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The Impact of Oil Price Fluctuations on Stock Performance of Clean Energy Companies

A global study on a corporate level

Authors

Nanda Baars

Alena Rukavishnikova

Supervisor

Håkan Jankensgård

Abstract

Course:	BUSN89 Degree Project in Corporate and Financial Management
Institution:	School of Economics and Management, Lund University
Authors:	Nanda Baars and Alena Rukavishnikova
Supervisor:	Håkan Jankensgård
Title:	The Impact of Oil Price Fluctuations on Stock Performance of Clean Energy Companies
Key words:	Oil price, stock performance, clean energy, wind energy, solar energy, hydro energy.

Research purpose:

The research aims at analyzing the relationship between oil price fluctuations and stock returns of clean energy companies. Furthermore, it aims to explore if there are differences in oil price dependence between different geographical areas (American, European, Asia/Oceania) and between different sectors (solar, wind, hydro). This is the first research conducted on the corporate level. Therefore, this research is novel and is expected to provide a good contribution to the literature.

Method:

This research is conducted as an explanatory study with features of an exploratory study. The approach of the study combines both deductive and inductive approaches. Quantitative method of analysis is applied, while carefully studying qualitative information for obtaining the most representative research sample which consists of 85 companies. Panel least squares regressions are used to answer the research questions.

Conclusion:

This research found a significant positive relationship between oil price fluctuations and clean energy stock returns. Next to this a significantly lower impact can be seen in the American region, compared to Europe and Asia/Oceania. Furthermore, all sectors are significantly different from each other. The solar sector has a significantly higher dependence compared to wind and hydro, the wind sector has a significantly higher dependence on the oil price fluctuations than the hydro sector.

Table of Contents

List of Abbreviations

CO_2 – Carbon dioxide

ECO – Wilderhill Clean Energy Index

EU – The European Union

MSCI – Morgan Stanley Capital International Global Equity Index

NEX – Wilderhill New Energy Global Innovation Index

NIEs – Newly Industrialized Countries

NYMEX – New York Mercantile Exchange

OECD – The Organization for Economic Co-operation and Development

OPEC – Organization of the Petroleum Exporting Countries

PSE – Arca Technology Index

R&D – Research and development

S&P 500 – Standard & Poor's 500 Index

SPGCE – Standard & Poor's Global Clean Energy Index

U.K. – The United Kingdom

U.S. – The United States

WTI – West Texas Intermediate

List of Variables

AM – Dummy variable for the American region

AO – Dummy variable for the Asia/Oceania region

DEBT_RATIO – Debt ratio

EU – Dummy variable for the European region

HYDRO – Dummy variable for the hydro energy sector

MARKET_CAP – Market capitalization

MSCI – Morgan Stanley Capital International Global Equity Index

OIL – Oil price returns (%)

PSE – Arca Technology Index

RET_BRENT – Brent Oil price returns (%)

RET_WTI – WTI oil price returns (%)

ROA – Return on assets

S – Stock price returns of clean energy companies (%)

SOLAR – Dummy variable for the solar energy sector

WIND – Dummy variable for the wind energy sector

List of Figures

List of Tables

1. Introduction

This chapter begins with the background description of the research in order to formulate the research problem. Based on the formulated problem, the research questions are identified. To present a comprehensive overview of the research, its scope and contributions to the literature are discussed, followed by the research limitations and the thesis structure.

1.1. Background

Environmental awareness is an important topic nowadays since the world is becoming more and more polluted. According to the study of Rockström et al. (2009) pollution of the environment causes unfavourable climate changes resulting in global warming. Humanity, especially in developed and rapidly developing countries, pollutes the Earth at a high rate and this will cause severe problems in the coming years/decades. Production, fossil fuel extraction, and energy generation based on fossil fuels are the major causes of high carbon dioxide emission that adversely impact our living environment in a rate which is unsustainable in the long run (Rockström et al., 2009).

Fossil fuels are hydrocarbons including oil, coal and natural gas, which were formed over millions of years from the remains of living organisms.[1] Among fossil fuel recourses, oil consumption is the highest and expected to triple by 2050 (United Nations Environment Programme, 2011). Reaching its critical level, oil resources are becoming scarce. Coal and natural gas have not reached critical levels yet, but due to the pollution caused by energy generation using these sources, consumption should be limited. Thus, the present society is in need of alternative energy sources which can have the least pollution effect and substitute fossil fuel based energy in the future.

There are two alternatives to fossil fuel based energy which are renewable energy and nuclear power. Oxford dictionary defines nuclear power as a power generated from atomic reaction, while renewable or clean energy as a form of energy generated from non-depleted sources.[2] According to Ghenai and Janajreh (2013), clean energy can be produced from wind, solar, hydro, ocean wave, tidal, geothermal and biomass natural resources. Renewable energy is more sustainable in a long run and serves as a substitute to the fossil fuel energy sources. However, it still has a negative, although lesser than fossil fuels, impact on the environment through the

[1] http://www.oxforddictionaries.com/definition/english/fossil-fuel?q=fossil+fuels
[2] http://www.oxforddictionaries.com/us/definition/american_english/nuclear-power

carbon dioxide emission that comes from construction and maintenance of renewable power plants (Ghenai and Janajreh, 2013).

1.2. Problem formulation

Even though clean energy is a sustainable and more environmentally friendly source of energy, the society is still highly dependent on fossil fuel based energy and particularly on oil based energy. Global consumption of oil energy in 2012 accounted for 33% among all energy sources, while clean energy accounted only for 13% (Energy, 2013). In order to provide a supply of renewable energy that will be able to replace the consumption of oil and other fossil fuel based energy in the future, the industry must become well-established. Nowadays, the clean energy industry is only at the development stage and therefore, clean energy generation is more expensive than energy generated from fossil fuels. Since clean energy is a perfect substitute to fossil fuel based energy, more investments are needed to make this industry more mature and cost efficient to be able to compete with fossil fuel based energy (Ghenai and Janajreh, 2013). Investors are more likely to invest when factors influencing the stock performance are known as this reduces uncertainty. Therefore this research intends to explain one factor, which is the impact of oil price fluctuations.

The oil price has a large impact on the global economy, and the performance of almost all companies is affected by oil price fluctuations and shocks (Rockström et al., 2009). Because renewable energy is a substitute of oil based energy, stock returns of clean energy companies must also be affected by oil price changes. From the theoretical perspective, based on the demand and supply theory formulated by Marshall (1890), an increase in oil price should drive demand for clean energy, consequently driving the price. This should result in an increase of clean energy companies' stock returns since this industry will be more attractive to investors.

Empirically, previous research found a positive relationship between oil price movements and stock returns of clean energy companies. However, these studies were conducted using mainly the Wilderhill Clean Energy Index (ECO), which consists of 53 companies (on average during 2008-2014) listed only on the U.S. Stock Exchange, and some of them also have operations in industries other than clean energy.[3]

Thus, the problem of this thesis is whether the results of previous research, indicating that there is a positive relationship between oil price fluctuations and stock returns of clean energy

[3] http://www.wildershares.com/about.html

companies, are applicable to a global set of clean energy companies listed on stock exchanges throughout the world and operating only in clean energy sectors.

1.3. Research questions

Based on the defined problem and characteristics of the collected data set of the clean energy companies, following research questions are intended to be answered in this thesis:

1. What is the effect of oil price fluctuations on clean energy companies' stock performance?
2. Is there a difference between American, European or Asia/Oceania regions regarding this relationship?
3. Is there a difference between the solar, wind or hydro energy sectors regarding this relationship?

1.4. Contribution and scope of the research

This research is based on a sample of 85 companies that operate globally, thus, this is the only study that has been conducted outside the United States and contains that many companies in the sample. It explores the relationship of oil price fluctuations and stock price returns of clean energy companies that are located either in American, European or Asia/Oceania geographical regions.

Moreover, this research is unique as it studies the effect of oil price fluctuations on stock returns of clean energy companies based on their sectorial division. It includes stock returns of companies that operate solely in either solar, wind or hydro energy sectors, because these sectors have the most representative amount of listed companies. Due to this factor, companies that also operate in other non-related to clean energy industries were excluded. In order to eliminate correlation of stock returns with oil price and obtain reliable inferences, companies that have oil-related operations are not included in the sample. Additionally, based on the scope of this research, only currently listed companies were studied.

This is the first research conducted on a corporate level and includes variables that reflect firm characteristics. Using these variables, it is possible to control for firm specific factors, which are disregarded in the index based studies. Therefore, this research is novel and is expected to provide a good contribution to the literature.

1.5. Limitations of the research

There is a number of limitations which are attributed to this research, but which have been taken into account. These limitations might have an impact on the number of observations which could reduce objectivity of the research. This research comprises only currently listed clean energy companies and excludes all companies that have been delisted during the period of 2004-2014 causing a survivorship bias. This limitation is due to a data availability constrain, as it was not possible to gather this data. Additionally, because not all companies were listed from the beginning of the studied period, there is a substantial amount of missing observations which results in unbalanced panel data. Another limitation is that companies that operate in other than solar, wind and hydro energy sectors and companies that operate in several clean energy sectors simultaneously are not included, thus not covering the whole clean energy market. However, this is done in order to study the effect between different sectors. Furthermore due to the limited number of companies in the sample, this research does not study the impact of oil price fluctuations on the stock returns of clean energy companies in solar, wind and hydro sectors within each geographical area.

1.6. Thesis structure

The introductory chapter of this thesis is followed by the second chapter that gives a broad overview of the energy market including oil and renewable energy markets, description of oil prices and policies of different geographical regions. The third chapter establishes a conceptual framework that describes major theories and former literature written about the relationship between the oil prices and stock markets, and oil prices and stock prices of clean energy companies. The fourth chapter is a methodological foundation of this research and describes in detail the data selection process. The fifth chapter presents empirical data and analysis based on econometric research methods. The final chapter includes conclusions that were obtained during the analysis and provides recommendations for future research.

2. Energy market overview

To give a profound understanding about the topic, this chapter gives an overview of the energy market with the focus on oil based and clean energy sources. Furthermore, different oil prices and the interconnection between the oil prices and clean energy are presented.

2.1. Oil based energy market

Oil based energy is a part of the fossil fuel energy market, which also includes coal and natural gas based energy (World Energy Outlook, 2013). Energy generated by burning the fossils corresponds to high levels of carbon dioxide (CO_2) emission. High level of CO_2 emission causes global warming that imposes a threat for sustainability of human race living environment. Due to its pollution effect, fossil fuel based energy generation is opposed by many environmentalists and to reduce their production policies are coming into place (Rockström et al., 2009). Therefore, alternative sources of energy are essential to sustain our energy consuming lifestyle and have less negative impact on the environment.

This research is limited to the oil based energy, since it is the most used source and produces the highest CO_2 output compared to coal and natural gas (Ghenai and Janajreh, 2013). Oil is a natural resource which is becoming scarcer. Fossil creation by nature takes millions of years, which is incomparably slower than the current consumption rate and for that reason, it is expected that oil resources will be exhausted in the coming years/decades (Rockström et al., 2009). Next to energy generation, oil is used for gasoline, the production of plastic and multiple other sources. Oil undergoes a chemical process in an oil refinery, after which different outputs are used in production of end-products. This whole process is very energy demanding and although efforts are made to reduce CO_2 and other harmful gasses emission the process leads to pollution.[4] Furthermore, oil extraction and oil transportation via pipelines can accidentally lead to environmental disasters caused by crude or processed oil leakage into the ocean or ground (Rockström et al., 2009).

The price of oil is dependent on supply and demand just as any other commodity, but in a short-term period it can be a subject to political issues, investor speculations and differences between forecasts and actual demand or supply. The oil prices are for a large part determined by the Organization of the Petroleum Exporting Countries (OPEC), which coordinates and unifies the policies in the largest exporting countries, aiming to stabilize the industry and ensure a regular

[4] http://www.bp.com/en/global/corporate/about-bp/what-we-do/making-fuels-and-products/how-refining-works.html

supply of crude oil. The members of OPEC are: Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela.[5]

Different types of oil are priced differently based on the demand and supply of oil with certain oil characteristics such as density and sulphur concentration. Therefore, there are multiple oil prices. All types of crude oil contracts are traded at the Intercontinental Exchange[6] in U.S. Dollars per Barrel. The prices of different types of oil are usually following the same trend and are highly correlated.[7] Three most common global benchmarks for the crude oil prices are West Texas Intermediate (WTI), Brent Blend and the OPEC basket. Since WTI and Brent are most traded and most relevant for the production of energy due to their characteristics, they will be used in our research.

The Brent crude oil derives its name from the Brent oil fields located to the north-east of Scotland, in the North Sea.[8] WTI derives its name from the major trading hub of crude oil which is located in the little town of Crushing, Oklahoma, and for over three decades the price of oil has been settled there[9]. The prices of Brent and WTI crude oil have been very volatile from 2008 onwards as can be seen in Figure 1. After the shock in 2008/2009 the WTI price was traded at discount compared to the Brent price, however, these measures were following the same trend and are converging again.[10]

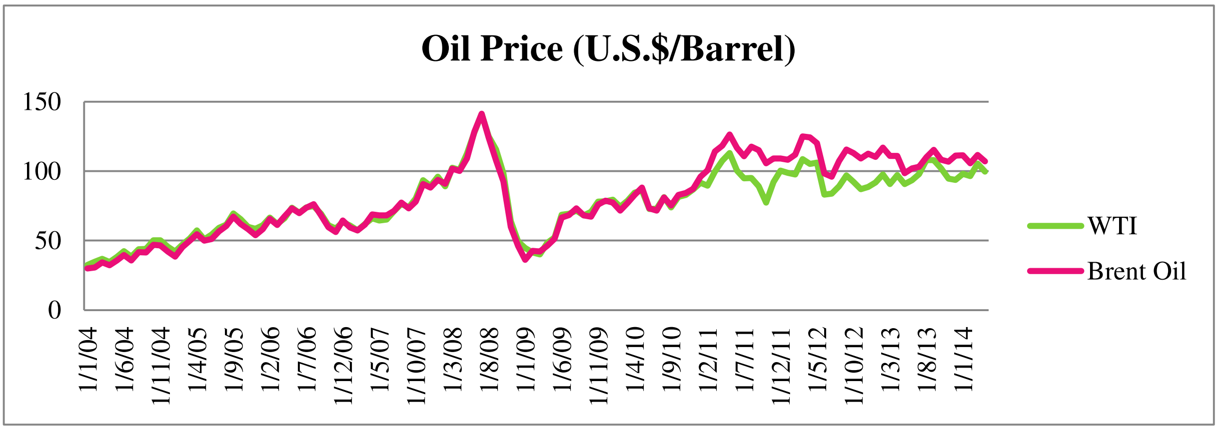

Figure 2. Historical WTI and Brent oil prices

[5] http://www.opec.org/opec_web/en/about_us/23.htm
[6] https://www.theice.com/homepage.jhtml
[7] http://commodityhq.com/2011/crude-oil-guide-brent-vs-wti-whats-the-difference/
[8] http://www.tradingeconomics.com/commodity/brent-crude-oil
[9] http://www.tradingeconomics.com/commodity/crude-oil
[10] http://www.eia.gov/todayinenergy/detail.cfm?id=11891

2.2. Clean energy market

Recent technological development has made it possible to generate energy from sources other than oil, coal and natural gas. The main characteristics of clean energy sources are that they cause less or no harm to the environment by low CO_2 emission. Clean energy is also called renewable or alternative energy. The following definition of renewable energy by Texas legislation[11] is used in this research, stating that renewable energy is: "*Any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources.*"

The most common sources of clean energy generation are wind, solar and hydro sources which form the scope of this research and have following definitions. "*Solar energy refers to the conversion of the sun's rays into useful forms of energy, such as electricity or heat*".[12] Wind energy is defined as "*energy collected from motion caused by heavy winds. Wind energy is collected in turbines with propellers that spin when the wind blows and turn the motion of the propeller into energy that can be used in the electrical grid*".[13] According to the definition "*Hydropower is electrical energy derived from falling or running water. The water pressure that is created by water is used to turn the blades of a turbine. The turbine is connected to a generator, which converts the mechanical energy into electricity*".[14]

Additionally, there is energy generated by means of wave power, tidal power, geothermal power, biomass and bio fuels. The market for biomass is mature, and slowly substituting fossil fuel based energy production. The other sources of clean energy are in the introductory or growth stadium, and require more investments. Nuclear energy is also an alternative source of energy, however, despite low pollution it imposes a threat to the environment through the radiation waste (Bloomberg New Energy Finance, 2013).

