapter 7.5 provides a general discussion.

Table 4 reports the benchmark model estimations for the European and US markets separately (Model 1).

Table 4. Benchmark

	(a) Europe	*(b) US*
	(Model 1) ROA(%)	(Model 1) ROA(%)
Log(SIZE)	20.79*	0.919
	(10.86)	(2.459)
LEVERAGE	-0.271**	-0.131***
	(0.0985)	(0.0155)
Log(OIL)	-1.172	12.39***
	(3.223)	(2.651)
DUMMY	-9.531***	-9.711***
	(1.925)	(2.186)
Intercept	-324.20*	-58.50
	(164.5)	(43.42)
N	153	243
R^2	0.402	0.428
F	23.61	94.76

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

These numbers depict of the regression of financial performance (defined as return on assets) on company size, company leverage, oil price and dummy variable for the years 2014-2015, without any transition indicators. The benchmark shows large differences between the European and the US market. For example, size is positive and significant at the 10% level for the European market but is insignificant for the US. On the other hand, the oil price is positive and significant at the 1% level for the US market but is insignificant for the European market. Leverage and the dummy variable representing the 2014-2015 oil crash are negative and significant for both markets.

The next subchapters discuss the empirical results of the transition indicators.

7.1 The effect of individual oil and gas company transition into low carbon production

The emission reduction score reflects a company's commitment to and effectiveness in reducing its carbon emission in the production process. A higher emission reduction score means a company is more dedicated in lowering its emission.

Table 5 and *Table 6* report results of the regressions with the EMISSION variable (Model 2), its quadratic term (Model 3), the moderating effect with oil price (Model 4) and with both its quadratic term and the moderating effect (Model 5) for European and US O&G companies respectively.

The effect of emission reduction indicator is estimated using its first lagged values, because it is likely that the decisions made to commit to a lower emission score will not be reflected on a company's financial performance until a year later.

Table 5. Regression results for emission reduction score (Europe)

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-386.56*	-375.81*	-411.26**	-406.58**
	(184.19)	(182.70)	(-177.87)	(174.73)
Log(SIZE)	25.39*	24.78*	25.23*	24.54*
	(12.22)	(12.18)	(-12.35)	(12.34)
LEVERAGE	-0.25**	-0.23**	-0.24**	-0.22*
	(0.10)	(0.10)	(-0.11)	(0.11)
Log(OIL)	-2.33	-0.72	-3.95	7.42
	(3.54)	(3.63)	(-6.83)	(7.67)
DUMMY	-9.08***	-9.20***	-8.97***	-9.07***
	(1.91)	(1.92)	(1.90)	(1.88)
L.EMISSION	-0.13*	-0.54**	0.24	-0.10
	(0.07)	(0.24)	(0.29)	(0.39)
$L.EMISSION^2$		.004*		0.004*
		(.002)		(0.002)
L.EMISSION*log(OIL)			-0.09	-0.11
			(0.06)	(0.07)
N	136	136	136	136
R^2	0.43	0.45	0.44	0.46
F	9.94***	12.74***	13.44***	19.16***
Joint significance of Transition Variables		4.02**	4.35**	6.08***

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

In the European market (*Table 5)* the emission reduction score has a negative effect on financial performance of oil and gas companies, which is statistically significant at the 10% level (model 2). However, there is a weak evidence that the relationship between the emission reduction score and financial performance is non-linear in nature as depicted by the 10% statistically significant quadratic emission term in model 3. We find EMISSION has an increasing effect on financial performance. When the emission reduction score initially increases, European companies face a lower return on assets one year later, ceteris paribus. However, when the emission reduction score increases above 67.5, the partial effect becomes positive[13]. For example, when European companies increase the emission reduction score from 71 to 72, on average, return on assets is expected to increase by 0,03 percentage points, ceteris paribus, on average. The average value of emission reduction score for European companies is 71.2, which means for the average value in the sample, a higher emission reduction score will have a positive effect on financial performance. There is no moderating effect between the emission reduction score and the oil price, as this variable is insignificant in both models 4 and 5.

[13] Turning point at $\frac{0.54}{0.004*2}$ ≈67.5.

Table 6. Regression results for emission reduction score (US)

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-28.82	-34.68	-11.09	-30.67
	(44.28)	(40.48)	(49.54)	(48.89)
Log(SIZE)	-2.46	-3.12	-2.43	-3.11
	(2.61)	(2.45)	(2.38)	(2.39)
LEVERAGE	-0.14***	-0.15***	-0.14***	-0.15***
	(0.02)	(0.02)	(0.02)	(0.02)
Log(OIL)	15.57***	17.24***	11.50*	16.32***
	(2.17)	(2.13)	(5.89)	(5.01)
DUMMY	-8.44***	-8.35***	-8.52***	-8.37***
	(2.20)	(2.15)	(2.23)	(2.17)
L.EMISSION	0.24**	0.80**	-0.08	0.72
	(0.10)	(0.34)	(0.39)	(0.48)
L.EMISSION^2		-0.01**		-0.005**
		(0.002)		(0.003)
L.EMISSION*log(OIL)			0.07	0.02
			(0.09)	(0.08)
N	216	216	216	216
R^2	0.44	0.46	0.44	0.46
F	80.27***	81.38***	64.7***	68.60***
Joint significance of Transition Variables		3.05*	2.92*	2.06

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

In the US market (*Table 6*), emission reduction score has a positive effect on financial performance, which is statistically significant at the 5% level (model 2). However, comparable to the European market, the relationship is non-linear in nature, as depicted by the 5% level statistically significant quadratic term in model 3. Interestingly, the quadratic effect has an opposite effect for the US market, as compared to the European market. When emission reduction score initially increases, it has a positive effect on the financial performance. However, when the emission reduction score rises above 40, the partial effect on financial performance becomes negative[14]. For example, when the US companies increase their emission reduction score from 54 to 55, on average, return on assets is expected to decrease by 0.29 percentage points, ceteris paribus, on average. The average value of emission reduction score for US companies is 53.6,

[14] Turning point at $\frac{0.8}{0.01*2} \approx 40$

which means that for the average value of emission score or the US companies in the sample, increasing the emission reduction score will decrease the financial performance. Models 4 and 5 show no moderating effect present between the emission reduction score and the oil price, the same result as the European market.

