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„Environmental Performance and its effect on the cost of equity within the energy sector in the case of Europe, the US and Canada.“

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Abstract

This thesis examines the effect of Environmental Performance on the cost of equity in the case of the European, the US and the Canadian energy sector and its sub-sectors for the years 2017 until 2019. In the wake of the climate crises the energy transition plays a crucial role, and this thesis aims to investigate the financial aspect of the effect of increased Environmental Performance. In this paper three models aim to investigate the research topic. In those models the cost of equity was approximated using implied and realized returns. The implied method followed the approach of Claus and Thomas 2001 while realized returns were the basis for a cross-sectional panel analysis as well as for a portfolio framework model. The Environmental Performance was measured through the proxy environmental score from Refinitiv Eikon. The results of the models were inconclusive and mostly not significant. Therefore, the findings do not show a consistent effect of Environmental Performance on the cost of equity for energy firms in Europe, the US and Canada.

Abstrakt

Diese Masterarbeit untersucht die Auswirkung der nachhaltigen Performance auf die Eigenkapitalkosten im Falle europäischer, US-amerikanischer und kanadischer Unternehmen im Energy Sektor, sowie dessen Sub-Sektoren in den Jahren 2017 bis 2019. Im Zuge der Klimakrise spielt die Energiewende wesentliche Rolle und darum befasst sich diese Thesis mit dem finanziellen Aspekt der Auswirkungen von steigender nachhaltiger Performance. In dieser Arbeit versuchen drei Modelle der Recherchethema zu erläutern. In diesen Modellen werden die Eigenkapitalkosten anhand impliziter und realisierter Renditen approximiert. Die implizite Methode folgt dem Modell von Claus und Thomas 2001, während die realisierten Renditen die Basis für eine Querschnittspanelanalyse sowie für eine Portfoliomodell bilden. Stellvertretend für die nachhaltige Performance wurde der Nachhaltigkeitsscore von Refinitiv Eikon herangezogen. Die Ergebnisse dieser Arbeit sind nicht eindeutig und nicht signifikant. Die Ergebnisse lassen darum auf keinen konsistenten Effekt von nachhaltiger Performance auf die Eigenkapitalkosten im Falle von Energiefirmen in Europa, den US und Kanada schließen.

Contents

1. Introduction

1.1. Motivation and Problem Description

The purpose of this thesis is to examine the effect of Environmental Performance on the cost of equity. In the last decade, environmental considerations were increasingly anchored into finance and investments. This is especially true for the EU where the Sustainable Finance Disclosure Regulation, in short SFDR, came into application in March 2021 (European Commission, 2023b). The regulation created common standards and introduced a framework for funds to cluster them by their sustainability objectives. Article 8 funds promote sustainable characteristics, Article 9 funds have sustainable objectives embedded and the remaining funds are compiled in Article 6 funds – having no sustainable objective. Since their launch and within 2 years the market share of Article 8 & 9 funds grew from roughly 30% to almost 60% measured by AuM. This indicates an immense increase in interest in sustainable financial instruments (Bioy et al., 2023). Companies had already taken notice of the growing influx of funds into more sustainable assets, and many rebuilt their business models to fit the new more sustainable narrative. In the EU, the introduction of the Corporate Sustainability Reporting Directive in 2023, i.e. CSRD, made it mandatory for large corporates and listed SMEs to issue regular sustainability reports and to create a level playing field (European Commission, 2023a). This helps investors in their decision-making process when comparing non-financial metrics of corporations. But how are sustainable metrics affecting the expected returns of investments? To answer this question, prior studies have been investigating the effects of various environmental and social metrics on the cost of capital as well as on its components, the cost of equity and cost of debt. These papers found a significant negative correlations between strong environmental, social as well as governance results and the cost of capital (Sharfman & Fernando, 2008; He et al., 2013; Chava, 2014; El Ghoul et al., 2018; Yao & Liang, 2019; Y. Chen et al., 2023). In their study, Sharfman & Fernando (2008) concluded that firms which are improving their environmental risk through better environmental risk management measures are rewarded by lower cost of equity. This is explained by lower volatility in the firms' stock, i.e., a lower beta and an increased investor base. He et al. (2013) conducted a study on firms within the S&P index that participated in the carbon disclosure project and their relationship among carbon disclosure, carbon performance and cost of capital. They found a negative correlation between cost of capital and carbon disclosure that is in line with the voluntary disclosure theory. This relationship was weaker for companies with good carbon performance. The author explains this finding by poor carbon performing firms wanting to avoid future punishment due to a lack of disclosure and therefore presenting more data. Whereas good performing firms published less extensive carbon disclosure reports. In the paper by Chava (2014), the author found that firms with severe negative environmental externalities are excluded by many investors, which is why the remaining investor base requires significantly higher expected returns. Furthermore, these companies also find fewer lenders on their debt and fewer banks participating in their loan syndicates. Hence, increasing the cost of debt as well. In El Ghoul et al. (2018) the authors argue that manufacturing firms with high corporate environmental responsibility (i.e., low environmental costs to total assets) have a lower ex ante cost of equity. Investments into corporate environmental responsibility reduce firm risk, therefore, reducing cost of equity. Yao & Liang (2019) investigated analyst following, environmental information disclosure and cost of equity in the case of Chinese manufacturing firms. In their analysis the environmental disclosure had a mediating effect on the relationship between analyst following and the cost of equity, as increased analyst following can decrease cost of equity through increased environmental disclosure. This effect was stronger for heavy-polluting firms. The results of the paper of Y. Chen et al. (2023) suggest that stronger ESG performance for Chinese listed A-share companies lowers the cost of equity. In addition, the authors observed also an indirect negative effect as higher ESG performance decreased the market beta and therefore, reduced the cost of equity.