Energy generation of solar power or wind energy is highly dependent on the sun or wind availability. At this point in time it is difficult to store energy and therefore, these sources cannot

[11] http://www.treia.org/renewable-energy-defined
[12] http://energync.org/assets/files/Solar%20Fact%20Sheet.pdf
[13] http://www.ecomii.com/ecopedia/wind-energy
[14] http://www.pembina.org/re/sources/hydro-power

provide a stable energy supply. The energy storage problem is not attributable for energy production based on biomass or bio fuel. Fossil fuel based resources can be burned at any time, and thus are able to match supply to expected demand, which is a large advantage over many clean energy sources (Bloomberg New Energy Finance, 2013).

According to Bloomberg New Energy Finance (2013) just 13% of energy was produced by clean sources of energy in 2012, hence, there is need for improvement in this field. The investments are growing each year, but for the first time in 2012, global R&D investments in clean energy have declined by 12% due to policy concerns about subsidies in the main markets; U.S. and Europe. Nevertheless, net investments in renewable energy are exceeding net investments in fossil-fuel generated energy. In addition, renewable energy investments are becoming more and more common outside the developed economies, which is slowly decreases the gap. Due to the importance of this newly emerging industry, government subsidies are not uncommon and amount for 3% of total investments. There are multiple types of subsidies possible, for example blending mandates, quotas, portfolio obligations, tax credits and feed-in tariffs. They are meant to offer a higher return to offset the higher costs. Also punishment for producers and users of non-environmentally friendly energy in form of fines and carbon prices is possible (Bloomberg New Energy Finance, 2013).

For investors, there are two common ways to invest in an industry; either by direct investments in corporate stocks or by investing in indexes specialized in a certain industry segment. At this point in time, the most common method to measure the performance of the market is using clean energy indexes. There are several clean energy indexes, which consist of companies that either solely or partially have a connection to clean energy, for example, companies which produce parts for energy generation products, companies which research how to improve the market, and energy production companies. The major indexes are the Wilderhill Clean Energy Index (ECO), which includes clean energy companies only listed in the U.S[15], the Wilderhill New Energy Global Innovation Index (NEX), which consists of companies active in renewable and low-carbon energy worldwide[16] and the Standard & Poor's Global Clean Energy Index (SPGCE), which also comprises clean energy related companies from all over the world[17].

According to World Energy Outlook (2013), the market for clean energy is expected to grow, as most countries are setting guidelines for the percentage of clean energy generated and

[15] http://www.wildershares.com/
[16] http://www.nexindex.com/
[17] http://us.spindices.com/indices/equity/sp-global-clean-energy-index

consumed in a certain future year. In addition, awareness of the damage to the Earth is spreading and next to developed economies also developing economies are striving to make their energy consumption cleaner. It is expected that the primary reason for rapid growth of this industry is the policy changes which encourage investments. Since expansion costs can be driven down, clean energy sources become more competitive to the more mature industry of fossil fuel based energy. It is expected that renewable energy will have a share of at least 15% in the total energy market by 2035, with projections ranging between 15% and 26%. To compare, clean energy had a share of 13% in 2012. The demand for clean energy generated by more technological sectors such as solar and wind is expected to increase from 8% to 14% of total energy demand. The demand is mainly driven by continuing government support and environmental pressure, as well as falling technology prices. The hydro market is expected to grow even faster, since in non-OECD countries a significant amount of new unexploited resources have been found, which will lead to an increase of scale and cost efficiencies (World Energy Outlook, 2013).

2.3. Relationship between oil based and clean energy

Oil based energy and clean energy are perfectly substitutable goods, as energy is homogenous. There are no quality differences to the end consumer, while the production of energy from different sources has different costs. At this point in time, it is difficult to substitute oil based energy with clean energy, partially due to higher costs of clean energy. Even though it is more favourable for the environment, the transformation from oil based energy to clean energy will take time and will not be finalized in the coming years (Haug, 2011). Therefore, different types of energy need to coexist leading to competition. According to the theory of supply and demand which is explained in the next chapter, when goods are perfect substitutes, a price increase in one good, will lead to an increase in demand in the other good in the short run. For the relationship between oil energy and clean energy this implies that if the oil price increases, and therefore, the price at which oil energy is sold increases, consumers will substitute oil based energy for clean energy, causing a rise in demand.

3. Conceptual framework

In this chapter all theories and literature that are of relevance for this research are discussed. Furthermore, since there is no previous literature that studied the relationship between oil price fluctuations and clean energy stock performance based on geographical and sectorial divisions, the information required to build the hypotheses is presented followed by the hypotheses formulation.

3.1. Theoretical background

In this section the most relevant theories are presented in order to provide a better understanding of how the stock market functions.

3.1.1. Efficient Market Hypothesis

In this research the capital market is assumed to be efficient, which is in line with the Efficient Market Hypothesis formulated by Fama (1970). An efficient capital market is defined as a market that at any point in time reflects all available public information. There are three forms of efficient markets; weak form, semi-strong form and strong form. These forms indicate at which level the efficient market hypothesis holds. In the weak form, stock prices are only based on the historical prices, while at the semi-strong form stock prices are also adjusted for obvious public information like corporate announcements. At last, the strong form assumes that all publicly available information is incorporated in the stock prices. According to Fama (1970), stocks are priced based on rational behaviour of investors and cannot be predicted using neither technical analysis, which extrapolates trends of past prices on the future stock prices, nor fundamental analysis, which helps to identify mispriced stocks.

This theory has been criticised by many researchers who believe that stock prices can be at least partially predicted. In line with studies conducted within the Behavioural Finance field, investors do not behave rationally and are subject to many behavioural biases which can affect their decisions next to the information that is publicly available. Among these biases are overconfidence (Fischhoff and Slovic, 1978, Barber and Odean, 2001, Gervais and Odean, 2001), overreaction (De Bondt and Thaler, 1985), loss aversion (Tversky and Kahneman, 1981, Shefrin and Statman, 1985, Odean, 1998), etc. Furthermore, the most controversial critique was made by Grossman and Stiglitz (1995) who argue that it is impossible for markets to be perfectly efficient, since otherwise the profit to collect information would be absent and there would be no reason to trade leading marking to collapse.

3.1.2. Economic model of supply and demand

As oil resources are becoming more limited while its demand is constantly increasing, this leads to an increase in oil price. This relationship can be explained by the demand and supply theory formulated by Marshall (1890). According to this theory the market price is determined by interactions between demand and supply of an underlying good. When demand equals supply, the prices are said to be in equilibrium. However, in the real world the demand and supply of goods constantly fluctuate and when there is a change in either demand or supply, the equilibrium will change, resulting in a price change. Therefore, an increase in demand of a good, while its supply remains at the same level, leads to a shortage which results in a higher equilibrium price.

The extent to which a demand or supply curve can react to a change in price of a good is defined by the curves' elasticity. Supply elasticity is the percentage change in the quantity of a good supplied when the price of this good changes. Demand elasticity is the percentage change in the quantity of a good demanded when the price of this good changes. Availability of substitutes is the most important factor that affects elasticity of demand. The stronger is the degree of substitution, the higher elasticity of the demand will be, since the switching power will be high (Perloff, 2004).

A substitute good is a good which can replace another good. In the case of energy, for the end consumer it does not matter what is used to generate energy, as energy is a homogenous good. According to the theory of supply and demand, if two goods are of comparable value, an increase in the price of one good will shift demand to its substitute good. Goods can also be partial substitutes; in this case the price difference must be larger for consumers to switch to this partial substitute (Varian, 2010).

3.2. Literature review

In this section the former literature written on the relationship between the oil price and stock markets in general and clean energy stock performance in particular is reviewed.

3.2.1. Former research on the relationship between oil prices and stock markets

Even though this topic has been studied for over 30 years, not much research has been conducted on the relationship between oil price fluctuations and the stock market. Moreover, the relationship is not clear and different results are found in different papers. Since our research looks at stock prices of clean energy firms, it is important to outline the relationship between stock prices and oil price fluctuations. The origin of this research is the well-studied relationship between the oil price and the economy (Hamilton, 1983, Gilbert and Mork, 1984, Mork et al., 1994), and the reasoning is that if the oil price influences the economy it should also affect stock markets.

Huang et al. (1996) has researched this relationship using NYMEX oil futures and the S&P500 index, but they have found no significant relationship between oil prices and stock market movements, except for movements of oil companies' returns. This is not in line with the research performed in the same year by Jones and Kaul (1996), who have used a sample of U.S. and Canadian stocks between 1947-1991. They have found a significantly negative impact of oil price shocks on the performance of the U.S. and Canadian stock market. However, for the Japanese and the U.K. markets the evidence was weak. Sadorsky (1999) has built further on this research and found that an oil price shock initially has a negative and statistically significant impact on stock returns of companies with oil-related production costs. The market responds in line with the efficient market hypothesis (Fama, 1970) and the effect of an oil price shock lasts for three months. Sadorsky (1999) also divided the data into two periods, before and after the large oil price shock in 1986. He found that there is a greater impact of the oil price on the stock market in the aftershock period. He also found that oil prices influence economic activity, but this relationship does not work the other way around.

Kilian and Park (2009) have constructed a new methodology following the research of Kilian (2009) and used it to study the U.S. stock market. They argue that former literature did not take into account the fact that oil price shocks are related to economic changes, which in turn can drive oil demand, and therefore, the oil price. Next to this, it was not considered that economic changes can also drive stock prices. Consequently, it was required to take into account what caused an oil price shock and what effect this shock had on the expected changes in demand and supply of oil. This study has found that stock returns respond only significantly to oil price changes if the price of oil increases due to an oil market specific demand change, for example a change in belief about future possible supply. Disruptions of oil production do not have a significant effect. They found that if the oil price increase is driven by an unanticipated global economic expansion, stock returns will be positively affected. Nevertheless, due to the upward driven oil price also caused by this phenomenon, the economy will be slowed down after the first year of initial stimulation.

Fang and You (2014) have researched whether the relationship between oil price shocks and stock markets is different in Newly Industrialised Countries (NIEs), since NIEs are usually more energy and oil-based product consuming due to their rapid growth. Therefore, they are expected to be affected more heavily by shocks in oil prices caused by an expected decrease in supply. It is important to notice that because NIEs have a large consumption of oil, they can also influence the price of oil through the demand side. This research has been conducted based on the stock markets in China, India and Russia, and the latter was expected to give different results, since it is one of the major oil exporters. Fang and You (2014) found no significant impact in the Chinese stock market. This can be due to the restrictions on the stock market in China, which was relatively illiquid and did not respond to changes as fast as other markets. For India a negative impact can be seen. India is an economy which is consuming oil at a high rate, and an increase in the oil price affects the whole economy adversely. For Russia it was found that when oil price movements are driven by Russian supply shocks, the effect on stock prices is positive, while in other situations the impact is negative.

In conclusion, most research has found a significantly negative relationship between stock prices and shocks of oil price. However, there are several factors that influence this relationship such as the origin of the shocks and whether oil is used in production. Furthermore, it was found that the relationship is clearer in an aftershock period.

3.2.2. Former research on how the oil price influences clean energy stock prices

Only five papers have studied the relationship between the oil price and clean energy stock returns (Kumar et al., 2012, Managi and Okimoto, 2013, Sadorsky, 2012, Wen et al., 2014, Henriques and Sadorsky, 2008). These studies have all used the Wilderhill Clean Energy Index (ECO), while Kumar et al. (2012) also included the Wilderhill New Global Innovation Index (NEX) and the Standard & Poor's Global Clean Energy Index (SPGCE). Since only five papers have been written, they will be discussed separately and in depth to give a good overview of all research conducted until now.

Henriques and Sadorsky (2008) have researched the relationship between stocks of alternative energy companies, the oil price, technology companies and the interest rate, with the aim of understanding the development of the alternative energy industry in the coming years. In this research the oil price is determined by the closing prices of WTI during 2001-2007, the stock price of alternative energy by the ECO index, the technology stock prices by the Arca Technology Index (PSE) and the interest rate by the yield of three month U.S. Treasury bill. Furthermore, the S&P 500 Index is used as a benchmark for the broad-based market. They found a high correlation of 83% between the ECO and PSE indexes, indicating that the alternative energy companies are perceived by investors as high technology firms. However, they also identified that the oil price is a significant risk factor for the ECO index, while not for the PSE index returns. Henriques and Sadorsky (2008) found that the alternative energy stock prices are explained by past oil price movements, technology stock prices and the interest rate. This shows that oil price is not the only and not the most important variable that influences alternative energy companies. They found that the initial response of the ECO index is positive to a shock in oil prices and this effect lasts for ten weeks. They also tested the effect of a one standard deviation shock of the technology stock price index, and found a larger significant influence lasting for ten weeks. This indicates that investors perceive the ECO index as more related to the technology sector than to the energy sector. The causal relationship between the ECO and PSE indexes is not determined, because a one standard deviation shock in the ECO index influences the PSE index in the same way. The oil price influences the PSE index price negatively, since an increasing oil price raises production costs.

Follow-up research by Sadorsky (2012) has found that on average it is possible to hedge a clean energy stock position of 1 U.S. Dollar by 20 Dollar cents through a crude oil future. He used the same ECO and PSE indexes and WTI oil price during 2001-2010. His study confirmed that the ECO index is more correlated with PSE index than with the oil market, which indicates that at that point in time renewable energy companies were still perceived more as high technology than energy companies.

Huang et al. (2011) has applied a different approach on this relationship using the ECO index in order to compare their results with the study conducted by Henriques and Sadorsky (2008). Huang et al. (2011) has looked at the dynamics of oil prices due to shocks in the Middle East during the period of January, 2001 – May, 2010, and divided the sample into three parts based on the major political shocks caused by the Iraq war in March, 2003 and the Lebanon war in July, 2006. The Middle Eastern countries produce a major share of the total oil production, and therefore, the conflicts in this region can affect prices of oil worldwide. They have repeated their research with three different oil price series, the spot prices of WTI, Brent and the NYMEX Crude Futures. Next to this, they have used the crude oil stock index of the American Stock Exchange to track the financial performance of the oil industry. For the whole time period, a significant causal relationship between the oil prices and the performance of the ECO index can be seen. With respect to the different time periods, only in the last period significant dependence was found. According to the authors this indicates a higher attention paid by investors to the oil prices after 2006, when investing in alternative energy stocks or indexes. Furthermore, only in the last period a two-way causality between the oil prices and the oil index was found. The findings of this paper indicate a higher interaction between the oil prices and the clean energy sector after 2006. Higher volatility than in the previous periods can also be detected in the post war period, showing that there could be a relationship between volatility in the oil market and the factor up to which investors take the oil price into account when investing in alternative energy.

Another more recent study conducted by Managi and Okimoto (2013) finds results in line with the Huang et al. (2011) research. Managi and Okimoto (2013) have repeated the research of Henriques and Sadorsky (2008) using a more advanced model. The variables are WTI and Brent oil prices, the ECO and PSE index, and the three-month U.S. Treasury bill yield obtained during the period of 2001-2010. The results are partly different in comparison with Henriques and Sadorsky (2008). A significant and positive impact of a one standard deviation shock in oil prices can be seen on the ECO index with a permanent effect for this sample set, indicating that there has been a change in investors' beliefs during the last couple of years. In line with Henriques and Sadorsky (2008) a technology index shock of one standard deviation also impacts the ECO index. A structural change has been found between the end of 2007 and the middle of 2008, due to the economic turmoil in the U.S. This is in line with the findings from Huang et al. (2011) with respect to changes after the Lebanon war in 2006, and there is evidence that the oil price shocks influence macroeconomic factors leading to economic downturns. Managi and Okimoto (2013) find that the relationship between oil price and alternative energy is positive and significant after this period and insignificant before. As has been seen in the other literature (Henriques and Sadorsky, 2008, Huang et al., 2011), the PSE index shocks have a significant effect on the ECO index.