7.2 The effect of global investment transition into renewable energy

The GENERATED variable measures the global renewable energy generated in terawatt hour, which is an indicator for global investment into renewable energy. The variable is used in its logarithmic form. The results are reported in *Table 7* (Europe) and *Table 8* (US).

Table 7. Regression results for global renewable energy generated (Europe)

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-305.71**	403.52	-977.29	-563.09
	(139.77)	(252.23)	(745.59)	(664.22)
Log(SIZE)	21.04*	22.04*	20.96*	22.53**
	(10.93)	(10.81)	(19.70)	(10.44)
LEVERAGE	-0.26***	-0.28***	-0.26***	-0.29***
	(0.09)	(0.09)	(0.09)	(0.09)
Log(OIL)	-2.69	-1.83	151.42	327.07*
	(4.82)	(4.70)	(140.88)	(178.06)
DUMMY	-9.45***	-7.07***	-7.90***	-2.20
	(1.93)	(1.60)	(1.93)	(2.30)
Log(GENERATED)	-2.25	-205.18***	89.46	-142.63*
	(3.13)	(66.56)	(84.35)	(72.22)
Log(GENERATED)^2		14.08***		23.29***
		(4.55)		(7.09)
Log(GENERATED) *log(OIL)			-21.07	-44.89*
			(19.74)	(24.77)
N	153	153	153	153
R^2	0.41	0.43	0.42	0.47
F	21.66***	20.18***	18.84***	15.4***
Joint significance Transition Variables		4.78**	0.59	4.36**

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

The European market (*Table 7*) shows no statistically significant results for a linear relationship between global renewable energy generated and financial performance (model 2). However, model 3 identifies a non-linear relationship, which is statistically significant at the 1% level. We witness an initial negative partial effect of global transition to renewable energy, which turns positive when the log(GENERATED) reaches a value of 7.29[15]. This means, as shown in *Figure 10* that up to the year 2014 an increase in global renewable energy generated had a negative effect on the financial performance of European O&G companies. In years after 2014, however, the partial effect becomes positive. The results mean that currently, as the global renewable energy generated increases, the return on assets of European O&G companies increase as well. For example, if GENERATED increases by 1% when at its value in 2018, ROA is expected to increase by 0.15 percentage points, ceteris paribus, on average. The moderating effect of the oil price is insignificant in model 3, and only 10% significant in model 4. Thus, we conclude that there is a weak evidence for the negative moderating effect of the oil price on global renewable energy generated for the European market.

Table 8. Regression results for global renewable energy generated (US)

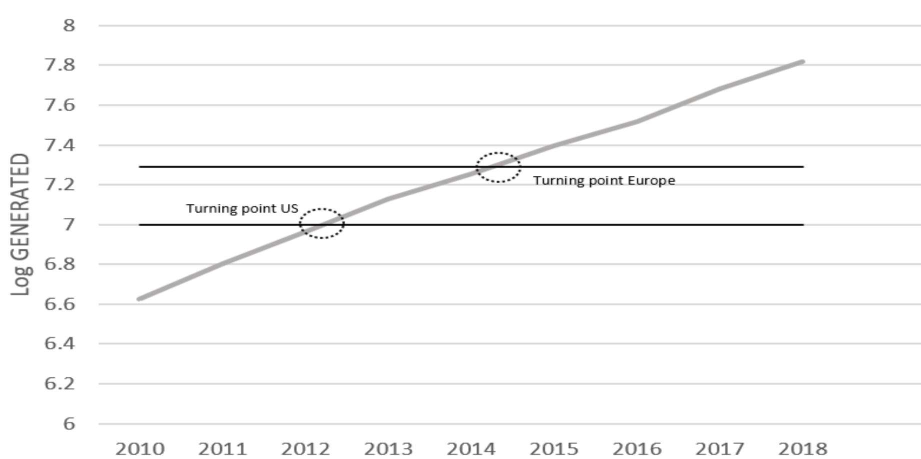
	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-130.41***	797.29**	-629.87*	-297.23
	(43.74)	(289.84)	(353.28)	(363.25)
Log(SIZE)	0.01	1.18	-0.06	1.19
	(2.00)	(2.38)	(1.99)	(2.37)
LEVERAGE	-0.13***	-0.13***	-0.13***	-0.13***
	(0.01)	(0.02)	(0.01)	(0.02)
Log(OIL)	19.12***	20.28***	134.96	305.25***
	(2.99)	(3.17)	(81.29)	(94.48)
DUMMY	-9.93***	-7.14***	-8.86***	-4.09*
	(2.30)	(2.30)	(2.15)	(2.23)
Log(GENERATED)	8.06***	-256.65***	75.85	-128.06
	(1.89)	(91.06)	(47.94)	(83.79)
Log(GENERATED)^2		18.33***		20.97***
		(6.38)		(6.78)
Log(GENERATED) *log(OIL)			-15.73	-38.68***
			(11.04)	(12.67)
N	243	243	243	243
R^2	0.45	0.47	0.45	0.47
F	108.37***	126.19***	107.21***	110.91***
Joint significance of Transition Variables		8.99***	9.31***	6.37***

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

[15] Turning point at $\frac{205.18}{14.08*2} \approx 7.29$.

The US market (*Table 8*) shows a positive effect of global renewable energy generated on return on asset, which is statistically significant at the 1% level (model 2). However, based on model 3 we identify a 1% level significant quadratic effect, which confirms the non-linear relationship between GENERATED and ROA. The model initially shows a negative effect, which later turns positive, the same results as the European market. Comparing the US results to the European results, the turning point in the US is 2 years earlier than in Europe, as seen in *Figure 10*[16]. Further, model 4 reveals no statistically significant moderating effect between the oil price and the global renewable energy generated. However, when the moderating effect is combined with the non-linear relationship between the global renewable energy generated and the financial performance (model 5), the effect is negative and statistically significant at the 1% level.