All studies illustrate that increased Environmental Performance or disclosure lowers cost of equity or capital. However, the scope of these studies included either multiple sectors or several regions. For that reason, the aim of this thesis is to build on the approaches of the aforementioned papers but to apply them on a regional and on a single sector-specific level. The most relevant sector to investigate in this matter is the energy sector, as the following three arguments will point out.

The first argument for the energy sector is its global importance for the environment. This sector alone is the major contributor to overall CO_2 emissions. In fact, in the EU the production and use of energy make up 75% of all CO_2 emissions on the continent (eurostat, 2022d) and globally energy use accounts for roughly two thirds of greenhouse gas emissions

(International Energy Agency, 2022). At the same time, every person must not exceed an annual amount of 2.3 tons of CO_2 emissions on average by 2030 to be in line with the 1.5°C goal set in the 2015 Paris Agreement (OXFAM International, 2022). In reality, the 2021 CO_2 emissions per capita in Canada, in the US and in the EU stood at 13.8, 13.6 and 6.1 tons of CO_2 respectively. These numbers illustrate the importance of the energy sector in the fight against the climate crises and the drastic changes needed to comply with the environmental goals set in the Paris agreement (International Energy Agency, 2022).

The second reason for investigating the energy sector on a standalone basis in contrast to the whole market is that it is heavily regulated, therefore, following its own rules. The sector is part of the critical infrastructure sectors and fuels the economy, inter alia all other sectors of the 21st century (Cybersecurity & Infrastructure Security Agency, 2023). To ensure a functioning economy, regulators introduced sector-specific regulations for the energy sector. Objectives of these regulations include reducing market inefficiencies, consumer production, environmental protection and security of supply. The EU for example identified the following threats which it aims to fight within the Energy policies general principles:

> Challenges facing the EU in the field of energy include issues such as increasing import dependency, limited diversification, high and volatile energy prices, growing global energy demand, security risks in producing and transit countries, growing threats of climate change, decarbonization, slow progress in energy efficiency, challenges posed by the increasing share of renewables, and the need for increased transparency, further integration, and interconnection in energy markets. A variety of measures aiming to achieve an integrated energy market, security of energy supply and a sustainable energy sector are at the core of the EU's energy policy (European Parliament, 2023, Article 194 of the Treaty on the Functioning of the European Union).

A crucial target for contemporary regulations is fulfilling the Sustainable Development Goal 7. The goal is to "ensure access to affordable, reliable, sustainable and modern energy for all" (United Nations: Department of Economic and Social Affairs, 2016). To ensure that companies in the energy sector follow this goal and others as well, national and supranational regulators create the legal foundation, as for instance in the publication Energy Sector Management Assistance Program by the World Bank, Washington, DC (2020).

The third reason lies in the relevancy of the energy sector within the economy. In the beginning of the century energy production and use was responsible for more than 50% of industrial growth in modern economies. Growth in energy use was a direct link to growth in GDP (Barney & Franzi, 2002). This link, however, is shifting as the process of continued decoupling of energy demand from economic growth is accelerating. Thanks to declining energy intensity, increasing energy efficiency and a growing use of renewables. Nonetheless, this does not change the fact of the importance of the sector to the overall economy. Global primary energy demand has not peaked yet, only growth has decelerated. The major change in the sector is the shift of energy sources towards a higher share of renewable energy in the energy mix (McKinsey & Company, 2019). Later in this section, the author will share detailed information on the energy mix in selected regions.