Kumar et al. (2012) contributed to this field of research by adding carbon prices as a possible influence on the clean energy stock performance during 2005-2008. As seen before they have also taken into account the relationship with technology stock prices (Henriques and Sadorsky, 2008). Kumar et al. (2012) has used three different indexes to measure clean energy stock performance (ECO, NEX and SPGCE indexes) and PSE index to measure technology stock prices. The oil price was determined by WTI and Brent crude oil future contracts, the carbon price by future contracts from the European Emission Trading and the interest rate by the three month Treasury bill. They expected that setting a price on carbon would stabilize carbon emission and stimulate investments in clean energy. The research found that there is a relationship between the three clean energy indexes and the technology index, with correlation of around 90%. Also it was found that the carbon price returns have an impact on the clean energy and technology indexes. The variation in the three clean energy indexes is significantly dependent on past movements of oil prices, stock prices of high technology firms and the interest rate. However, a significant relation between carbon prices and clean energy stock prices was not confirmed. According to the authors this could be due to two main reasons. Firstly, the carbon prices used were from the European market, while all other data was from the U.S., thus the assumption that these carbon prices are a proxy for the global market is possibly not true. Secondly, the carbon prices in the U.S. were low since there were no/little regulations and thus possibly not able to stimulate investment in clean energy.

To summarize, the research, conducted at this point in time, has mainly used U.S. stock prices and other U.S. variables. The most recent papers have found a structural change around 2007, which is connected to the Lebanon War. Before this shock, the oil price was fairly stable and no significant relationship between the oil prices and clean energy stock returns was found. After the shock, a positive relationship between oil prices and clean energy company stock returns was found, but the causality has not been fully determined. Moreover, there is also a high correlation between clean energy stock returns and high technology stock returns, indicating that from an investor point of view these industries are related.

3.3. Policy discussion

As there was no research conducted on a corporate level, this section presents information regarding governmental policies in the American, European and Asia/Oceania regions required for hypotheses formulation. For each geographical area, the policies of the majority (>10%) of the countries included in the sample are discussed.

3.3.1. Policies in the American region

The main countries that represent the sub-sample of the American region are the U.S. and Canada. In the U.S., renewable energy stimulation is organized on a state level. The problems in the U.S. which makes it more difficult to start a renewable energy company are price competitive reasons and state regulations. State regulations are associated with difficulties of getting permits, lack of standards with regard to connection to the electric utility's grid and lack of infrastructure to transport the energy from more remote areas where there is a potential for energy generating utilities. These problems are state related, and therefore, a large difference can be seen between renewable energy development in the southwest and northeast states, and the rest of the country, where the policies to support renewable energy sector are less advanced. In this part of the U.S. there are standards, which for example oblige electricity providers to have a certain percentage of the renewable energy in total energy they distribute; public benefit funds that are available in some states to make use of governmental investments in clean energy projects; limits on CO_2 emission and new standard in place about renewable energy connection to the electric grid[18]. Overall, there is a high potential for stimulation improvements and more centralized initiatives in the U.S. to make the renewable energy sector grow.

The second largest part of companies in this sub-sample is located in Canada. The Canadian government is promoting renewable energy development and there are initiatives such as the climate change plan, which is a commitment that governmental operations need to use at least 20% clean energy, but it is not fully implemented at the moment. Furthermore, there is a one billion Canadian dollar budget to stimulate environmental technologies and renewable energy alternatives. Next to this, there are multiple incentive programs to encourage low-impact renewable energy use by residential and small-business customers and initiatives to make energy generation more efficient. It can be concluded that Canada effectively stimulates renewable energy production and consumption[19].

3.3.2. Policies in the European region

Since all countries that comprise the European region, except Norway and Russia, are part of the European Union (EU), EU regulations define the policies for this region. According to the EU regulations, each EU member state must develop a National Renewable Action Plan, which is a detailed plan of how the country is going to reach the goals for the stimulation of renewable energy production. These goals can be found in the Renewable Energy Sources Directive of the EU, published in 2009. It aims at 20% of all energy in Europe to be renewable by 2020, and for the transport sector, which today is almost fully oil based, a target of 10% is set.[20] These targets are very ambitious, and the execution of these plans, submitted by all member states, is under control of the European Commission.

Overall, in general the degree of environmental awareness in Europe is high, and there are strict guidelines all countries need to comply with (Szabo et al., 2014). All members have to comply with these guidelines and form and implement action plans which will be controlled both on a national and European level. Nevertheless, some countries are more concerned with renewable

[18] http://www.epa.gov/statelocalclimate/state/topics/renewable.html#a03
[19] https://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=6766D86C-1
[20] http://ec.europa.eu/energy/renewables/targets_en.htm

energy than others. For example, Germany scores very high in stimulating renewable energy and has started to implement regulations and policies even before EU interference.

3.3.3. Policies in the Asia/Oceania region

Our sample consists mainly of Chinese companies. Therefore, policies of China are expected to have the most influence on our results. China is a country which is rapidly developing and requires a high amount of energy. The Energy Foundation China is an organization established by the Ministry of Civil Affairs that offers grants to sustainable energy initiatives. The goal of this organization is to assist in the transition of China to a future with sustainable and efficient energy. China targets to have 15% of its energy generated from non-fossil fuels sources by 2020. Despite the target and good initiatives, there are some problems with growth of the renewable energy sector and especially with the grid integration. China is a very large country and a large amount of technical updates, changes in rules of the power sector's operations and institutional reforms are needed to make energy distribution possible. Supportive policies and management need to be established to have a large interconnected energy distribution grid. Also, large governmental spending and strong incentives are required to subsidize the higher costs of renewable energy to make it possible to compete with more established fossil-fuel based energy. Finally, China does not have an established national strategy to guide renewable energy development, which results in policy conflicts and difficulties enforcing the policies, slowing down the growth of the renewable energy sector. The Energy Foundation China does have a Renewable Energy Program in place to solve these problems[21].

3.4. Regional investment levels

In Figure 2 and Figure 3 below the investments by geographical areas and by sectors in billions of U.S. Dollars are illustrated. The data for the graphs is based on the Bloomberg New Energy Finance (2013) report.

The investments in the Middle East/Africa geographical region are very low and only a small amount of companies is established. From 2011 onwards, an increasing trend can be seen, thus the amount of companies in this area is subject to change. The investment level in Europe has been growing steadily until 2008 but afterwards the trend of volatility can be seen. From 2011 onwards investments decreased rapidly. A similar trend can be depicted in the American region, but the volatility was higher. The overall investment level was lower in the American region compared to Europe, and also lower compared to Asia/Oceania after 2008. Throughout the

[21] www.efchina.org

period of 2004-2012, the investments in renewable energy in Asia/Oceania have been constantly increasing at a stable rate and resulted in the highest amount of investments in 2012, while a disturbance in 2008-2009 and a decline after 2011 can be seen in other regions. It can be seen from the figure that the investments in clean energy shift from developed to developing countries (Bloomberg New Energy Finance, 2013).

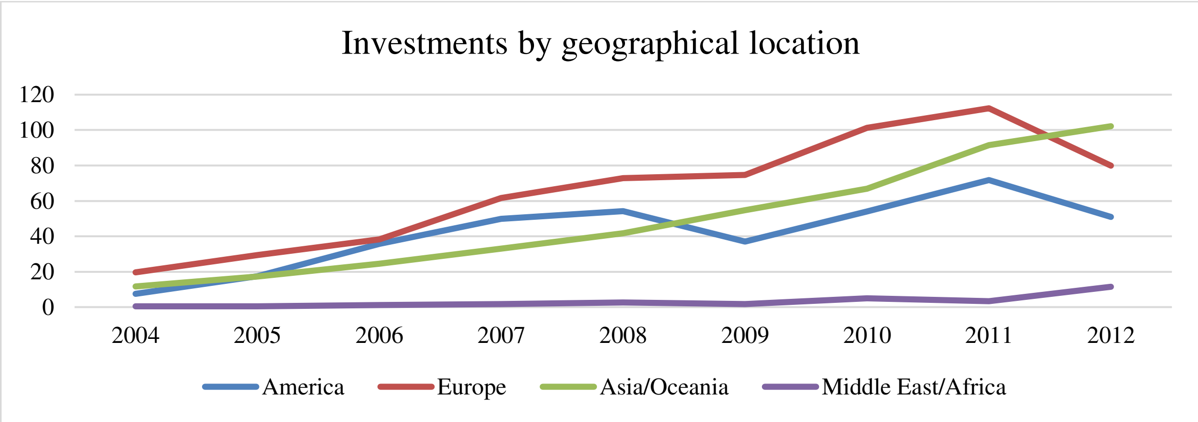

Figure 2. Investment levels by geographical locations

The investments in the hydro sector during the period 2004-2012 were the lowest compared to the wind and solar sectors. They remained at a stable level and only a slight growth can be seen in 2007-2008 and after 2011. The wind sector attracted most investors before 2010, but during the last years investments decreased having a decline of 10% in 2012. The solar sector's investments increased rapidly after 2009, causing the investments to double in a two year time span. However, as in the geographical locations, there was a downward trend in the solar sector after 2011, with a decline of 10% in 2012. Nevertheless, investments were very high, and double of the amount in the wind sector, indicating investors' interest in this sector (Bloomberg New Energy Finance, 2013).

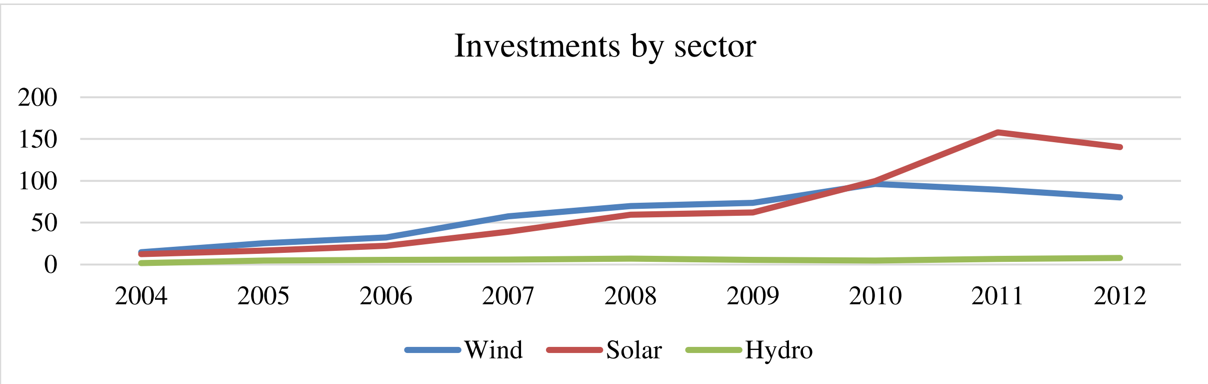

Figure 3. Investment levels by sectors

3.5. Hypothesis

Based on the former literature discussed in the previous sections, we can expect that our research will find a positive significant relationship between clean energy companies stock returns and oil prices after the shock in 2007/2008 caused by the Lebanon war. Before this shock there will most likely not be a significant relationship. The total research sample consists mostly of data points after the shock, thus we expect a significant relationship to be in the whole sample.

Despite the critiques about the Efficient Market Hypothesis, for the purpose of this research it is assumed that clean energy company stock prices adjust immediately to the changes of oil price or any other factors, meaning that there should not be any lags. In order to answer the first research question the following hypothesis was formulated:

Hypothesis 1: There will be a positive significant relationship between the oil price fluctuations and clean energy stock returns.

To formulate the hypotheses required for answering the second research question with regards to the different geographical areas, policies and investment levels were taken into account, because they both show the level of stimulation of clean energy industrial development in different countries. Since we do not have any clean energy companies in the Middle East and African region, this geographical area is excluded from our analysis.

In Europe, despite the decline of the investments during the last years, the investment level in renewable energy was the highest. This could possibly be explained by the constant development of the most European countries and therefore, it is expected that a larger amount of energy will be needed in this area, which is in in line with Fang and You (2014) evidence. The implication of this for our research is that we expect lower dependence on oil price when the investments are high, since based on already established infrastructure it will be possible to switch to clean energy faster.

We expect that investments stimulate growth in the industry and attract new investors, especially since in Asia/Oceania and to a lesser extent in Europe this trend can be seen over the last 10 years. As a consequence, solely based on investments we, therefore, expect that in Europe and Asia/Oceania the influence is lower than in the American region. However, it is important to emphasize that we do not have an access to investment levels during the last two years (2013/2014) of our sample and if the negative trend will continue, it is reasonable to assume that the picture will change.

Next to investment levels, we looked at the policies in different geographical areas. We believe that if a country subsidizes clean energy or punish companies which cause pollution by means of for example carbon taxes, the oil price will have less influence. This will occur because companies that use large amounts of energy will be affected by these policies through the revenue changes and will begin to use clean energy more. These companies will drive the demand for clean energy and therefore, a larger demand will stimulate investments in the stock market since clean energy companies are expected to perform well under these conditions.

It is expected that the more strict European policies will make the European region to be less dependent on the oil price fluctuations compared to the American region, which still has a potential for stimulation policies improvement. Based on policy matters, we expect the Asia/Oceania region to be stimulated by policy, but due to many problems among which are difficulties with infrastructure, policy will stimulate clean energy demand less than in the European region but more than in the American region.

Taking both investment and policy factors into account we hypothesize that the highest oil beta is expected in the American region, due to low and unstable investments and a policy which is not centralized and as stimulating as in the other areas. In the Asia/Oceania region a lower oil beta is expected, mainly due to difficulties with policy implementation, which can deteriorate corporate performance, while the stimulation through policy is expected to be effective and investment will continue to grow. The lowest oil beta is expected to be observed in Europe since policies are strict and ambitious, there is a strong control throughout all of Europe, and investments have been the highest until the last couple of years. Therefore, based on the information above in order to answer the second research question, the following hypotheses were formulated:

Hypothesis 2: There will be a higher oil beta in the American region than in the European and Asia/Oceania regions.

Hypothesis 3: There will be a higher oil beta in the Asia/Oceania region than in the European region.

In order to answer the third research question with regard to the sectors, sector characteristics such as cost of investments, period of starting production, resource dependency, regulations, and customer accessibility were analyzed for hypotheses formulation. We believe that these characteristics are important in researching the relationship between the oil price and stock returns of clean energy companies because they define a degree of sectorial development.

The majority of companies in the hydro sector generate energy. This sector is highly capital intensive since costs of building power plants are the highest among other sectors. Because the hydro sector is highly governmentally regulated and requires large capital investments, this sector is not accessible to a wide range of investors in contrast to the wind and to even larger extent solar sectors, where investments are smaller. To build a hydropower plant takes on average about 4-7 years depending on the plant size[22] which is expected to operate for 80-100 years (Ghenai and Janajreh, 2013). This means that investments in the hydro sector have a long-term time horizon. Additionally, hydroelectricity generation is highly dependent on the water availability. Based on these characteristics and a fact that the capacity of hydropower stations is fixed, when oil price rises causing the increase in demand for alternative energy, it is not possible to extend the capacity in the short run. Therefore, we expect the hydro sector not to be effected by oil price fluctuations.

In the solar sector there is a high diversity of companies which operations varies from equipment production, solar farm installation to energy generation. In contrast to the hydro sector, investments needed in this sector are not that high, which makes it more accessible to a larger number of investors. Investments in the solar energy sector have a short-term time horizon, since the period between the business establishment and products/energy production is not very long. Thus, the investments will be paid off faster than while investing into hydro sectors. Additionally, the expected life time of the solar as well as wind farms is only 20-30 years (Ghenai and Janajreh, 2013), meaning that there will be a demand for product renewal. Because products such as solar panels are widely available to the customers, cost efficiency can be achieved through the economies of scale leading to corporate performance improvement. Low entrance barriers and faster returns on investments make this sector attractive to investors. Therefore, when oil price increases, investors are able to react fast to this changes, and therefore it is expected that the solar sector will be the most dependent on the oil price fluctuations.

The business diversity of companies in the wind sector is comparable to the solar sector, which also provides a whole production chain from wind-mill equipment manufacturing, wind farm installation to wind energy generation. The wind sector is more capital intensive in installing

[22] http://en.aqper.com/index.php/faq-hydro/23-how-long-to-build-run-of-the-river-hydro-plant

and maintaining wind farms or producing wind turbines than the solar sector, but not to the extent of the hydro sector. Also this sector is stricter than the solar sector in terms of regulations of where power plants or wind-mills can be located, but less regulated than the hydro sector. The capacity of a wind farm is difficult to increase in comparison with other sectors, because the wind flows needed to generate power cannot be controlled. Therefore, we expect the wind sector to be more dependent on the oil price fluctuations than the hydro sector, but less dependent than the solar sector.