Figure 10. Difference in turning points for US and Europe- Generated



Model 5 shows that the effect of global renewable energy generated on financial performance is dependent on both its own magnitude and the oil price. The partial effect of increasing GENERATED by 1% on ROA is defined as follows:

$$\frac{\Delta ROA\%}{\Delta GENERATED} = -\frac{128.06}{100} + \frac{20.97 \times 2}{100}\log(GENERATED) - \frac{38.68}{100}\log(OIL) \qquad (9)$$

Assume the oil price to be at its average level, where log(OIL)=4.26. Further, consider log(GENERATED) at its minimum (6.63), mean (7.24), and maximum value (7.82). Keeping the

[16] Turning point at $\frac{256.65}{18.33*2} \approx 7$.

oil price fixed at its average level, and increasing GENERATED with 1%, it affects ROA by -0.15, 0.11 and 0.35 percentage points, respectively. Now, also consider the same situation when the oil price is high or low. These results are summarized in *Table 9*.

Table 9. Partial effect of GENERATED on ROA, model 5 (US)

		Oil price		
		Low *Log(OIL)=3.77*	Mean *Log(OIL)=4.26*	High *Log(OIL)=4.58*
GENERATED	Low *Log(GENERATED)=6.63*	0.04	-0.15	-0.27
	Mean *Log(GENERATED)=7.24*	0.30	0.11	-0.02
	High *Log(GENERATED)=7.82*	0.54	0.35	0.23

Note: table shows the partial effect of a 1% increase in GENERATED on ROA for different levels of oil price and GENERATED. The results shown are percentage points.

The results show that a high log(OIL) decreases the effect of log(GENERATED) on ROA. Further, the results show log(GENERATED) has an increasing effect on ROA. Therefore, when renewable energy generated is high, it has a positive effect on the financial performance of US O&G companies, though a higher oil price decreases this positive effect. Contrarily, when log(GENERATED) is low and the log(OIL) is high, the effect of renewable energy generated is negative. The high oil price magnifies this negative effect. The value of global renewable energy generated has only increased every year since it is being measured. Therefore, the row portraying the "high" renewable energy generated portrays the current situation. This means that currently, when the oil price is low, US O&G companies can enjoy the highest benefit of global renewable energy generated and can suffer the low return on asset from investing in oil exploration and production.

7.3 The effect of global consumption transition into renewable energy

The variable CONSUMED measures the share of global energy consumption with respect to total energy consumption. The results are reported in *Table 10* (Europe) and *Table 11* (US).

Table 10. Regression results for share of global renewable energy consumed (Europe)

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-320.40*	-311.72*	-429.01	-561.30*
	(155.74)	(150.40)	(246.76)	(266.98)
Log(SIZE)	20.89*	22.07*	20.84*	22.70**
	(10.95)	(10.81)	(10.76)	(10.47)
LEVERAGE	-0.27***	-0.28***	-0.26***	-0.29***
	(0.09)	(0.09)	(0.09)	(0.09)
Log(OIL)	-2.11	-3.55	22.63	53.67*
	(4.82)	(4.95)	(21.55)	(28.90)
DUMMY	-9.58***	-6.76***	-7.99***	-1.19
	(1.94)	(1.67)	(1.87)	(2.70)
CONSUMED (%)	-0.61	-18.24**	39.47	64.43
	(1.35)	(6.47)	(39.43)	(45.13)
$CONSUMED^2$ (%)		3.19***		5.29***
		(1.05)		(1.74)
CONSUMED (%)*log(OIL)			-9.23	-21.70*
			(9.23)	(12.26)
N	153	153	153	153
R^2	0.40	0.43	0.41	0.47
F	20.71***	20.25***	18.10***	15.20***
Joint significance of Transition Variables		5.12**	0.50	4.49**

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

The European market (*Table 10)* shows no statistically significant results for a linear relationship between share of global renewable energy consumed and financial performance (model 2). However, a non-linear relationship is identified, considering the 1% significant quadratic term in model 3. Similar to renewable energy generated, the initial effect is negative, but it turns positive as the share of renewable consumption reaches a level of 2.9% [17], which occurs in 2015. This means, after the year 2015, European O&G companies experience a positive partial effect of global share of renewable energy consumed on return on assets. For example, when CONSUMED increases by 1 percentage point when at its value in 2016, ROA is expected to increase by 1.86 percentage points, ceteris paribus. The moderating effect of oil price on share of renewable energy consumed is insignificant in model 3, and only 10% significant in model 4. Thus, we conclude that

[17] Turning point at $\frac{18.24}{3.19*2} \approx 2.9$.

there is a weak evidence for the negative moderating effect of the oil price on global renewable energy consumed for the European market.

Table 11. Regression results for share of global renewable energy consumed (US)

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Intercept	-89.39**	-81.1**	-248.73***	-320.16***
	(39.21)	(37.63)	(80.33)	(94.91)
Log(SIZE)	0.14	0.88	-0.03	0.86
	(1.97)	(2.35)	(1.96)	(2.34)
LEVERAGE	-0.13***	-0.13***	-0.13***	-0.13***
	(0.01)	(0.02)	(0.01)	(0.02)
Log(OIL)	20.17***	18.95***	57.37***	75.00***
	(3.19)	(2.78)	(17.01)	(19.12)
DUMMY	-9.37***	-7.55***	-7.18***	-3.63
	(2.23)	(2.50)	(1.90)	(2.38)
CONSUMED (%)	4.05***	-8.51	61.70**	74.84***
	(0.94)	(6.80)	(26.09)	(26.43)
$CONSUMED^2$ (%)		2.26*		3.00**
		(1.29)		(1.37)
CONSUMED (%)*log(OIL)			-13.46**	-20.43***
			(6.01)	(6.59)
N	243	243	243	243
R^2	0.46	0.46	0.46	0.47
F	121.85***	117.59***	109.70***	104.86***
Joint significance of Transition Variables		9.06***	9.50***	6.25***

Notes: 1. Robust Standard errors are in parentheses. 2. *p<0.1, **p<0.05, ***p<0.01

The US market (*Table 11*) shows a positive effect of share of global renewable energy consumed on ROA, which is statistically significant at the 1% level (model 2). However, model 3 identifies a 10%-level significant quadratic effect. The model initially shows a negative effect, which turns positive as CONSUMED increases in value. The quadratic term has a rather low significance level of 10%. However, the variables CONSUMED and $CONSUMED^2$ are jointly significant at the 1% level (model 3). Further, when adding the moderating effect of the oil price (model 5), the quadratic term becomes significant at the 5% level. Therefore, we confirm the non-linear relationship between CONSUMED and ROA.

However, when combining both the quadratic effect and the moderating effect of the oil price (model 5), CONSUMED has a positive effect on ROA, contrary to the negative effect seen in model 3. The moderating effect of oil price is statistically significant at the 5% level in model 4, and at the 1% level in model 5. Therefore, we conclude model 5 best represents the relationship between CONSUMED and ROA. This means the negative increasing effect of CONSUMED in model 3 is biased and is in fact positive increasing.

Model 5 shows that the effect of share of global renewable energy consumed on US financial performance is dependent on both its own magnitude and the oil price. The partial effect of increasing CONSUMED by 1 percentage point on ROA is defined as follows:

$$\frac{\Delta ROA\%}{\Delta CONSUMED} = 74.84 + 2 \times 3\text{CONSUMED} - 20.43\log(OIL) \qquad (10)$$

The effect is positive and increasing in its own magnitude and decreasing with the oil price. Assume the oil price at its average level, where log(OIL)=4.26 and CONSUMED at its minimum (0.85), mean (1.41), and maximum value (4.05). Keeping the oil price fixed at its average level and increasing CONSUMED by 1 percentage point affects ROA by -7.09, -3.73 and 12.11 percentage points, respectively. Now, also consider the same situation when the oil price is high or low. These results are summarized in *Table 12*.

Table 12. Partial effect of CONSUMED on ROA, model 5 (US)

		Oil price		
		Low *Log(OIL)=3.77*	Mean *Log(OIL)=4.26*	High *Log(OIL)=4.58*
CONSUMED	Low *CONSUMED=0.85*	2.92	7.09	-13.63
	Mean *CONSUMED=1.41*	6.28	3.73	-10.27
	High *CONSUMED=4.05*	22.12	12.11	5.57

Note: table shows the partial effect of a 1 percentage point increase in CONSUMED on ROA for different levels of oil price and CONSUMED. The results shown are percentage points.

The results show the negative moderating effect of the oil price on CONSUMED and the increasing effect of CONSUMED on ROA. Share of renewable energy consumed has an increasing positive effect on US financial performance, though a higher oil price decreases this positive effect. This means high levels of share of global renewable energy consumed combined with a low oil price has the highest positive effect on US financial performance. Meanwhile, the effect of CONSUMED on ROA is negative when the value of CONSUMED is low and the oil price is high.

7.4 Robustness tests

As the robustness checks, first we estimate the same models described in chapter 5 using the panel OLS approach. The results are reported in Appendix 10.2, Tables A2 to A7. Among others, the panel OLS approach confirms the non-linear relationship between EMISSION and ROA described in subchapter 7.1 with regards to the European model (Table A2, model 3). Model 4 and model 5 of Tables A2 and A3 also confirms no moderating effect of the oil price for both the European and the US market. Panel OLS further confirms the presence of both the non-linear negative increasing relationship between GENERATED and ROA (1% significant level), and the negative moderating effect of the oil price (5% significant) for the US market (Table A5, model 5). Lastly, Table A7, model 5, confirms the positive and increasing non-linear relationship between CONSUMED and ROA (5% significant level), and the negative moderating effect of the oil price (5% significant level) in the US market.

Second, we estimate the same fixed effects models that are described in chapter 5 but apply return on equity as the dependent variable, measuring financial performance. The results are reported in Appendix 10.3, in Tables A8 to A13. Using return on equity as the dependent variable confirms the non-linear negative increasing relationship between both GENERATED and financial performance (Table A10, model 3), and CONSUMED and financial performance in the European market (Table A12, model 3). Both quadratic effects are statistically significant at the 1% level. In both Tables A10 and A12 no moderating effect of the oil price was found in the European market.

Overall, the results estimated in subchapters 7.1 to 7.3 reoccur in the robustness checks.

7.5 General discussion

The main research question in this study is, what is the effect of low carbon transition on the financial performance of oil and gas companies in Europe and the US. We approach the research question from two different angles, one from the perspective of individual company transition towards low carbon production, and one from the perspective of global transition towards renewable energy.

Using the results described in this chapter, we can discuss our hypotheses:

Hypothesis 1. *Individual transition towards low carbon investments affects the financial performance of European and US oil and gas companies.*

Financial performance is defined as return on assets, and transition towards low carbon investments is defined as the emission reduction score indicator for individual oil and gas companies. The results show that transition towards low carbon investments does affect financial performance of both European and US oil and gas companies. The effect is different between both markets and appears non-linear in nature. The effect is discussed in more depth under hypotheses 3 and 5.

We conclude that transition towards low carbon investments affects financial performance of European and US oil and gas companies.

Hypothesis 2. *Global transition towards low carbon energy affects the financial performance of European and US oil and gas companies.*

Global transition towards low carbon investments is defined as global renewable energy generated and as global share of renewable energy consumed. The results for both the European and US market show that global transition towards low carbon does affect financial performance of oil and gas companies. The effect is non-linear in nature and is different between both markets. The effect is discussed in more depth under hypotheses 4 and 6.

We conclude that transition towards low carbon investments affects financial performance of European and US oil and gas companies.

Hypothesis 3. *Individual transition towards low carbon investments has a non-linear effect on the financial performance of European and US oil and gas companies.*

The results show that an increase in emission reduction score initially has a negative effect on financial performance of European oil and gas companies, but the effect turns positive as the emission score increases further. For the average European oil and gas company in the panel, this means an increase in emission score favorably affects financial performance. However, the results show that for US oil and gas companies the effect is opposite. An increase in emission reduction score first increases financial performance, but at higher levels an increase in emission reduction score has a negative effect of financial performance.