To conclude based on the industry distinct characteristics we expect the hydro sector to be the most independent from oil price fluctuations in comparison with the wind and solar sectors, while the solar sector will be the most dependent on the oil price changes. In line with the reasoning presented above, the following hypotheses can be formulated:

Hypothesis 4: There will be a higher oil beta in the solar sector than in the wind and hydro sectors.

Hypothesis 5: There will be a higher oil beta in the wind sector than in the hydro sector.

4. Methodology

This chapter presents the scientific approach of this thesis. It includes the research method, which is applied to the whole thesis, describes in detail the data collection process and in the econometric part it is explained how the econometric analysis is performed.

4.1. Research method

The research method of the thesis is determined by the topic selection, research design, research strategy and research approach, followed by the description of the research process.

4.1.1. Topic selection

In order to identify the research topic two groups of technique such as rational thinking and creative thinking were applied. In this research, rational thinking method was employed through scanning the media and literature, while creative thinking was originated from ideas and brainstorming (Saunders et al., 2009).

Initially, the inspiration about the research topic was obtained from scanning the media. From the Dutch article "Expected Oil Demand will Reach a Record in 2014" it was identified that oil demand in 2014 is expected to growth at the record rate, while the supply of oil at the end of 2013 experienced the strongest decline since 1999[23]. This situation led to an idea that due to the shortage of oil supply, price of oil will increase drastically in the future. After looking for more information regarding what can be influenced by this increase, from the article "6 Industries Hoping that Oil Prices Go Higher"[24] it was detected that different oil substitutes and alternative energy benefit from the increase in the oil price. Therefore, using brainstorming, the technique that can be applied to generate and refine research ideas (Saunders et al., 2009), the idea to study the effect of oil price increase on the performance of renewable energy companies was identified. Simultaneously, academic articles related to this topic were reviewed in order to identify whether previous research within this area was profound and if there is a gap in the literature that can be further eliminated and contributions to the existing literature can be made.

4.1.2. Research design

This research was initially designed as an explanatory study which aimed to describe the relationship between the variables (Saunders et al., 2009); stock performance of clean energy companies and oil price fluctuations. In line with the design of explanatory study, statistical

[23] http://www.nu.nl/beurs/3701461/olievraag-record-in-2014.html
[24] http://www.investopedia.com/financial-edge/0411/6-industries-hoping-that-oil-prices-go-higher.aspx

methods were applied and additional qualitative data was collected to explain the existence of this relationship. However, because this research is unique and intends to discover new insights of this relationship based on sectorial and geographical divisions, it also incorporates features of an exploratory study. The exploratory study design is applied when few or no previous research exists and concerned with new theory development (Saunders et al., 2009). Therefore, this thesis combines both explanatory and exploratory study designs which complements each other.

4.1.3. Research strategy

Based on the nature of this research, the large amount of measurable information was required to be processed and analyzed. Therefore, the quantitative research method was applied that explains phenomena through collecting numerical data and application of statistical methods (Aliaga and Gunderson, 2005). The major advantage of this method is the ability to conduct objective and transparent analysis based on quantifiable data that enables generalization to larger population (Bryman and Bell, 2011). In comparison to qualitative method that provides analysis through expressions rather than figures, this research method is highly detailed and structured (Fisher and Buglear, 2010). However to the lesser extent, qualitative method was also applied by reviewing and analyzing qualitative information for hypotheses formulation.

4.1.4. Research approach

A combined research approach using both deductive and inductive methods was applied in order to conduct this thesis. Under the deductive approach hypotheses are developed based on the defined literature framework, while under inductive approach, initially the data is collected and then hypotheses are formulated based on the results of data analysis (Saunders et al., 2009). Therefore, in order to answer the first research question the deductive approach was applied. The hypothesis was formulated based on the review of former theories and literature, after which the data set was collected for the hypothesis testing. Since the previous research conducted on this topic was not profound, based on the qualitative characteristics of the companies included in the sample, the second and third research questions were identified. Therefore, inductive method was applied in order to formulate corresponding hypotheses and test them for further contribution to the literature.

4.1.5. Research process

The process of this research was originated from the identification of a topic which can be of current interest. Followed by the topic selection, the literature framework review regarding the possible relationship between the oil price and clean energy stock prices was conducted and the research gap in the existing literature was discovered. In order to obtain a profound understanding about the clean energy industry, this market was explored and served as a basis for the formulation of the major research question and the corresponding hypothesis. After the data selection process was originated and the sample was obtained. Based on the characteristics of the included in the sample companies, more literature was reviewed in order to form four additional hypotheses. To perform more profound study on a corporate level, supplementary control variables were collected. All obtained information allowed to perform a profound quantitative and qualitative analysis aiming to answer formulated research questions. Consequently, the conclusions were drawn together with the suggestions for further research. The research process is visualized in Figure 4.

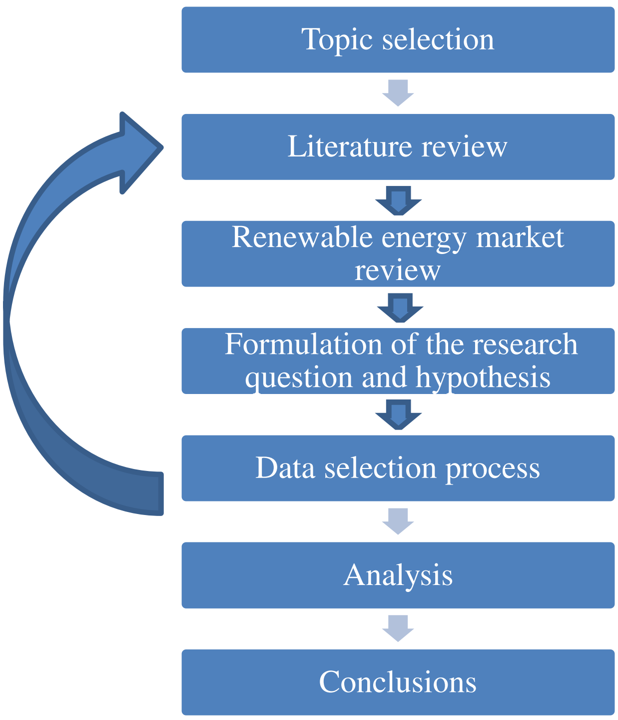

Figure 4. Research process

4.2. Data collection

This section describes two types of data used in the thesis; secondary data and academic data. Primary data was not used in this research because no unique data was obtained. In order to construct a representative sample a number of selection criteria were applied.

4.2.1. Secondary data

Two types of secondary data such as qualitative and quantitative were obtained in order to conduct the research.

4.2.1.1. Qualitative secondary data

Qualitative secondary data was carefully selected to obtain the most representative sample of the companies, which is presented in the Appendix 1. Originally, companies included in the research sample were retrieved from the Internet databases such as Alt Energy Stocks[25], Sustainable Business[26], Resource Renewables[27] and companies that comprise Wilderhill index[28]. These databases include names of currently listed renewable energy companies sorted by the energy type, updated stock prices, stock volume and companies' tickers. In order to obtain more profound sample of companies, key words such as "listed clean energy companies", "renewable energy stocks", "wind energy stocks", etc. were entered in the Google searching engine.

To collect information regarding companies, each company's ticker was entered into Yahoo Finance searching engine and under the title "company profile" facts regarding each company's headquarter and corporate web-page were obtained. If the company's ticker did no longer exist, the company's name was entered again in the Yahoo Finance search engine and after that the required information was collected. Further, for identifying what businesses companies operate in, each corporate web-page was carefully studied. The sections "investor relations", "our company", "our business", "about us", etc. were researched in order to understand each company's businesses and operations.

Information regarding clean energy industry, oil prices and other qualitative data that were used in the research were obtained through the reliable sources such as governmental web-pages, web-pages of different organizations and associations.

4.2.1.2. Quantitative secondary data

All quantitative secondary data used to conduct the research was retrieved during several sessions from DataStream database accessed in the LINC Finance Lab at the School of Economic and Management in Lund University. Stock prices of each corporation were retrieved by entering the company's name or ticker. In order to extend existing data set, key words such as "hydro power", "hydro energy", "wind energy", "solar energy" were entered into DataStream searching engine. Internet portal Yahoo Finance! was used to identify the volume of traded stock issues and which share class issues belong to. Corporate control variables;

[25] http://www.altenergystocks.com
[26] http://www.sustainablebusiness.com
[27] http://resourcesrenewables.com
[28] http://www.wildershares.com

market capitalization, return on assets, and total asset and leverage used to calculate debt ratio, were also obtained by entering corporate ticker. Other control variables represented by MSCI and PSE indexes were also obtained from DataStream. The Brent and WTI oil prices were obtained from DataStream database by searching in the section “commodities”.

4.2.2. Academic data

In this research, academic data was selected from scientific articles and books. Articles were the major source of the theoretical framework and they were found in the Lund University database LUBsearch, thus, their reliability and content were approved. The books used in this research were borrowed from the library of the School of Economics and Management. Different points of view were considered in order to create a complete and fair theoretical base for the analysis. Besides, attempts were made to use most updated information and researches. However, some less recent articles were still employed because of their critical content and applicability for the present time.

4.3. Econometric method

This section provides a description of the econometric data collected to conduct the research and explains what econometric method was chosen to perform the analysis.

4.3.1. Econometric data

Econometric data sub-section describes in the detail what selection criteria were applied in order to collect the representative sample, presents the sample size and explains what types of data were used in this research.

4.3.1.1. Sample selection criteria

The process of selecting secondary quantitative data was very complex. The major selection criteria for a company to be included in the sample was what renewable sector it operates in. However, other criteria were also applied in order to collect representative data sample for the research. Originally, the idea was to include into the sample as much listed companies that operate in all renewable energy sectors as possible. After studying each company, it was identified that many of them operate not only in different renewable energy sectors, but also in other unrelated business such as construction, transportation, mining, etc. Therefore, in order to have more representative results these companies were excluded. Additionally, companies that operate in any kind of oil-related business were also left out to ensure that results will not be biased due to correlation with oil prices. Also, initially it was decided that companies from a full range of renewable energy sectors such as wind, solar, hydrogen, hydro, biofuel, etc.

should be included in order to create a profound dataset. However, because there is very limited amount of companies in some sectors, only companies operating in the solar, wind and hydro sectors were included.

The solar energy sector includes companies that both generate energy by operating solar energy farms and/or produce equipment for this sector such as solar panels and solar cells. Wind industry also include companies that generate wind energy through the establishment of wind farms and/or produce wind energy related equipment such as wind turbines and windmill engines. The solar and wind energy sectors include only companies that have business within these areas, while the situation within the hydro sector is different. Due to limited amount of "pure" hydroelectric companies that only generate energy by means of river power or ocean power, it was decided to broaden the selection criteria. Thus, the companies were chosen based on the criteria that either the majority of the plants (>75%) owned by the company are hydroelectric plants, or because this type of energy is mostly generated by the company.

Regarding the geographical criteria which was identified after the sample was selected, companies were grouped based on their headquarter location. This factor was chosen over their market share position because not all companies provide this information on their web-pages. After identification of the corporate headquarters location, three main geographical area were clearly formed; American, European and Asia/Oceania. Since there are few companies located in Australia and New Zealand, which was not enough to create a separate representative group of Oceania, it was logical to combine the Asian and Oceania regions. The same situation is applied to the American and European regions. There are only two Brazilian companies and one Russian company in the sample, thus they were allocated to the American and European regions respectively.

Additionally, only companies that are currently listed were included in the sample. This criteria was identified because in general it was difficult to find companies operating in renewable energy industry, because there is no constantly updated complete database, and it was even more challenging to find companies that were previously listed during 2004-2014 and currently delisted.

Depending on the location of stock exchange where each company is listed, stock prices are quoted in different currencies. Since oil prices are originally in U.S. Dollars and DataStream database allows for currency conversion, each company's stock prices were retrieved in U.S.

Dollars. This automatic conversion was conducted in order to avoid possible currency fluctuations impact on stock prices and consequently stock returns.

Additionally, since the majority of listed companies have multiple share issues, it was important to identify which issue was the most appropriate to select. This was necessary in order to avoid stock correlation of one company within the sample. Ordinary shares issues were chosen over preferred shares because ordinary shares are publicly traded and better reflect the market changing environment. In case where several issues have large volumes, the issue with the largest volume was chosen.

4.3.1.2. Sample size

Based on the selection criteria described in the previous sub-section, 85 companies were included into the research sample. Based on the division into three sectors, 47 selected companies operate in the solar sector, 24 in the wind sector and 14 in the hydro sector.

Since the data was collected on a monthly basis during the last ten years and four months, the sample consists of 10 540 data points. However, because some selected companies were not listed during the whole period of January 2004 – April 2014, 2 690 data points are missing representing 26% of the sample. By the regional division, 3 235 observed data points were collected based on the American region, 2 583 observed data points based on the Asia/Oceania region and 2 032 observed data points based on the European region.

In the percentage equivalent, even though sub-sample of the European region consists of the least amount of observed data points, only 11% of the data points are missing in comparison with the American and Asia/Oceania regions' sub-samples, in which 25% and 38% of data points are missing, respectively. This can be explained by the fact that European countries started to be aware about environmental issues earlier than other countries, which in turn affected earlier emergence of publicly listed companies. Even though observed data points in the sample seem to be better represented by the European region, there is an adequate amount of observed data points in both the American and Asia/Oceania regions that enabled to provide objective and representative research.

4.3.1.3. Time Series Data

Brent Blend and West Texas Intermediate oil prices as well as control variables MCSI and PSE indexes were collected based on time series dimension. The time series data dimension reflects data that has been collected during a specified period of time on one or several variables (Brooks, 2008). Including in the regression, the oil prices and indexes were obtained from the

DataStream database on the monthly basis of the 1st day of each month during the period of January 2004 till April 2014 in U.S. Dollars.

4.3.1.4. Panel Data

The stock prices and control variables, except for market indexes, were collected and included in the data set as a panel data which by definition has the dimensions of time series and cross-sectional data (Brooks, 2008). The data obtained for the hypothesis testing was collected on a monthly basis during the period of the last ten years. Each data point is retrieved from DataStream on the 1st of each month. Selected data set begins from January 2004 and ends in April 2014 in order to conduct the most up-to-date research.

Cross-sectional data is data collected on one or more than one variable at a single point in time (Brooks, 2008). In the research individual observation number from 1 to 85 was denoted as an index for the each company in the sample. These numbers were randomly assigned following the order when including each company in the Excel file data set. However, for better organization each company was included based on their geographical location and sector in which the company operates. For example, first companies from the American region operating in the solar sector were included, then companies from the European region operating in the solar sector and finally companies from the Asian/Oceania region operating in the solar sector. The same principle was applied in order to include data from these regions in the wind and hydro sectors.

4.3.1.5. Control variables

Control variable is a variable included into the regression to study the relationship between two other variables[29]. Including control variables into this research enables to test the relative impact of oil price fluctuations on stock returns of clean energy companies while controlling for company specific variables. Adding control variables usually improves the fit of the model expressed by R^2 and adjusted R^2. However, it is important to take into account that including extra variables does not necessary lead to a better explained model. Adjusted R^2 imposes a penalty when an extra variable is added, making it possible to determine whether a new variable has any explanatory power. By adding the control variables the coefficients should be more reliable, as variability which is due to unexplained variables is excluded (Wooldridge, 2009).

[29] http://www.businessdictionary.com/definition/control-variable.html

It is expected that stock performance of a clean energy company is dependent on its firm size, profitability and debt level. Market capitalization, used as a control variable (*MARKET_CAP*), was chosen to be the most appropriate measure of a company's size as it represents the total firm value. This variable was calculated as a number of stocks outstanding multiplied by a stock price. A large volume of traded stocks indicate a company's liquidity, since investors are willing to invest more in a stock with a relatively high liquidity and or/market capitalization (Kerry Cooper et al., 1985).

Return on assets control variable (*ROA*) was used as a proxy for profitability. The higher the return on assets, the more efficient company is considered to be over a company with similar assets but lower return on assets (Brooks, 2012). As profitability can have a large influence on stock performance, this control variable was included into the regression in order to increase explanatory power.

Debt ratio control variable (*DEBT_RATIO*), expressed as a ratio of total debt and total assets, indicates a portion of corporate assets financed by debt (Brooks, 2012). Increase in a firm's leverage will lead to an increase of firm's financial risk, which can influence investors' behaviour (Shefrin, 2007). Change in debt ratio can reduce investors' willingness to invest in risky stocks which will result in lower stock returns. Therefore, having a significant impact on stock returns this control variable was included into the regression.