Our findings for the US are confirmed by previous studies of oil majors' investments into renewable energy. There is a trend among oil majors that switching to renewable energy production is simply not profitable enough (Csomós, 2014). Cases have been reported of oil majors investing small amounts into renewables but halting their investments after finding it was not profitable (Csomós, 2014). This could be more profound in the US market than in the European market, because certain US oil majors have a strong lobby to prevent utility companies from switching to renewables (Csomós, 2014). The difference between Europe and the US can further be explained by the different government policies. Europe has a strong focus on production of renewable energy, as Europe tries to meet its Paris Agreement goals of mitigating its GHG emissions by at least 40% before 2030 (European Parliament, 2019). Meanwhile, the US announced in 2017 they will withdraw from the Paris Agreement and instead will focus on producing low cost fossil fuel energy (Hersher, 2019; Vakhshouri, 2017). As a result, most of US companies choose energy efficiency rather than renewable energy development (Lu et al., 2019). We believe this explains the diminishing effect of the quadratic term of the emission reduction score in US companies.

We conclude that transition towards low carbon investments has a non-linear effect on the financial performance of European and US oil and gas companies, though the effect is opposite between both markets.

Hypothesis 4. *Global transition towards low carbon energy has a non-linear effect on the financial performance of European and US oil and gas companies.*

The results show the same effect for both indicators of global transition for the European companies. Both global renewable energy generated and global share of renewable energy consumed show that the initial effect on financial performance is negative, but as global renewable energy increases, the effect turns positive. Since 2014, the effect of renewable energy generated has been positive and since 2015, the effect of renewable energy consumed has been positive.

The results are more complicated for the US market. Absolute global renewable energy generated shows similar results as in the European market, with an initial negative effect on financial performance, but the effect turns positive as renewable energy generated increases. However, the results for global share of renewable energy consumed shows a different relationship. In this model, the effect of renewable energy consumption is positive and increasing, which means that even at low levels of global renewable energy consumption share, the effect on financial performance is positive.

It is expected that global energy demand will increase due to the increasing world population (Csomós, 2014). Meanwhile, global share of renewable energy is expected to increase (IEA, 2017). However, most oil and gas companies believe that demand can only be met by increasing supply from oil and gas. Due to this belief, the main investment focus of oil and gas companies is still on exploration of fossil fuels, instead of investments in renewable energy. Especially ExxonMobil openly opposes investments into renewable energy, while Royal Dutch Shell and Total are making steps into the renewable energy market. However, even in these companies the total investments into renewable energy equals only 1-4% of the total investments *(*Shojaeddini et al., 2019*)*. The results show that for both the European and the US market, an increase in global renewable energy has a positive effect on the financial performance. The positive effect on financial performance of an increase in the absolute value of renewable energy can be prescribed to the global increase of energy demand due to the rising population, which also increases absolute demand of oil and gas (Csomós, 2014). The positive effect on financial performance of an increase in the share of renewable energy consumption can be explained through oil and gas companies diversifying into renewable energy. In the US, the effect becomes especially apparent when the oil price is low. This effect is discussed in more depth under hypothesis 6. Another explanation could be that and increase the share of renewable energy consumed does not necessarily equate a decrease in share of oil and gas consumption. It is expected that coal consumption will take the most significant fall (IRENA & IEA, 2017).

We conclude that global transition towards low carbon investments has a non-linear effect on the financial performance of European and US oil and gas companies, though the effect is not identical between markets.

Hypothesis 5. *The effect of individual transition towards low carbon investments on the financial performance of European and US oil and gas companies depends on the oil price.*

The results show no moderating effect between the oil price and transition towards low carbon investments for individual companies for either European or US oil and gas companies.

We conclude the effect of transition towards low carbon investments on the financial performance of European and US oil and gas companies does not depend on the oil price. Therefore, hypothesis 5 is rejected.

Hypothesis 6. *The effect of global transition towards low carbon energy on the financial performance of European and US oil and gas companies depends on the oil price.*

The results show there is weak evidence that the effect of global transition towards low carbon investments on the financial performance of European oil and gas companies depends on the oil price. The effect is much stronger for US companies. The results for both markets show a negative moderating effect of the oil price on both global transition indicators effect. This means, for the US market, the effect of global transition is dependent on both the magnitude of transition and the oil price. The negative moderating effect means that high levels of global renewable energy combined with a low oil price has the most positive effect on the US financial performance. Meanwhile, a high oil price reduces this positive effect. This means that US oil and gas companies have more incentive to invest in renewables when the oil price is low, but when the oil price is high, this incentive is lost and investing in oil and gas related activities is preferred. This means a high oil price halts oil and gas company’s investments into renewables, slowing the low carbon transition process in the US.

8 Conclusion

8.1 Background and motivation

Renewable energy is expected to become a major global energy source in future years (IEA, 2017, Csomós, 2014). Driven by threats of climate change and high greenhouse gas emissions, the Paris Agreement was signed in 2016 and brought global attention to the climate change challenge. As a major player in greenhouse gas emissions, oil and gas companies face pressure from both governments and stakeholders to transition towards low carbon production. This entails investments in renewable energy production, zero carbon or green technologies like electrification, as well as low carbon technologies, such as carbon capture and sequestration (CCS), and hydrogen fuels. Nevertheless, such "green" investment are still only a small part of oil and gas companies' capital expenditures (IEA, 2020). Meanwhile, the oil and gas sector may gradually lose its dominant position in the energy market in the nearby future. Therefore, standing aside in the transition towards low carbon production could have a negative impact on the oil and gas industry (Fattouh et al., 2019). On the other hand, some oil and gas companies are reluctant to invest in low carbon technology, due to its lower returns on investment compared to investments in oil and gas related activities (Fattouh et al., 2019; Zhong & Bazilian, 2018). Therefore, it is important to understand the magnitude and direction of effect that transition towards low carbon energy had so far on oil and gas companies' financial performance. This will shed a light on the possible consequences that their future transition strategies might have.

8.2 Research question

The main research question of this study is to determine the effect of transition towards low carbon investments on the financial performance of oil and gas companies. The research question is approached from both the perspective of individual company transition and from the perspective of global transition. The study is focused on two panel data sets, including the European and the US companies from 2010-2018. Financial performance is defined as return on assets.

8.3 Findings

The emission reduction score is used as an indicator of oil and gas company's transition towards low carbon energy production. The results show that the effect of transition on financial performance depends on the magnitude of transition. In European oil and gas companies, the initial effect is negative but turns positive when transition reaches a higher level. However, the results show an opposite effect for US oil and gas companies. Low levels of transition have a positive effect, but this effect becomes negative when transition reaches a higher level. This could be more profound in the US market than in the European market, because certain US oil majors have a strong lobby to prevent utility companies from switching to renewables (Csomós, 2014). The difference between the results for European and US companies can further be explained by different governmental policies. Europe has a strong focus on production of renewable energy, as Europe tries to meet its Paris Agreement goals of mitigating its GHG emissions by at least 40% before 2030 (European Parliament, 2019). However, the US announced in 2017 they will withdraw from the Paris Agreement and will focus on producing low cost fossil fuel energy (Hersher, 2019; Vakhshouri, 2017). We conclude that transition towards low carbon investments has a non-linear effect on the financial performance of European and US oil and gas companies, though the effect is opposite between both markets.

Global transition towards low carbon investments is defined in this study as global renewable energy generated and as global share of renewable energy consumed. The results for European oil and gas companies show both transition indicators have an initial negative effect on financial performance, which turns positive when transition reaches a higher level. This level of transition was reached in 2015. For the US companies the two indicators for global transition towards low carbon investments show different results. When applying global renewable energy generated as independent variable, the results are the same as the European market. However, the results for global share of renewable energy consumed shows that the effect of renewable energy consumption is positive and increasing. This means that even at low levels of global renewable energy the effect of transition on financial performance is positive. The question arises why an increase in global renewable energy has a positive effect on the financial performance of European and US oil and gas companies. First of all, part of the increase in renewable energy generated is likely due to a global increase in energy demand because of the rising population (Csomós, 2014).

A higher global energy demand will simultaneously increase demand in both renewable energy and oil and gas. Second, oil and gas companies are diversifying into renewable energy. Especially Total, BP and Equinor have made big steps into the renewable energy market (Shojaeddini et al., 2019). Another finding is the presence of a negative moderating effect between the oil price and transition. This means a high oil price reduces this positive effect of transition. Therefore, it can be argued that a high oil price reduces incentive from oil and gas companies to invest in low carbon energies. Hence, a high oil price halts oil and gas company's investments into renewables and slows the low carbon transition process.

As the renewable energy usage is expected to increase globally in the future, both in absolute and in relative terms. Therefore, in the next years further investment in renewable energy is expected to have a positive effect on financial performance of US and European oil and gas companies.

8.4 Limitations

A limitation of this study is the difficulty we encountered acquiring data. Ideally, we would have done an analysis of oil and gas companies' investment into renewable energy compared to its total capital expenditure. However, finding investment data of individual companies proved difficult to find. Nonetheless, there is to be a trend in oil and gas companies to focus more on renewable and low carbon energy, and some companies have started reporting investment data in this field.

8.5 Suggestion for future research

In the future, when more data is available, first, an analysis using individual company investment data on renewable energy could be of interest as an expansion of this work. Second, this same analysis performed in this study could be repeated in several years as the world has moved closer to its carbon-reduction goals. Third, this same analysis could be performed on other markets besides the Europa and the US, such as Asia or Latin America.

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Appendices

Appendix 1. List of company names

Table A1. List of company names

(a) European panel	
LUNDIN	BP
OMV	Total
PREMIER OIL PLC	ROYAL DUTCH SHELL
TULLOW OIL PLC	EQUINOR
CAIRN ENERGY PLC	ENI
MOL NYRT	GALP
DNO ASA	POLSKIE GORNICTWO
ETABLISSEMENTS	JKX OIL AND GAS
PHAROS ENERGY PLC	
(b) US panel	
EXXON MOBIL CORP	CIMAREX ENERGY CO
CHEVRON CORPORATION	EQT CORPORATION
CONOCOPHILLIPS	MURPHY OIL CORP
EOG RESOURCES	CHESAPEAKE ENERGY
SM ENERGY CO	COMSTOCK RESOURCES
OCCIDENTAL PETROLEUM	OASIS PETROLEUM INC
HESS CORPORATION	SANDRIDGE ENERGY
MARATHON OIL CORP.	ULTRA PETROLEUM
PIONEER NATURAL RES	UNIT CORPORATION
APACHE CORPORATION	CONTINENTAL RESOUR
CONCHO RESOURCES	DENBURY RESRCS INC.
NOBLE ENERGY, INC.	SOUTHWEST ENERGY CO
DEVON ENERGY CORP	WHITING PETROLEUM
CABOT OIL & GAS CORP	

Appendix2. Panel OLS robustness check

Table A2. EMISSION, panel OLS, Europe

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
L.EMISSION	-0.066	-0.581**	0.427	0.057
	(0.067)	(0.286)	(0.535)	(0.624)
Log(SIZE)	1.275***	1.027***	1.295***	1.038***
	(0.411)	(0.318)	(0.403)	(0.302)
LEVERAGE	-0.018	-0.008	-0.012	0.000
	(0.038)	(0.040)	(0.039)	(0.041)
Log(OIL)	5.903***	7.271***	14.170	18.640**
	(2.014)	(1.776)	(9.568)	(9.061)
DUMMY	-8.941***	-8.929***	-8.779***	-8.708***
	(1.543)	(1.528)	(1.572)	(1.526)
L.EMISSION2		0.004**		0.006**
		(0.002)		(0.002)
L.EMISSION* log(OIL)			-0.116	-0.158
			(0.114)	(0.112)
Intercept	-36.89***	-25.87**	-72.71*	-74.00*
	(11.43)	(12.82)	(43.60)	(43.56)
N	136	136	136	136
R^2	0.247	0.293	0.254	0.305
F	11.36	11.56	10.12	10.67

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3. EMISSION, panel OLS, US

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
L.EMISSION	0.012	0.09	-0.351	-0.259
	(0.045)	(0.136)	(0.584)	(0.692)
Log(SIZE)	-0.192	0.017	-0.162	0.011
	(1.052)	(1.219)	(1.048)	(1.221)
LEVERAGE	-0.104***	-0.103***	-0.104***	-0.104***
	(0.035)	(0.035)	(0.035)	(0.035)
Log(OIL)	13.960***	14.080***	9.457	9.885
	(2.699)	(2.760)	(8.768)	(9.213)
DUMMY	-9.812***	-9.866***	-9.888***	-9.928***
	(2.482)	(2.501)	(2.501)	(2.518)
L.EMISSION * log(OIL)			0.084	0.078
			(0.132)	(0.138)
L.EMISSION 2		-0.001		-0.001
		(0.001)		(0.002)
Intercept	-48.77**	-54.01*	-29.70	-35.46
	(23.27)	(27.89)	(44.98)	(52.54)
N	216	216	216	216
R^2	0.401	0.402	0.403	0.404
F	11.71	10.06	12.95	11.55