Previous research have found a great impact of macroeconomic environment on clean energy index returns and a large positive correlation between clean energy and technology index returns (Henriques and Sadorsky, 2008, Sadorsky, 2012, Huang et al., 2011, Kumar et al., 2012, Managi and Okimoto, 2013). Therefore, understanding the importance of these factors, Morgan Stanley Capital International Global Equity Index (*MSCI*) [30] and Arca Technology Index (*PSE*) were included as control variables.

4.3.2. Method of econometric analysis

This sub-section describes what regressions were used to perform the analysis, explains what tests were conducted to prove the model reliability and states how the regression should be interpreted.

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[30] http://www.msci.com/

4.3.2.1. Regressions

To identify whether the formulated hypotheses can be true or not, multiple regressions were run. In this research panel data was used. Using panel data either a pooled regression can be performed or, when unobserved heterogeneity is identified as a problem over time, fixed or random effects can be added to the pooled regression to mitigate this problem (Wooldridge, 2009).

When using fixed effects, dummy variables are added to the regression to control for time or cross-sectional effects. Random effects are a type of fixed effects, which are more efficient than regular fixed effects. Heterogeneity refers to an omitted variable which is fixed over time and correlated with independent variables. In this research, no fixed effect is used as in line with the research of Stărică and Granger (2005) we do not expect there to be heterogeneity, thus fixed effect have no explanatory power.

A panel least squares regression were run. Because this is a pooled regression the OLS assumptions should hold in order to interpret the data correctly. Therefore, in this research the OLS assumptions were taken into account and tested for (Brooks, 2008).

Returns of the stocks and oil prices were calculated. Stock return reflects stock price changes and indicates how much was earned or lost by investor in one time period. Therefore, stock return serves as a measure of corporate stock performance. Oil price return indicates the changes of oil price and measures oil price fluctuations. Furthermore, control variables *PSE* and *MSCI* were calculated as returns and these variables are unit free.

For the initial regression, which aims at researching the general relationship between stock price performance and oil price fluctuations, stock price returns of clean energy companies were used as a dependent variable. On the other side of the regression, oil price return based on WTI were used as an independent variable.

Therefore, the initial regression looks as follows:

1. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \mu_{t,i}$

S = Stock price returns of clean energy companies (%);

α_1 = intercept, indicates the expected mean value of the dependent variable when all independent variables are equal to zero;

β_i = sensitivity/slope coefficient of the respective variable;

OIL = Oil price returns (%).

In order to test whether the relationship between stock returns and oil price fluctuations differs in different geographical areas and sectors, dummy variables and interaction terms were added to the regressions. Dummy variable is included to incorporate qualitative factors into the regression. This variable can take a value of either 1 or 0 to indicate whether the characteristic is present or not (Wooldridge, 2009). The interaction term shows the interation between two variables and is generated by multiplying these variables (Wooldridge, 2009).

In this research three dummy variables were used to indicate in which geographical region a company is located (*AM, AO, EU*) and three dummies to indicate in which sector a company operates (*SOLAR, WIND, HYDRO*). Three dummy variables were used simulteneously (e.g. sectorial dummies) to test whether these sectors are significantly different from one another. In order to test this relationship, one sector was set as a base dummy variable (e.g. *SOLAR*) and the other two were tested against this one. The interaction term *OIL*WIND* indicates the difference in relationship with the oil price fluctuations between the wind sector and the solar sector. The interaction term thus shows the interaction between the variables *OIL* and *WIND*.

The base dummy variables *AM* and *SOLAR* were randomly chosen which should not have an impact on the results. Therefore, two following regressions look as follows:

2. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * AO + \beta_3 OIL * AO + \beta_4 * EU + \beta_5 OIL * EU + \mu_{t,i}$

3. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * WIND + \beta_3 OIL * WIND + \beta_4 * HYDRO + \beta_5 OIL * HYDRO + \mu_{t,i}$

AO = Dummy variable for the Asia/Oceania region;

EU = Dummy variable for the European region;

WIND = Dummy variable for the wind energy sector;

HYDRO = Dummy variable for the hydro energy sector.

In order to improve the goodness of fit of the three previous regressions and conduct a study on a corporate level, the control variables introduced in the previous section were included. Therefore, the following regressions were run:

4. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * MARKET\_CAP_{t,i} + \beta_3 * ROA_{t,i} + \beta_4 * DEBT\_RATIO_{t,i} + \beta_5 * MSCI_t + \beta_6 * PSE_t + \mu_{t,i}$

5. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * AO + \beta_3 OIL * AO + \beta_4 * EU + \beta_5 OIL * EU + \beta_6 * MARKET\_CAP_{t,i} + \beta_7 * ROA_{t,i} + \beta_8 * DEBT\_RATIO_{t,i} + \beta_9 * MSCI_t + \beta_{10} * PSE_t + \mu_{t,i}$

6. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * WIND + \beta_3 OIL * WIND + \beta_4 * HYDRO + \beta_5 OIL * HYDRO + \beta_6 * MARKET\_CAP_{t,i} + \beta_7 * ROA_{t,i} + \beta_8 * DEBT\_RATIO_{t,i} + \beta_9 * MSCI_t + \beta_{10} * PSE_t + \mu_{t,i}$

MARKET_CAP = Market capitalization;

ROA = Return on assets;

DEBT_RATIO = Debt ratio;

MSCI = Morgan Stanley Capital International Global Equity Index;

PSE = Arca Technology Index.

To test whether there is an actual difference between the Asia/Oceania and European regions and between the wind and hydro sectors, four additional regressions were performed using *AO* and *WIND* as base dummy variables. Two of these regressions were without the control variables and in the other two they were included:

7. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * AM + \beta_3 OIL * AM + \beta_4 * EU + \beta_5 OIL * EU + \mu_{t,i}$

8. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * SOLAR + \beta_3 OIL * SOLAR + \beta_4 * HYDRO + \beta_5 OIL * HYDRO + \mu_{t,i}$

9. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * AM + \beta_3 OIL * AM + \beta_4 * EU + \beta_5 OIL * EU + \beta_6 * MARKET\_CAP_{t,i} + \beta_7 * ROA_{t,i} + \beta_8 * DEBT\_RATIO_{t,i} + \beta_9 * MSCI_t + \beta_{10} * PSE_t + \mu_{t,i}$

10. $S_{t,i} = \alpha_1 + \beta_1 * OIL_t + \beta_2 * SOLAR + \beta_3 OIL * SOLAR + \beta_4 * HYDRO + \beta_5 OIL * HYDRO + \beta_6 * MARKET\_CAP_{t,i} + \beta_7 * ROA_{t,i} + \beta_8 * DEBT\_RATIO_{t,i} + \beta_9 * MSCI_t + \beta_{10} * PSE_t + \mu_{t,i}$

AM = Dummy variable for the American region;

SOLAR = Dummy variable for the solar energy sector.

4.3.2.2. Ordinary Least Squares assumptions tests

In order to identify if an OLS regression can be used, the following OLS assumptions have to be tested (Brooks, 2008):

1. The errors have a zero mean: $E(\mu_t) = 0$
2. Homoscedastisity, the variance of the errors is constant and finite over all values of x_t: Var $(\mu_t) = \sigma^2$
3. Autocorrelation, the errors are statistically independent of each other: Cov $(\mu_j , \mu_i) = 0$
4. Exogeneity, there is no relationship between the error and corresponding x variables: Cov $(\mu_t , x_t) = 0$

The first assumption indicates that the error term should be normally distributed. To measure this a Jarque-Bera test (Jarque and Bera, 1980) should be performed using a distribution histogram. A deviation from normality can have two causes; either the distribution is not symmetrical (skewness) or the tails are too fat (kurtosis). A normal distribution is said to be mesokurtic, when the coefficient of kurtosis equals to 3 and the skewness equals to 0. Deviations from this will result in either leptokurtic (kurtosis > 3) or platykurtic (kurtosis < 3). If the skewness is positive, the distribution is skewed to the right, while negative indicates that distribution is skewed to the left (Brooks, 2008).

The second assumption of homoscedasticity can be tested by the Breusch-Pagan-Godfrey test and the White test. Homoscedasticity indicates a constant variance in the error terms and if this is ignored, the standard errors can be incorrect leading to wrong inferences. It can be tested by regressing the independent variables on the squared residuals of the regression. If the F-statistic of the regression is significant, the null hypothesis of homoscedasticity is rejected and heteroscedasticity is detected. This problem can be solved by using either White Heteroscedasticity-robust Standard Errors or logged variables to reduce the size effect (Brooks, 2008).

Next to normality it is important to test for autocorrelation, especially if time-series data is used. Autocorrelation refers to the relationship between a residual and its preceding residual. The consequence of ignoring autocorrelation are inefficient regression coefficients, which means that when positive autocorrelation is detected in the serial residuals, the standard error will be downward biased compared to the "true" standard errors. Thus, the variability is understated. This increases the tendency to reject the null hypothesis of the regression when it should not be rejected. Also the fit of the model (R^2) is likely to be inflated indicating a better fit than actually is the case (Brooks, 2008). Autocorrelation can be tested by looking at the Durban-Watson test statistic for first order autocorrelation (Durbin and Watson, 1951). The Durban-Watson test statistic ranges between 0, indicating perfect positive autocorrelation, and 4, indicating perfect negative autocorrelation. A value of 2 indicates no autocorrelation (Brooks, 2008).

If the fourth assumption is violated, the problem of endogeneity arises. Endogeneity is correlation between the independent variables and the error term which can be caused by omitted variables, simultaneity, measurement error etc. If not mitigated it can lead biased and inconsistent parameter estimates resulting in unreliable inferences. Endogeneity can be detected by using two-stage Hausman test. This problem can be mitigated using instrumental variables that should be both partially correlated with the endogenous variable (instrumental relevance) and have no correlation with the dependent variable (instrumental exogeneity) (Roberts and Whited, 2011).

4.3.2.3. Interpretation of the regression results

The purpose of this study is to observe whether fluctuations in the oil price affect stock returns of clean energy companies, and if this relationship is different between the three geographical areas and between the three sectors. Therefore, the interest is in the coefficient (β value) of *OIL*. For the geographical regions, the coefficient of the American region was obtained by looking at β_1 in the regression, while the coefficients for the Asia/Oceania and European regions were obtained by adding up the β_3 and β_5 to β_1 respectively. Coefficients β_3 and β_5 state the difference between Asia/Oceania and Europe, and America with respect to the influence of the oil price fluctuations. The same logic will be applied when testing for the sectors.

4.3.2.4. Robustness check

The robustness check tests whether the model is robust, meaning that the model has to be consistent while adding or removing regressors. Its purpose is to test the model validity and the insensitivity to alterations of assumptions (Lu and White, 2014). In this research this test was conducted in two different ways. At first, control variables were added to see if the same result were yielded and afterwards the whole research were repeated with another benchmark of oil, to see if the relationship holds in general, and not solely for the WTI oil price. Therefore, the whole research was replicated with the Brent oil price. These two measures are used to price oil with similar characteristics, and thus should follow the same trend and influence stock prices in the same way.

5. Empirical Analysis

This chapter begins with the summary of the collected data used for conducting this research. Then, the descriptive statistics is presented followed by the analysis section, which includes the discussion of the obtained results.

5.1. Data Description

Based on the selection criteria described in the methodological chapter, the sample of this research consists of 85 companies. According to the sector criteria, all companies were divided into three groups. As can be seen in Figure 5, there are 47 companies (55%) in the solar sector, 24 companies (28%) in the wind sector and 14 companies (16%) in the hydro sector.

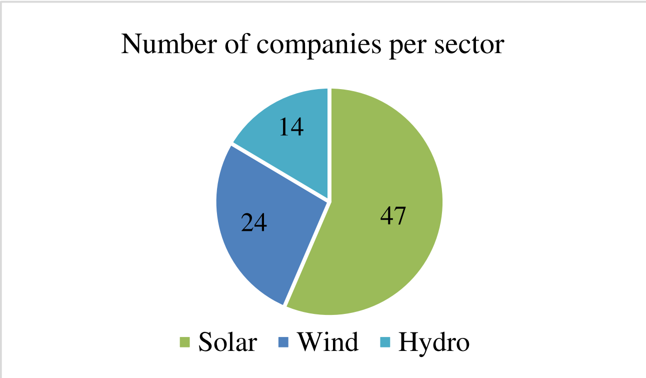


Figure 5. Sample division based on sectorial criteria

Companies operating in the solar sector produce a wide range of solar energy related products. The most common products manufactured by the companies and included into the sample are solar panels. Some companies produce only components such as solar cells, while another provide the whole chain for solar panels assembly and fully integrated plants. There are 18 companies in the sample that produce only components and/or solar panels. Another 14 companies provide complex solutions and fully integrated systems that include manufacturing, installation, servicing and maintenance of solar panels. There are 2 companies that build solar farms and generate solar energy which afterwards is sold to the end customer. Additionally, one company in the sample provides capital equipment for manufacturing solar cells and modules, one company produces only inverters that transmit energy from solar panels to central inverter devices, and one company develops and installs electric vehicle autonomous. The remaining 10 companies are diversified and produce a wind range of different products and services in the solar energy sector. A number of companies develop unique technologies secured by patents and trademarks. Companies selected into the sample operate either in the local market or has international operations.

With regards to the wind energy sector, companies included in the sample can be divided into 4 categories. The majority (9 out of 24 companies) develops and manufactures wind turbines, and provides related services. There are 8 companies in the sample that not only produce wind turbines, but also plan, install and operate large scale wind power plants. Another 6 companies that own wind farms, generate wind energy. Additionally, one company is a manufacturer of wind turbine components such as wheels and gear boxes. The companies, as in the solar sector, operate both locally and globally.

The sub-sample of the hydro sector consists of the companies which generate at least 75% of total energy production by means of hydroelectric power. In this sector, 23 companies out of 24 generate energy from river power and only one company from ocean power. All companies in the sub-sample are regulated utilities. 10 companies are privately owned and operate locally due to more easy access to the national hydro resources. One company that operates in the country of origin is not privately owned, but operates under contractual agreement with the government. The remaining companies in the sub-sample have operations both locally and internationally, having a tendency to realize projects and run energy generating plants in the neighboring countries. There are 2 companies that are privately owned and one company that operates as an asset management company.

According to the geographical criteria, the sample was divided into three geographical regions based on the headquarter location of each company. As can be seen in Figure 6, there are 34 companies (40%) that operate in the American region, 31 companies (36%) operating in the Asia/Oceania region and 20 companies (24%) that operate in the European region.

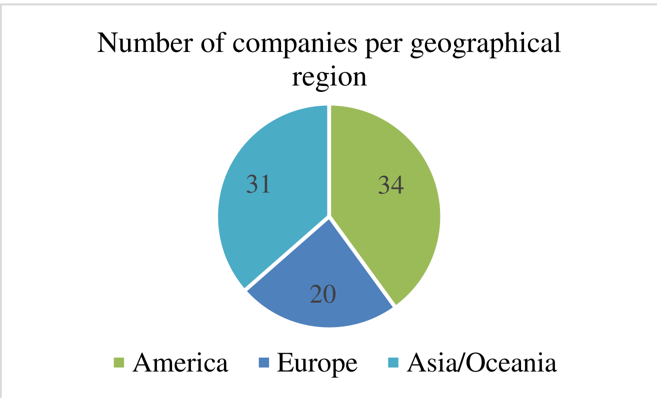


Figure 6. Sample division based on geographical criteria

Looking at the solar sector independently, 18 companies (38%) are located in the American region, 17 companies (36%) are located in Asia/Oceania region and 12 remaining companies (26%) come from European region as can be seen in Figure 7.

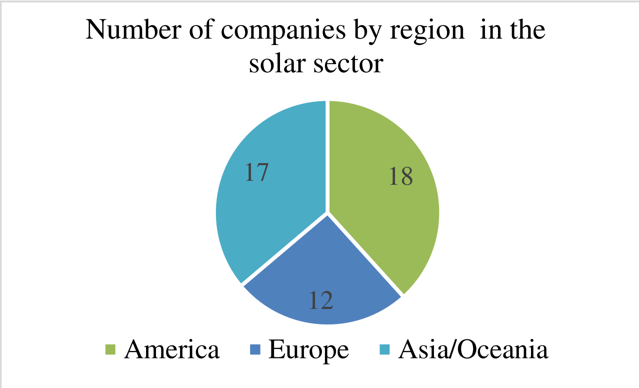


Figure 7. Number of companies by region in the solar energy sector

Furthermore, from the sub-sample of the solar energy companies presented in Appendix 2, it can be seen that the majority of the companies in this sector are located in the U.S., China and Germany. These companies comprise 72% of all companies operating in the solar energy sector. In the remaining countries there are only 1 to 3 companies operating in this sector.