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4. GENERATED, panel OLS, Europe

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Log(GENERATED	-1.760	-129.1	96.990	-71.670
	(2.743)	(89.69)	(77.360)	(94.680)
Log(SIZE)	0.757**	0.763**	0.756**	0.767**
	(0.315)	(0.312)	(0.316)	(0.311)
LEVERAGE	-0.030	-0.031	-0.029	-0.032
	(0.037)	(0.037)	(0.036)	(0.036)
Log(OIL)	4.884**	5.672**	170.800	300.000**
	(2.139)	(2.339)	(131.1)	(150.3)
DUMMY	-9.119***	-7.619***	-7.444***	-3.271
	(1.515)	(1.565)	(1.965)	(2.415)
Log(GENERATED)* log(OIL)			-22.690	-40.150*
			(17.960)	(20.500)
Log(GENERATED)2		8.832		16.970**
		(6.305)		(7.282)
Intercept	-15.31	438.60	-739.60	-424.90
	(24.80)	(315.60)	(566.20)	(550.70)
N	153	153	153	153
R^2	0.238	0.247	0.250	0.276
F	11.51	9.739	9.497	8.273

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5. GENERATED, panel OLS, US

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
Log(GENERATED	8.022***	-264.1***	73.780	-132.100
	(2.007)	(80.67)	(77.810)	(91.550)
Log(SIZE)	0.043	0.164	0.038	0.167
	(0.667)	(0.701)	(0.668)	(0.701)
LEVERAGE	-0.102***	-0.099***	-0.102***	-0.099***
	(0.034)	(0.035)	(0.034)	(0.035)
Log(OIL)	20.360***	21.950***	132.700	314.100**
	(3.613)	(3.798)	(132.2)	(137.0)
DUMMY	-10.390***	-7.293***	-9.360***	-4.161
	(2.358)	(2.632)	(2.449)	(2.921)
Log(GENERATED)* log(OIL)			-15.260	-39.660**
			(17.900)	(18.450)
Log(GENERATED)2		18.860***		21.560***
		(5.639)		(6.034)
Intercept	-137.30***	831.70***	-622.60	-290.90
	(31.57)	(274.30)	(576.20)	(546.10)
N	243	243	243	243
R^2	0.428	0.445	0.429	0.449
F	11.680	11.110	9.733	9.516

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6. CONSUMED, panel OLS, Europe

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
CONSUMED	-0.537	-11.820*	42.330	60.680
	(1.300)	(6.601)	(35.950)	(37.780)
Log(SIZE)	0.756**	0.763**	0.755**	0.768**
	(0.314)	(0.312)	(0.316)	(0.311)
LEVERAGE	-0.030	-0.031	-0.03	-0.032
	(0.037)	(0.037)	(0.036)	(0.036)
Log(OIL)	5.228**	4.575**	31.660	54.840**
	(2.265)	(2.140)	(22.140)	(25.640)
DUMMY	-9.232***	-7.414***	-7.532***	-2.543
	(1.462)	(1.643)	(1.936)	(2.623)
CONSUMED* Log(OIL)			-9.875	-18.99*
			(8.363)	(9.686)
CONSUMED2		2.045		3.848**
		(1.266)		(1.493)
Intercept	-28.11**	-11.73	-145.10	-222.30**
	(12.44)	(14.26)	(96.61)	(106.50)
N	153	153	153	153
R^2	0.237	0.248	0.247	0.276
F	11.50	9.711	9.525	8.282

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7. CONSUMED, panel OLS, US

	(Model 2) ROA(%)	(Model 3) ROA(%)	(Model 4) ROA(%)	(Model 5) ROA(%)
CONSUMED	4.074***	-9.012	61.700	76.840**
	(0.938)	(6.432)	(39.090)	(38.700)
Log(SIZE)	0.0586	0.131	0.0460	0.135
	(0.669)	(0.697)	(0.668)	(0.697)
LEVERAGE	-0.102***	-0.100***	-0.102***	-0.100***
	(0.034)	(0.035)	(0.034)	(0.035)
Log(OIL)	21.510***	20.480***	58.640**	78.200***
	(3.741)	(3.605)	(25.96)	(27.070)
DUMMY	-9.802***	-7.750***	-7.643***	-3.708
	(2.302)	(2.811)	(2.387)	(3.153)
CONSUMED* Log(OIL)			-13.460	-21.040**
			(9.047)	(9.386)
CONSUMED2		2.358**		3.124**
		(1.195)		(1.276)
Intercept	-95.04***	-76.03***	-256.60**	-322.50***
	(24.07)	(21.83)	(114.90)	(118.40)
N	243	243	243	243
R^2	0.434	0.439	0.437	0.446
F	11.86	10.59	9.931	9.067

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 3. Return on equity robustness check

Table A8. EMISSION, ROE, Europe

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
L.EMISSION	-0.190*	-0.670**	0.146	-0.242
	(0.098)	(0.277)	(0.384)	(0.537)
Log(SIZE)	30.450*	29.720*	30.290*	29.460*
	(15.490)	(15.500)	(15.700)	(15.770)
LEVERAGE	-0.831***	-0.809***	-0.821***	-0.795***
	(0.198)	(0.196)	(0.207)	(0.206)
Log(OIL)	-0.146	1.760	5.581	9.684
	(4.979)	(5.047)	(9.495)	(11.340)
DUMMY	-18.34***	-18.470***	-18.240***	-18.340***
	(4.193)	(4.209)	(4.185)	(4.162)
L.EMISSION* log(OIL)			-0.0783	-0.107
			(0.082)	(0.114)
L.EMISSION2		0.005		0.005*
		(0.003)		(0.003)
Intercept	-455.80*	-442.90*	-478.10**	-472.50**
	(231.80)	(231.00)	(220.30)	(217.60)
N	132	132	132	132
R^2	0.482	0.488	0.483	0.490
F	18.61	23.50	21.86	28.08

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A9. EMISSION, ROE, US

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
L.EMISSION	0.0219	-1.093	23.090	24.510
	(1.112)	(3.217)	(19.120)	(19.610)
Log(SIZE)	-26.240	-24.660	-19.590	-20.920
	(73.520)	(75.640)	(64.120)	(64.560)
LEVERAGE	-9.841**	-9.863**	-10.100**	-10.080**
	(4.080)	(4.119)	(4.272)	(4.282)
Log(OIL)	-40.230	-43.680	247.200	255.300
	(46.800)	(51.540)	(225.500)	(229.400)
DUMMY	-12.390	-12.270	-3.593	-3.560
	(19.030)	(18.960)	(14.030)	(13.970)
L.EMISSION* log(OIL)			-5.217	-5.306
			(4.380)	(4.416)
L.EMISSION2		0.0111		-0.010
		(0.029)		(0.022)
Intercept	961.90	971.40	-417.20	-449.50
	(946.70)	(931.10)	(1744.70)	(1751.00)
N	204	204	204	204
R^2	0.409	0.409	0.447	0.447
F	8.936	7.691	7.701	6.548

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A10. GENERATED, ROE, Europe

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
Log(GENERATED	-2.603	-413.700***	94.660	-323.000**
	(5.325)	(124.1)	(141.300)	(138.200)
Log(SIZE)	24.010	25.970	23.930	26.650*
	(15.160)	(14.890)	(14.930)	(14.350)
LEVERAGE	-0.837***	-0.875***	-0.831***	-0.877***
	(0.195)	(0.192)	(0.191)	(0.182)
Log(OIL)	-0.552	1.501	162.900	469.300
	(7.518)	(7.161)	(235.700)	(290.000)
DUMMY	-19.02***	-14.230***	-17.370***	-7.334
	(4.147)	(3.890)	(4.212)	(4.561)
Log(GENERATED)* log(OIL)			-22.360	-63.850
			(32.620)	(40.030)
Log(GENERATED)2		28.530***		41.510***
		(8.481)		(11.460)
Intercept	-341.40	1094.00**	-1053.70	-286.50
	(201.90)	(464.20)	(1180.90)	(1092.60)
N	149	149	149	149
R^2	0.449	0.476	0.452	0.498
F	27.81	23.98	24.37	24.40

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A11. GENERATED, ROE, US

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
Log(GENERATED	68.220***	818.200	806.300*	1229.000*
	(20.520)	(589.600)	(426.400)	(610.400)
Log(SIZE)	30.420	26.490	29.520	26.510
	(63.300)	(62.280)	(63.700)	(62.500)
LEVERAGE	-7.845*	-7.947**	-7.860*	-7.940*
	(3.847)	(3.865)	(3.839)	(3.871)
Log(OIL)	26.500	21.550	1287.200*	945.300
	(33.240)	(33.800)	(734.300)	(819.100)
DUMMY	-30.050	-37.600	-18.290	-27.680
	(22.920)	(26.740)	(23.820)	(30.050)
Log(GENERATED)* log(OIL)			-171.300*	-125.400
			(97.770)	(109.000)
Log(GENERATED)2		-51.930		-42.960
		(40.860)		(43.330)
Intercept	-830.60	-3438.80	-6262.80*	-6965.30*
	(897.80)	(2719.80)	(3375.70)	(3612.00)
N	231	231	231	231
R^2	0.331	0.331	0.331	0.332
F	13.17	12.59	11.29	11.13

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A12. CONSUMED, ROE, Europe

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
CONSUMED	-0.400	-34.640**	36.530	77.840
	(2.296)	(12.020)	(68.490)	(76.470)
Log(SIZE)	23.800	26.010*	23.750	26.840*
	(15.220)	(14.870)	(15.070)	(14.410)
LEVERAGE	-0.841***	-0.872***	-0.837***	-0.872***
	(0.197)	(0.190)	(0.195)	(0.181)
Log(OIL)	0.600	-1.881	23.360	75.850
	(7.508)	(7.676)	(40.190)	(49.850)
DUMMY	-19.160***	-13.660***	-17.710***	-6.140
	(4.084)	(3.920)	(4.188)	(5.158)
CONSUMED* Log(OIL)			-8.512	-29.480
			(15.830)	(20.010)
CONSUMED2		6.224***		9.031***
		(1.964)		(2.757)
Intercept	-360.60	-344.30	-460.60	-683.30*
	(218.50)	(208.90)	(360.40)	(382.30)
N	149	149	149	149
R^2	0.447	0.476	0.449	0.497
F	27.59	24.33	23.69	24.64

Notes 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A13. CONSUMED, ROE, US

	(Model 2) ROE(%)	(Model 3) ROE(%)	(Model 4) ROE(%)	(Model 5) ROE(%)
CONSUMED	28.800***	139.900**	557.200***	488.800**
	(9.211)	(56.400)	(196.100)	(187.200)
Log(SIZE)	33.140	25.250	31.140	25.130
	(62.890)	(61.880)	(63.310)	(62.190)
LEVERAGE	-7.783*	-7.956**	-7.808*	-7.946**
	(3.875)	(3.862)	(3.854)	(3.862)
Log(OIL)	25.940	33.480	366.000**	268.300*
	(33.110)	(32.750)	(132.000)	(131.400)
DUMMY	-25.980	-41.440	-5.867	-25.010
	(22.370)	(28.770)	(20.37)	(29.410)
CONSUMED* Log(OIL)			-123.400**	-85.620*
			(44.940)	(42.940)
CONSUMED2		-19.950*		-16.750
		(9.856)		(9.892)
Intercept	-456.80	-487.70	-1905.50	-1488.20
	(861.80)	(900.70)	(1211.40)	(1079.20)
N	231	231	231	231
R^2	0.330	0.332	0.331	0.333
F	13.49	12.83	11.86	11.48

Notes: 1. Robust standard errors in parentheses. 2. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$