In the wind energy sector, as can be seen in Figure 8, there are 10 companies (43%), the majority, located in the Asia/Oceania region, while 8 companies (33%) located in America region and 6 companies (25%) in Europe region.

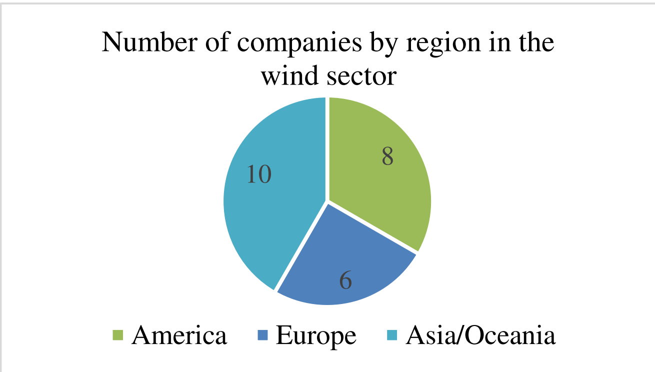


Figure 8. Number of companies by region in the wind energy sector

From Appendix 2, it can be seen that the majority of companies operating in the wind sector are located in China, Canada and the U.S. These companies comprise 63% of total companies operating in wind energy sector. The remaining countries have only 1 or 2 companies that are located in this sector.

Looking independently at the wind energy sector in Figure 9, 9 companies (64%) are located in the American region, 4 companies (29%) are located in Asia/Oceania region and 1 remaining company (26%) comes from European region. In Europe, there is the only publicly listed company located in Russia, because companies that represent Europe are state owned.

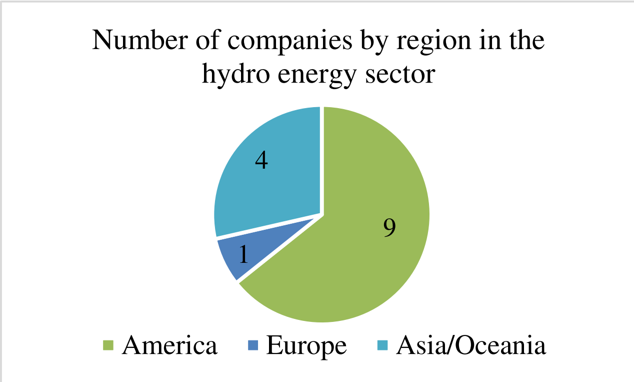


Figure 9. Number of companies by region in the hydro energy sector

From the sub-sample of hydro companies presented in Appendix 2, it can be seen that the majority is located in Canada, China, Brazil and the U.S. These companies comprise 79% of total number of companies that operate in the hydro energy sector. The remaining 3 companies that generate hydroelectricity are located in Bermuda, Russia and India.

5.2. Descriptive statistics

In order to summarize the sample, the descriptive statistics is presented in the Table 1.

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
Dependent variables						
RETURN	0.069206	0.00	297.7424	-1000000.	3.473736	7757
RETURN_TRM	0.000417	0.00	0.433159	-0.34	0.187219	7757
Independent variables						
RET_WTI	0.013679	0.014624	0.314488	-0.35	0.093804	10455
RET_BRENT	0.015159	0.025466	0.296744	-0.35	0.095971	10455
Control variables						
MARKET_CAP	1610325.	165943.0	25114975	17.00000	3567624.	6719
ROA	-0.31	0.008050	27.06580	-5376000.	2.817999	7416
DEBT_RATIO	0.597991	0.244481	157.0000	0.000000	6.207850	7987
MSCI	0.012369	0.017391	0.372900	-0.26	0.114193	6460
PSE	0.009403	0.008659	0.150838	-0.16	0.054206	10455

Table 1. Descriptive statistics

As depicted from the table, *RETURN* has a mean value of 6.92% and a very high maximum, which indicates a return of 29774%. *RETURN_TRM* was created in order to eliminate a problem of extreme outliers, but it will be discussed later in the analysis. It can be seen that *RETURN_TRM* has a slightly positive mean of 0.04% and a standard deviation of 18.72%. This indicates a positive trend with a high volatility. The means of *RET_WTI* and *RET_BRENT* are 1.37% and 1.52% respectively, with standard deviation values of 9.38% and 9.60% respectively. These variables follow the same trend in all descriptive statistics and are less volatile than the dependent variable.

The WTI and Brent oil prices are correlated for 87%, as can be seen in the correlation matrix (Table 2). Another significant correlation of 70% can be seen between the *MSCI* and *PSE*. The dependent variable is significantly positively correlated with *RET_WTI* (35%) and *RET_BRENT* (29%). Also the *MSCI* and *PSE* are correlated with the prices of oil, indicating that oil price fluctuations affect the stock market. In order to perform a regression, there must not be high correlation between two independent variables. Multicollinearity affects the coefficient calculation of the correlated independent variables, but not the predictive power of the model as a whole (Brooks, 2008). As can be seen in the matrix, multicollinearity was not detected for this set of variables. *RET_WTI* and *RET_BRENT* are correlated, but never used simultaneously in a regression, thus there is only one independent variable. Furthermore, the *MSCI* and *PSE* indexes are also highly correlated, but as they are only used as control variables and their coefficients are not interpreted, this is not a problem.

	RETURN_TRM	RET_WTI	RET_BRENT	MARKET_CAP	ROA	DEBT_RATIO	MSCI	PSE
RETURN_TRM	1							
RET_WTI	0.35*** (25.00)	1						
RET_BRENT	0.29*** (20.11)	0.87*** (117.53)	1					
MARKET_CAP	0.05*** (3.03)	0.01 (0.66)	0.01 (0.50)	1				
ROA	0.02 (1.40)	-0.01 (-0.63)	-0.02 (-1.22)	0.13*** (8.60)	1			
DEBT_RATIO	-0.02 (-1.54)	0.00 (0.107	0.00 (0.06)	-0.03** (-2.04)	-0.03* (-1.94)	1		
MSCI	0.36*** (28.30)	0.54*** (42.11)	0.45*** (33.34)	0.02 (1.30)	-0.00 (-0.15)	0.00 (0.24)	1	
PSE	0.47*** (34.79)	0.65*** (56.82)	0.52*** (40.11)	0.02 (1.17)	-0.01 (-0.80)	0.01 (0.49)	0.70*** (63.90)	1

* , ** , *** denote 10%, 5%,1% significance levels respectively, t-statistic in parentheses.

Table 2. Correlation matrix

5.3. Analysis

5.3.1. OLS Assumptions

At first, the OLS assumptions are tested for the initial regression: $S_{t,i} = \alpha_1 + \beta_1 * Oil_t + \mu_{t,i}$. In Table 3, the test results of the initial regression are illustrated. The goodness of fit, measured by the R^2 equals to zero, indicating that the model has no explanatory power. The regression is highly insignificant (0.76).

Pooled regression, no effects Dependent variable: RETURN	
	Model 1
Independent variables	
RET_WTI	0,127 (0,303)
R^2	0,000
Adjusted R^2	-0,000
F- statistic	0,0917
Prob. (F-statistic)	0,762
Durban-Watson statistic	2,029
Observations	7757

* , ** , *** denote 10%, 5%, 1% significance levels respectively. Standard Errors are presented in parentheses

Table 3. Regression result

The result of the normality test is illustrated in Figure 10**.** The output shows that there is a large deviation from normality and several outliers can be depicted. As also seen in the descriptive statistics table, the most extreme outlier gives in one month a stock return of around 30 000% and therefore is not representative for the sample. This resulted in highly positive skewness of the residuals equal to 81.63 and a kurtosis equal to 6959.99, which indicates that the residuals are highly leptokurtic and highly deviate from the expected value of 3. Since the calculations of the coefficients depend on the assumption of normality, this problem needs to be mitigated.

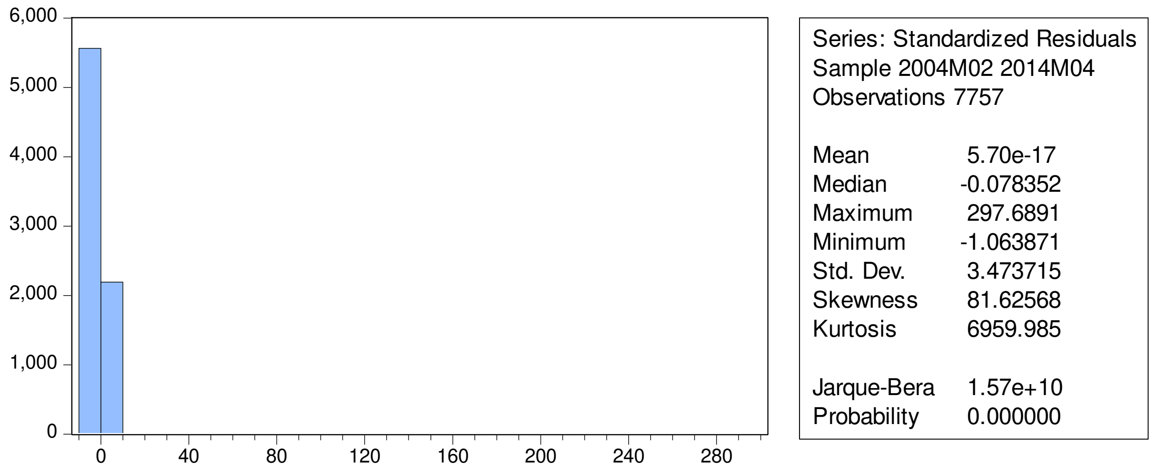
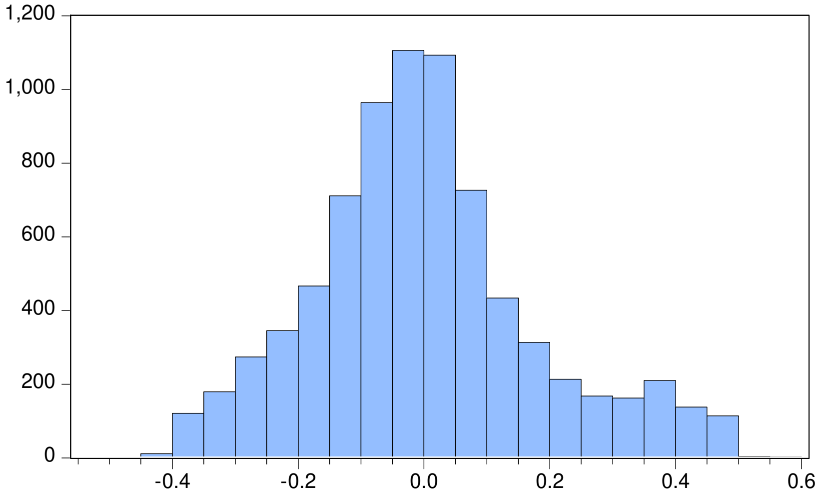


Figure 10. Histogram of the initial regression

In order to mitigate the normality problem, and make the regression more reliable, there are two possible options; either to "trim" the data or use winsorization. When trimming the data, outliers are removed from the sample using a dummy variable. Winsorizing brings back outliers to a certain point and no data is excluded from the sample (Salkind, 2010). We use winsorization for this dataset because we believe that these outliers indicate a relationship and do not want to exclude the observations due to their limited amount. The outliers below the 5^{th} percentile and above the 95^{th} percentile are set to these values. The results of the regression with the new dependent variable *RETURN_TRM* can be found in Appendix 3 and the histogram in Figure 11**.** As can be seen in the histogram the situation has improved. The kurtosis has a value of 3.28, which is close to normality, and the Skewness is slightly positive at 0.48. Nevertheless, the null hypothesis of the Jarque-Bera test is rejected, thus the normality assumption is rejected. However, for not distorting the data any further, it was decided that we will take this fact into account when analysing the final regression.



Series: Standardized Residuals	
Sample 2004M02 2014M04	
Observations 7757	
Mean	1.13e-17
Median	-0.012682
Maximum	0.557135
Minimum	-0.503635
Std. Dev.	0.180036
Skewness	0.487258
Kurtosis	3.289057
Jarque-Bera	333.9506
Probability	0.000000

Figure 11. Histogram after winsorization

The goodness of fit increased to 7.5%, and the regression output is significant. The R^2 explains how much of the independent variable is explained by the independent variables (Wooldridge, 2009). The R^2 is still very low and the coefficients should be interpreted more carefully, but conclusions can be drawn from the research if the coefficients are statistically significant. A low goodness of fit does mean there are other factors unknown to us or difficult/impossible to measure, which can influence the coefficient. Goodness of fit is not an OLS assumption, and thus has no large influence on the significance of the model.

Next to normality, it is important to test for autocorrelation, since the time-series data is used. In Appendix 3, the result of the Durbin-Watson test is presented. The Durbin-Watson test statistic is equal to 2.06, which indicates no autocorrelation because this value is very close to 2. For all models, the Durbin-Watson test statistics is close to 2. This means that the second OLS assumption holds.

Heteroscedasticity test was performed in order to test whether the third OLS assumption holds. Homoscedasticity can be tested for by regressing the independent variables on the squared residuals, as can be seen in Table 4. The F-statistic of the regression is not significant at a 5% level, and thus the null hypothesis is not rejected meaning that no heteroscedasticity is found. Therefore, it can be concluded that the third OLS assumption of homoscedasticity is confirmed.

Pooled regression, no effects Dependent variable: REDIS_SQ	
Independent variables	
RET_WTI	0,032*** (0,001)
R^2	0,000
Adjusted R^2	0,000
F- statistic	3,489
Prob. (F-statistic)	0,062
Durban-Watson statistic	1,665
Observations	7757

* , ** , *** denote 10%, 5%, 1% significance levels respectively. Standard Errors are presented in parentheses

Table 4. Heteroscedasticity test

Finally, the fourth OLS assumption of exogeneity should be tested. In this field of studies, there are no instrumental variables to be found that influence oil price but not clean energy stock prices, as due to the substitution effect stock prices in the whole energy market are affected when the supply or demand of oil changes. Even if there is endogeneity problem, it is impossible to solve it using instrumental variables. Therefore, in this research it is assumed that there is no endogeneity.

5.3.2. Hypotheses testing

Hypothesis 1: There will be a positive significant relationship between the oil price fluctuations and clean energy stock returns.

In Appendix 3 the outputs of all regressions can be found. Models 1 and 4 test the overall sample on this relationship, while models 2, 3, 5 and 6 test whether there are differences between geographical locations or sectors. In almost all cases the coefficients of *RET_WTI* are significantly positive, indicating this relationship is true and our hypothesis can be confirmed.

When including the control variables, in all cases the R^2 and adjusted R^2 have increased to 23%. Compared to the initial regression, the influence of oil price fluctuations is lower when using control variables. However, as the distribution is not normal, we will not be able to draw conclusions based on the actual values of the coefficients, but we will look at the relationship in terms of positive/negative and higher/lower. Since former research tested the relationship with the PSE index, this research has taken this into account. In all models using control variables the PSE has a significant positive effect of approximately 0.97, which is higher than the dependence of clean energy stock returns on the oil price fluctuations. The result of the regressions including control variables make the answer to the research question more reliable, as we increased the model fit. We can conclude a positive relationship; when the oil price increases, the stock price of clean energy companies increases significantly.

Hypothesis 2: There will be a higher oil beta in the American region than in the European and Asia/Oceania regions.

Hypothesis 3: There will be a higher oil beta in the Asia/Oceania region than in the European regions.

Models 2 and 5 show the regressions, including dummy variables for the geographical locations. America (*AM*) is used a base dummy variable and Europe (*EU*) and Asia/Oceania (*AO*) are compared to it. This is conducted in order to prove whether Hypothesis 2 is true. The regression output can be seen in Appendix 3.

The regression is performed two times using different base dummy variables to obtain the significance of the coefficients. At first, base variable *AM* is used, as indicated before, and afterwards *AO* is used as a base variable to make it possible to compare the European region to Asia/Oceania for testing Hypothesis 3. The result of this regression can be seen in Appendix 4.

The coefficient in the American region equals 0.444. This indicates that when the oil price rises by 1 unit, the stock performance significantly increases by 0.444 units. The interaction term *AO*RET_WTI* indicates interaction between geographical location Asia/Oceania and the oil price, compared to the influence of oil price in the American region. The coefficient for the Asia/Oceania region is calculated as 0.444 + 0.184 = 0.628, which is also consistent with the coefficient when we use *AO* as a base dummy variable. This indicates a higher dependence of clean energy stock performance on oil price changes in the Asia/Oceania region compared to the American region, which is not in line with our expectations based on policy and recent investment levels. In the European region the coefficient is 0.607. This indicates a higher dependence in the European than in the American area, which is again not in line with our expectations. To summarize, the highest dependence can be seen in the Asia/Oceania, followed by the European and lastly American region. The Asia/Oceania and European region cannot be proved to be significantly different from one another.

When adding control variables the coefficients become lower, which can also be seen in the initial regression. The results of Model 5 are slightly different from Model 2. The highest influence can be seen in Asia/Oceania, but it is not significantly different. The American region does not show a significant relationship, which is not in line with Hypothesis 1. The other two regions do show a significant positive dependence on the oil price fluctuations. Asia/Oceania and Europe are significantly different from the American region, but not significantly different compared to one another, therefore Hypotheses 2 and 3 have to be rejected. However, the data does show a significant difference between the American region and the other two regions, indicating that the regions are not affected by oil price fluctuations at the same degree.

Overall, clean energy companies stock returns in the American region shows the lowest dependence on oil price fluctuations. When adding control variables no significant dependence can be concluded. Companies in the Asia/Oceania region and the European region do show a significantly higher dependence. The latter two regions cannot be proved to be significantly different from one another. To conclude, there is a significant difference in dependence between different geographical regions.

Hypothesis 4: There will be a higher oil beta in the solar sector than in the wind and hydro sectors.

Hypothesis 5: There will be a higher oil beta in the wind sector than in the hydro sector.

The results of Models 3 and 6 take into account dummy variables for the three different sectors. Compared to the solar sector, hydro and wind sectors are significantly different in both models. In Appendix 4, the regression using *WIND* as a base dummy variable is presented, and it can be concluded that the wind and hydro sectors are not significantly different from one another in Model 3. This significance changes in Model 6, where it can be seen that companies in these sectors are affected at a different degree by oil price fluctuations.

The solar sector is significant and positively influenced by the oil price changes with a coefficient of 0.653 without and 0.710 with control variables. The regression without control variables shows the highest dependence on the oil price for the solar sector followed by the wind sector and lastly the hydro sector. This does not change when adding control variables, but when adding them, all relationships become significant, where initially hydro and wind were not significantly different from one another.

In conclusion, we can see a clear positive relationship for all sectors and differences between the sectors are also significant. The highest influence is found in the solar sector, followed by the wind sector and the lowest influence can be observed in the hydro sector. Therefore, it can be concluded that the hypotheses are true.

5.4. Robustness check

To test for robustness of the model, the regressions were replicated using the Brent oil price and the results can be seen in Appendix 5. The positive relationship between oil price fluctuations and clean energy company stock returns can be depicted in all regressions but Model 5. However, the coefficients are lower when testing for the Brent oil price without control variables and higher when adding control variables. This indicates that the relationship is different when using the Brent oil price compared to using WTI. This also indicates further research is necessary to establish the actual relationship between oil price fluctuations and clean energy stock return. However, the significant positive relationship between oil price fluctuations and stock returns of clean energy companies is confirmed again.

5.5. Possible explanations for deviations from Hypotheses 2 and 3

We hypothesized the highest oil beta to be in the American region, while the results show this is the lowest compared to other regions. The deviation from our hypotheses is probably due to factors we have not taken into account when formulating the hypotheses. The U.S. is recently becoming an oil exporter[31] and since it is the largest part of the sample for the American region this could have an impact. Asteriou et al. (2013) has researched the relationship between oil price fluctuations and stock prices, and found that the impact of an oil price shock on oil importing countries is more significant than on oil exporting countries. This could explain the significantly lower dependence on oil price in this region compared to the other regions. We did not take this factor into account when building hypotheses, as we did not expect this to be of relevance since research from Wang et al. (2013) suggests the opposite. Another factor which can explain the deviation is that we did not have an access to investment levels during the last two years (2013/2014) of our sample and if the negative trend will continue, it is reasonable to assume that the relationship will change.

[31] http://www.bloomberg.com/news/2013-11-12/u-s-nears-energy-independence-by-2035-on-shale-boom-iea-says.html

6. Conclusion

This final chapter provides the summary of the research intentions and the research results. Furthermore, the contribution of this research, implications for both investors and managers of clean energy companies, and further research suggestions are presented.

6.1. Summary of the research results

This thesis aimed to find a relationship between oil price fluctuations and clean energy companies' stock returns. Furthermore, the research aimed to explore whether there are differences in oil price dependence between different geographical areas and between different sectors. This topic is of importance, as more investments are needed in this sector. The present society is in need of alternative energy sources which can have the least pollution effect and substitute fossil fuel based energy in the future. In the transition period, the different sources of energy need to coexist and companies are direct competitors. The price of oil and consequently price of oil based energy influence the demand for clean energy, therefore influencing the performance of clean energy firms. Our aim is to explain a part of the performance of clean energy stocks, as investors are more willing to invest when there is more information known. To research this topic three research questions were formulated:

1. What is the effect of oil price fluctuations on clean energy companies' stock performance?
2. Is there a difference between the American, European or Asia/Oceania regions regarding this relationship?
3. Is there a difference between the solar, wind or hydro energy sectors regarding this relationship?

With regards to the first research question, a clear positive relationship was found in all regressions in line with the former literature. As no former research has been conducted with regards to geographical locations, we have built our hypotheses based on policies and investment levels to answer the second research question. We expected that there would be differences between the geographical locations, and based on policies and investment levels we hypothesized there to be a low dependence in the European region, as policies are very strict and investments have been very high. For the Asia/Oceania region we expected a higher dependence than in Europe, as policies are in place, but infrastructure is lacking and policy implementation faces difficulties. Investments in this region grow rapidly and steadily, which we believed is decreasing dependence on the oil price. We expect the American region to be most dependent on the oil price, as policies are in need of centralization, and investment levels are lower compared to the other regions.

Our research found the highest dependence in the Asia/Oceania region, followed by the European region, and lowest dependence can be seen in the American region, therefore the formulated hypotheses were not confirmed. Adding control variables companies in the American region are not significantly dependent on oil price fluctuations. The deviation from our hypotheses is probably due to factors we have not taken into account while building the hypothesis. The U.S. is becoming an exporter in recent years and since it is the largest part of the sample for the American region this should have an impact. Asteriou et al. (2013) has researched the relationship between oil price fluctuations and stock prices, and found that the impact of an oil price shock on oil importing countries is more significant than on exporting countries. This could explain the significantly lower dependence on oil price in this region compared to the other regions. We did not take this factor into account when building hypotheses, as we did not expect this to be of relevance since research from Wang et al. (2013) suggest the opposite.

In order to answer the third research question with regard to the sectors, sector characteristics such as cost of investments, period of starting production, resource dependency, regulations, and customer accessibility were analyzed for hypotheses formulation. We expected there to be differences between these sectors. We hypothesized that the solar sector should be dependent the most on the oil price fluctuations, as low entrance barriers and faster returns on investments make this sector attractive to investors. The least dependence was expected to be in the hydro sector, as during operations there is limited possibility to increase capacity, the high regulations in the industry and other factors. The wind sector also has limited capacity improvement capabilities, but the industry is less regulated, and therefore there is more flexibility than in the hydro sector. As a result of our analysis, the formulated hypotheses were confirmed.

In conclusion, a significant positive relationship can be found. Next to this, also significantly lower impact can be seen in the American region, compared to European and Asia/Oceania. Furthermore, all sectors are significantly different from each other. The solar sector has a significantly higher dependence compared to wind and hydro, and the wind sector has a significantly higher dependence on the oil price fluctuations than the hydro sector.

6.2. Contribution of the research

This is the first research conducted on the corporate level since it includes variables that reflect firm characteristics. Using these variables, it was possible to control for firm specific factors, which are disregarded in the index based studies. Additionally, this research studied only "pure" clean energy companies, which do not have operations within unrelated to clean energy and/or oil related businesses. Therefore, this research is novel and is expected to provide a good contribution to the literature.

6.3. Implications for investors and management of clean energy companies

This study has shown a significant positive effect on clean energy stock prices when the price of oil increases. As the oil price is expected to rise in the coming years, clean energy companies are expected to perform well. One factor that explains clean energy company performance is emphasized, which can lead to better investor knowledge enabling investors to make more informed and rational choices. As part of the stock return changes can be attributed to oil price fluctuations and are thus explained, more risk-averse investors can have a higher willingness to invest in clean energy stocks. This serves the purpose of our research: to get more investments in the clean energy market in order to reduce environmental impact.

From a managerial perspective, there is more knowledge about what influences performance on the demand side. When the oil price is forecasted, there can be better forecasts of demand, and supply can be adjusted accordingly. Managers can make better business decisions with regards to investments, and the performance of the firm can be enhanced.

6.4. Further research suggestions

In order to improve the knowledge in this field of studies, companies which were delisted during the observed period should be included to give a better overview. Also performing the research with a larger sample would increase reliability. We recommend testing the relationship including more sectors of renewable energy in order to expand the research further. This would benefit the smaller sectors, as uncertainty about their performance can be reduced and attract new investors. Furthermore, testing the dependence of companies which specialize in multiple sources of clean energy can add to the knowledge about the market. By performing research with a bigger sample on a country level, it can be tested if there is a relationship in dependence between oil importing and oil exporting countries, and macroeconomic factors can be controlled for at a country level, for example interest rate and policy. As our research was limited by the low R^2, it is recommended that more factors explaining clean energy stock performance are sought and investigated. It can also be tested whether the relationship differs when using coal or natural gas prices, as it is desirable to substitute these sources of energy generation as well.

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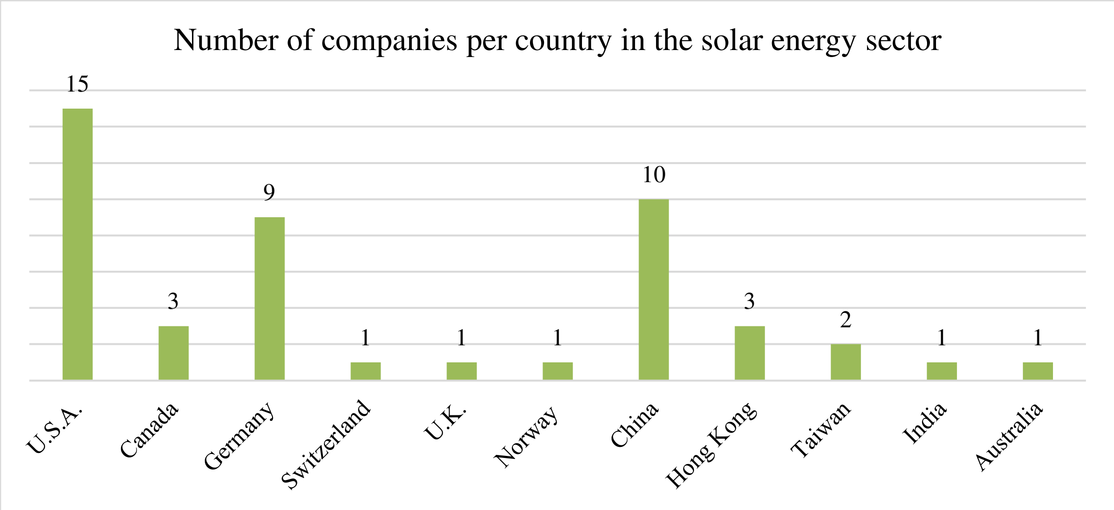
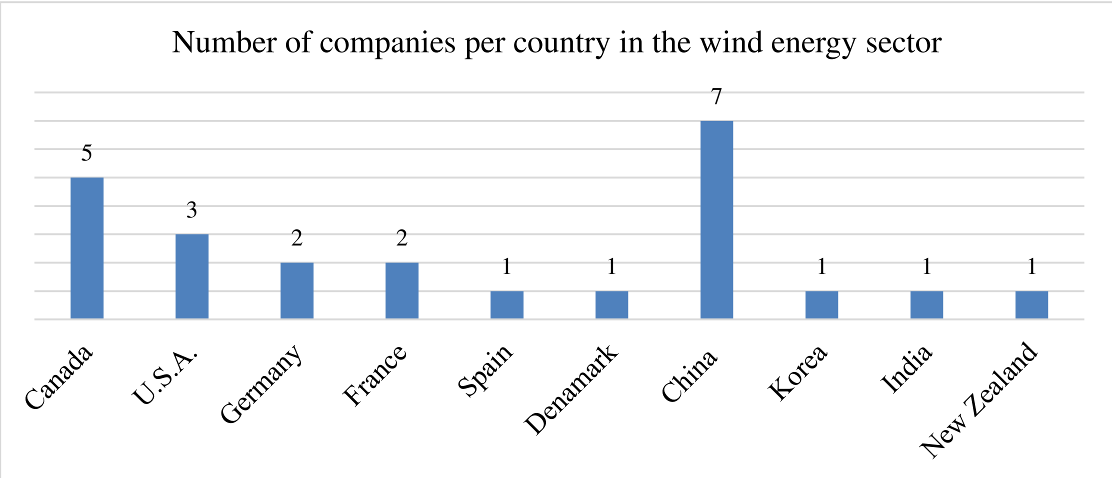
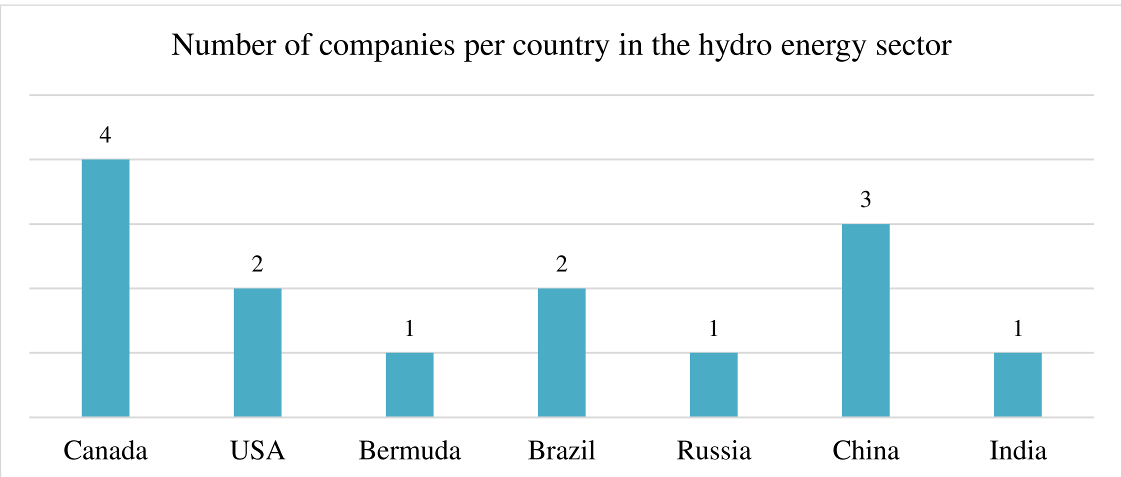
Appendices

Appendix 1. Number of companies in each country per sector







Appendix 2. Summary of the companies

NAME	HQ LOCATION	REGION	SECTOR	BUSINESS	WEB-PAGE
ASCENT SOLAR TECHNOLOGIES	United States	America	Solar	flexible thin-film solar panels for application in building, consumer electronic, defense, military, transportation and aerial industries	www.ascentsolar.com
BIOSOLAR	United States	America	Solar	a comprehensive line of low cost bio-based films and resins to replace higher cost solar panel components	www.biosolar.com
EMCORE	United States	America	Solar	fiber optics, space photovoltaic, terrestrial solar cells	www.emcore.com
FIRST SOLAR	United States	America	Solar	provider of comprehensive photovoltaic (PV) solar energy solutions	www.firstsolar.com
SPIRE CORPORATION	United States	America	Solar	capital equipment provider to manufacture PV modules & cells, turnkey solar manufacturing lines and PV systems	www.spirecorp.com
STR HOLDINGS	United States	America	Solar	solutions in solar panel encapsulation	www.strsolar.com
SUNPOWER	United States	America	Solar	designs, manufactures and delivers solar cells, solar panels and smart, single-axis trackers	www.us.sunpower.com
ANDALAY SOLAR	United States	America	Solar	fully integrated solar panels	www.andalaysolar.com
ENPHASE ENERGY	United States	America	Solar	semiconductor-based microinverter systems	www.enphase.com
ENVISION SOLAR INTERNATIONAL	United States	America	Solar	solar renewable electric vehicle charging stations, turn-key photovoltaic shade systems	www.envisionsolar.com
REAL GOODS SOLAR	United States	America	Solar	solar energy services	www.realgoodssolar.com
SOLARCITY	United States	America	Solar	solar system installation and energy services provision	www.solarcity.com
SUNEDISON	United States	America	Solar	production of solar materials and semiconductors	www.sunedisonsilicon.com
SUNVALLEY SOLAR	United States	America	Solar	solar power technologies and integration systems	www.sunvalleysolarinc.com
HOKU CORPORATION	United States	America	Solar	Polysilicon, turnkey PV systems and related services	www.hokucorp.com
CANADIAN SOLAR	Canada	America	Solar	PV modules, system kits, application systems	www.canadiansolar.com
CARMANAH TECHS	Canada	America	Solar	solar LED lights and solar power systems	www.carmanah.com
DAYSTAR TECHNOLOGIES	Canada	America	Solar	PV modules	www.daystartechinc.com

ALEO SOLAR AG	Germany	Europe	Solar	solar module, inverters and installation systems	www.aleo-solar.de
CENTROSOLAR GROUP AG	Germany	Europe	Solar	sale and project development of roof PV solar modules and integrated systems	www.centrosolar-group.com
CONERGY AG	Germany	Europe	Solar	solar roof-top solutions, field projects and solar parks	www.conergy.com
PHOENIX SOLAR	Germany	Europe	Solar	design, plan and build modules, turnkey photovoltaic power plants and systems	www.phoenixsolar-group.com/de.html
SAG SOLARSTROM AG	Germany	Europe	Solar	plans, installs, and supports photovoltaic systems	www.solarstrompark.net
SMA SOLAR TECHNOLOGY AG	Germany	Europe	Solar	solar inverters, monitoring systems, plant planning	www.sma.de
SOLAR FABRIK	Germany	Europe	Solar	solar modules and components	www.solar-fabrik.de/home/?L=1
SOLARWORLD	Germany	Europe	Solar	solar modules, kits, mounting systems,	www.solarworld.de
SUNWAYS	Germany	Europe	Solar	design solutions, solar inverters, solar modules and cells	www.sunways.eu/en
ETRION CORPORATION	Switzerland	Europe	Solar	builds, owns and operates utility-scale solar power generation plants	www.etrion.com
PV CRYSTALOX SOLAR	United Kingdom	Europe	Solar	manufacturer of multicrystalline silicon ingots and wafers, the key component in solar power systems	www.pvcrystalox.com/home
REC SILICON	Norway	Europe	Solar	polysilicon for the solar energy industry	www.recsilicon.com
CHINA SUNERGY	China	Asia/Oceania	Solar	mono- and polycrystalline modules	www.csun-solar.com/index.html
JINKOSOLAR HOLDING ADR	China	Asia/Oceania	Solar	solar cells, modules and mounting systems	www.jinkosolar.com/index.html
LDK SOLAR SPN	China	Asia/Oceania	Solar	entire photovoltaic value chain	www.ldksolar.com/index.php
RENESOLA	China	Asia/Oceania	Solar	solar panels, mono- and string inverters, LED, solar battery storage systems	www.renesola.com
SUNTECH POWER	China	Asia/Oceania	Solar	mono/multicrystalline silicon PV cells modules, silicon ingots/ polysilicon wafers and integrated photovoltaic products	www.suntech-power.com
TRINA SOLAR	China	Asia/Oceania	Solar	mono- and multicrystalline modules and solutions	www.trinasolar.com/uk/index.html
YINGLI GREEN	China	Asia/Oceania	Solar	solar panels manufacturing and solar power plants installation	www.yinglisolar.com/en
DAQO NEW ENERGY	China	Asia/Oceania	Solar	polysilicon and silicon wafers	www.dqsolar.com
GCL-POLY ENERGY HOLDINGS	Hong Kong	Asia/Oceania	Solar	silicon materials and silicon wafers	www.gcl-poly.com.hk/en

UNITED PHOTOVOLTAICS	Hong Kong	Asia/Oceania	Solar	investor and operator of solar farms	www.unitedpvgroup.com/en/home
RENEWABLE ENERGY TRADE BOARD CORPORATION	Hong Kong	Asia/Oceania	Solar	solar modules, power stations, home systems, solar lighting, and solar chargers	www.chinactdc.com
HANWHA SOLARONE	China	Asia/Oceania	Solar	silicon ingots, solar cells, modules	www.hanwha-solarone.com/en
JA SOLAR HDG	China	Asia/Oceania	Solar	solar cells, modules and PV systems	www.jasolar.com
INVENTECH GROUP E-TON	Taiwan	Asia/Oceania	Solar	solar cells	www.e-tonsolar.com
MOTECH	Taiwan	Asia/Oceania	Solar	solar cells, PV modules, inverters, systems	www.motechsolar.com/en/index.php
WEBSOL ENERGY SYSTEMS	India	Asia/Oceania	Solar	solar photovoltaic cells and modules	www.webelsolar.com
DYESOL	Australia	Asia/Oceania	Solar	DSC chemicals, components and equipment used in the production of DSC cells and modules	www.dyesol.com
HELIX WIND	United States	America	Wind	wind turbines	www.helixwind.com/en
SAUER ENERGY	United States	America	Wind	small wind turbines systems	www.sauerenergy.com
CROWNBUTTE WIND POWER	United States	America	Wind	development and operation of utility scale wind parks	www.crownbutte.com
FINAVERA WIND ENERGY	Canada	America	Wind	development, construction, and operation of wind farms	www.finavera.com
WIND WORKS POWER	Canada	America	Wind	development and operation of wind parks	www.windworkspower.com
CHINA WIND POWER INTERNATIONAL	Canada	America	Wind	installation of wind farms and energy generation	www.chinawindpowerinternational.com
AMERICAS WIND ENERGY	Canada	America	Wind	wind turbines	www.awewind.com
NAIKUN WIND ENERGY GROUP	Canada	America	Wind	development of wind energy projects	www.naikun.ca
NORDEX	Germany	Europe	Wind	wind turbines and project services	www.nordex-online.com/en
PNE WIND	Germany	Europe	Wind	development, realisation, financing and operation of wind farms on land and at sea	www.pnewind.com/en
THEOLIA	France	Europe	Wind	production of electricity from wind energy	www.theolia.com/en
VERGNET SA	France	Europe	Wind	wind turbines	www.vergnet.com
GAMESA CORPORATION	Spain	Europe	Wind	wind turbines	www.gamesacorp.com/es
VESTAS WINDSYSTEMS A/S	Denmark	Europe	Wind	wind turbines, maintenance, project planning	www.vestas.com
XINJIANG GOLDWIND SIENCE & TECHNOLOGY	China	Asia/Oceania	Wind	wind turbines	www.goldwindglobal.com/web/index.do

CHINA MING YANG WIND POWER	China	Asia/Oceania	Wind	wind turbines and integrated solutions	www.mywind.com.cn/English/index.aspx
SINOVEL WIND GROUP	China	Asia/Oceania	Wind	large-scale onshore, offshore and intertidal series of wind turbines	www.sinovel.com/en/index.aspx
SHANGHAI TAISHENG WIND POWER	China	Asia/Oceania	Wind	wind towers	www.shtspchina.com
FAR EAST WIND POWER	China	Asia/Oceania	Wind	development, construction, and operation of utility-scale wind energy projects	www.fareastwind.com
TITAN WIND ENERGY	China	Asia/Oceania	Wind	wind turbine towers	www.titan-wind.com
JIANGSU JIXIN WIND ENERGY	China	Asia/Oceania	Wind	wind turbine parts	www.jyjxm.com/en
UNISON	Korea	Asia/Oceania	Wind	wind turbines ad wind park development	www.unison.co.kr
SUZLON ENERGY	India	Asia/Oceania	Wind	wind turbines	www.suzlon.com
WINDFLOW TECHNOLOGY	New Zealand	Asia/Oceania	Wind	wind turbines and wind farms	www.windflow.co.nz
INNERGEX RENEWABLE ENERGY	Canada	America	Hydro	development, ownership, and operation run-of-river hydroelectric facilities, wind farms, and solar photovoltaic farms	www.innergex.com/en
RUN OF RIVER POWER	Canada	America	Hydro	run-of-river hydro projects	www.runofriverpower.com
SYNEX INTERNATIONAL	Canada	America	Hydro	development and operation of hydro energy facilities	www.synex.com
ALASKA HYDRO	Canada	America	Hydro	acquisition and development of primarily hydropower projects	www.alaskahydro.com
OCEAN POWER TECHNOLOGIES	United States	America	Hydro	ocean wave electricity production and supply	www.oceanpowertechnologies.com
IDACORP	United States	America	Hydro	hydroelectric, natural gas-and coal-fired steam electric generating plants	www.idacorpinc.com
BROOKFIELD RENEWABLE ENERGY PARTNERS	Bermuda	America	Hydro	hydroelectric, wind and natural gas-fired plants	www.brookfieldrenewable.com
AES TIETE SPN	Brazil	America	Hydro	hydroelectric power plants	www.ri.aestiete.com.br/Default.aspx?linguagem=en
TRACTEBEL ENERGIA	Brazil	America	Hydro	hydroelectric and thermoelectric, power plants	www.tractebelenergia.com.br
RUSHYDRO JSC	Russia	Europe	Hydro	Hydroelectric, wind and geo-thermal power plants	www.eng.rushydro.ru
ZHAOHENG HYDROPOWER	China	Asia/Oceania	Hydro	small and medium-sized hydropower station	www.zhyp.hk/en

				investment, development, and management company	
CHINA HYDROELECTRIC	China	Asia/Oceania	Hydro	operation of small hydroelectric power plants	www.chinahydroelectric.com
CHINA YANGTZE POWER	China	Asia/Oceania	Hydro	hydropower production plants	www.cypc.com.cn/EN
NHPC	India	Asia/Oceania	Hydro	hydroelectric power stations	www.nhpcindia.com

Appendix 3. Regression results

Pooled regression, no effects
Dependent variable: RETURN_TRM
AM and SOLAR as base dummy variables

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables						
RET_WTI	0.546***	0.444***	0.653***	0.121***	0.019	0.710***
	(0.022)	(0.034)	(0.029)	(0.03)	(0.044)	(0.032)
AO		0.005			-0.005	
		(0.005)			(0.006)	
EU		0.005			-0.003	
		(0.005)			(0.006)	
WIND			-0.007			-0.003
			(0.005)			(0.006)
HYDRO			0.004			-0.002
			(0.006)			(0.008)
Interaction terms						
AO*RET_WTI		0.184***			0.206***	
		(0.051)			(0.055)	
EU*RET_WTI		0.163**			0.112*	
		(0.054)			(0.058)	
WIND*RET_WTI			-0.206***			-0.136**
			(0.051)			(0.060)
HYDRO*RET_WTI			-0.307***			-0.320***
			(0.060)			(0.075)
Control variables						
MARKET_CAP				0.000**	0.000**	0.000**
				(0.000)	(0.000)	(0.000)
ROA				0.003	0.003	0.003
				(0.002)	(0.002)	(0.002)
DEBT_RATIO				-0.001*	-0.001*	-0.001*
				(0.000)	(0.000)	(0.000)
MSCI				0.192***	0.192***	0.191***
				(0.029)	(0.029)	(0.029)
PSE				0.969***	0.968***	0.970***
				(0.060)	(0.060)	(0.060)
R^2	0.075	0.078	0.080	0.233	0.236	0.238
Adjusted R^2	0.075	0.077	0.079	0.232	0.234	0.236
F- statistic	631.239	130.260	134.518	218.78	133.017	134.370
Prob. (F-statistic)	0.000	0.000	0.000	0.000	0.000	0.000
Durban-Watson statistic	2.060	2.062	2.063	2.095	2.094	2.097
Observations	7757	7757	7757	4321	4321	4321

* , ** , *** denote 10%, 5%, 1% significance levels respectively. Standard Errors are presented in parentheses

Appendix 4. Regression results using AO and WIND dummy variables

Pooled regression, no effects Dependent variable: RETURN_TRM AO and WIND as base dummy variables				
	Model 7	Model 8	Model 9	Model 10
Independent variables				
RET_WTI	0.628***	0.446***	0.225***	0.574***
	(0.038)	(0.043)	(0.045	(0.051)
AM	-0.005		0.005	
	(0.005)		(0.006)	
EU	-0.000		0.003	
	(0.005)		(0.006)	
SOLAR		0.007		0.003
		(0.005)		(0.006)
HYDRO		0.012*		0.001
		(0.006)		(0.009)
Interaction terms				
AM*RET_WTI	-0.184***		-0.206***	
	(0.051)		(0.055)	
EU*RET_WTI	-0.021		-0.095	
	(0.057)		(0.060)	
SOLAR*RET_WTI		0.206***		0.136**
		(0.051)		(0.060)
HYDRO*RET_WTI		-0.100		-0.184**
		(0.068)		(0.085)
Control variables				
MARKET_CAP			0.000**	0.000**
			(0.000)	(0.000)
ROA			0.003	0.003
			(0.002)	(0.002)
DEBT_RATIO			-0.001*	-0.001*
			(0.000)	(0.000)
MSCI			0.192***	0.191***
			(0.029)	(0.029)
PSE			0.968***	0.970***
			(0.060)	(0.060)
R^2	0.078	0.080	0.236	0.238
Adjusted R^2	0.077	0.079	0.234	0.236
F- statistic	130.260	134.518	133.017	134.370
Prob. (F-statistic)	0.000	0.000	0.000	0.000
Durban-Watson statistic	2.062	2.063	2.094	2.097
Observations	7757	7757	4321	4321

* , ** , *** denote 10%, 5%, 1% significance levels respectively. Standard Errors are presented in parentheses

Appendix 5. Robustness check

Pooled regression, no effects
Dependent variable: RETURN_TRM
AM and Solar as base dummy variables

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables						
RET_BRENT	0.454***	0.393***	0.516***	0.093***	0.053	0.568***
	(0.022)	(0.034)	(0.029)	(0.028)	(0.042)	(0.034)
AO		0.006			-0.005	
		(0.005)			(0.006)	
EU		0.006			-0.002	
		(0.005)			(0.006)	
WIND			-0.008*			-0.003
			(0.005)			(0.007)
HYDRO			0.003			-0.002
			(0.006)			(0.008)
Interaction terms						
AO*RET_BRENT		0.101*			0.094*	
		(0.052)			(0.056)	
EU*RET_BRENT		0.110**			0.028	
		(0.054)			(0.059)	
WIND*RET_BRENT			-0.110**			-0.056
			(0.052)			(0.062)
HYDRO*RET_BRENT			-0.196***			-0.191**
			(0.060)			(0.079)
Control variables						
MARKET_CAP				0.000**	0.000**	0.000**
				(0.000)	(0.000)	(0.000)
ROA				0.003	0.003*	0.003
				(0.002)	(0.002)	(0.002)
DEBT_RATIO				-0.001*	-0.001*	-0.001*
				(0.000)	(0.000)	(0.000)
MSCI				0.195***	0.195***	0.194***
				(0.029)	(0.029)	(0.029)
PSE				1.015***	1.015***	1.018***
				(0.056)	(0.056)	(0.056)
R^2	0.052	0.053	0.054	0.233	0.233	0.234
Adjusted R^2	0.052	0.053	0.054	0.232	0.231	0.232
F- statistic	428.062	87.384	89.114	217.928	131.070	131.822
Prob. (F-statistic)	0.000	0.000	0.000	0.000	0.000	0.000
Durban-Watson statistic	2.082	2.085	2.087	2.098	2.099	2.0104
Observations	7757	7757	7757	4321	4321	4321

* , ** , *** denote 10%, 5%, 1% significance levels respectively. Standard Errors are presented in parentheses