These three arguments, the importance of the energy sector for the environment, the stringent regulations in the sector as well as the overall importance for the economy engaged the author to investigate the effect of Environmental Performance on the cost of equity solely on the energy sector.

Fonseka et al. (2019) spotted the importance of the energy sector in overcoming environmental challenges. In their paper, they investigated the effects of environmental information disclosure (EID) on the cost of equity within the Chinese energy sector and its sub sectors and whether EID influences investment decisions. The study found a negative relationship between the two variables; however, this varies based on the energy source. For companies engaging in fossil-fueled thermal power and oil-based energy activities, raising the EID led to increased cost of equity. On the other hand, the opposite was the case for power grid, solar and wind power firms. The analysis was conducted between 2008 and 2014, data on the EID was collected manually comprising 368 firm-year observations. The EID is comprised of 10 components relating to environmental management. The cost of equity was calculated using an ex ante method through Price-Earnings Growth (PEG) and Modified Price-Earnings Growth (MPEG) models introduced by Easton (2004). In these models, analysts' forecasted earnings per share for the next two years were used to approximate growth, subsequently divided by the current share price. The authors considered the following control variables: age of the firms, firm leverage, return on assets, analyst forecast dispersion, agency cost, ownership of largest shareholders, the Herfindahl index of the five largest shareholders, natural log of regional gross production per capita in China. The authors then conducted a cross-sectional time-series analysis regression to test the relation between EID and the cost of equity for Chinese energy firms as well as for individual energy types. Based on the findings described above, the authors suggested to introduce mandatory reporting of energy product information as well as pollution discharge statistics in EID regulation, to control pollution through a market-based measure where higher pollution is penalized by higher cost of equity (Fonseka et al., 2019).

1.2. The Energy Sector in Europe, the US and Canada

The following parts will focus on the size and the energy mix of the energy sector in Europe, the US and Canada. Arguments for choosing these respective regions versus China in Fonseka et al. (2019) are laid out in the following section. Particular emphasis in this section is given to the energy mix, as this thesis will further investigate the effect of Environmental Performance on the cost of equity in the energy sector's sub-sectors.

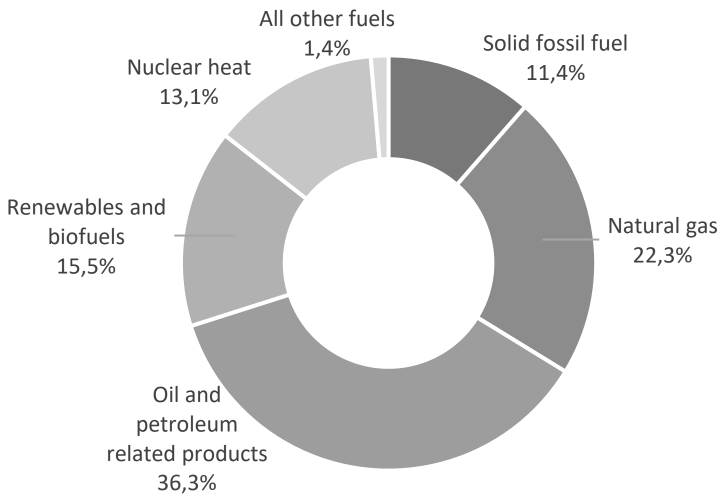

Figure 1 EU Gross Available Energy Mix in 2019. Adapted from Gross available energy, EU, 1990-2021 by Eurostat, 2022, Energy statistics - an overview. Retrieved 10.12.2022 from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Final_energy_consumption. Copyright by 2022 by eurostat

In the EU the latest available Energy data stems from 2020, however, due to the drop in energy consumption in that year caused by the Covid-19 outbreak, the following statistics analyze the year 2019. In 2019 the EU gross available energy amounted 62,828 Petajoule (eurostat, 2022b). Gross available energy is calculated by aggregating Gross available energy = Primary production + Recovered & Recycled products + Imports – Export + Stock changes (eurostat, 2022c). To put this into perspective, the EU average per capita household electricity consumption stood at roughly 1,700kWh. So, 1 Petajoule is the equivalent to the annual household electricity consumption of around 160,000 individuals (eurostat, 2022a). The 2019 EU energy production stood at 25,891 PJ, so the import dependency was at 58.8% (eurostat, 2022b). Figure 1 and 2 illustrate the EU gross energy mix as well as the EU energy production mix.

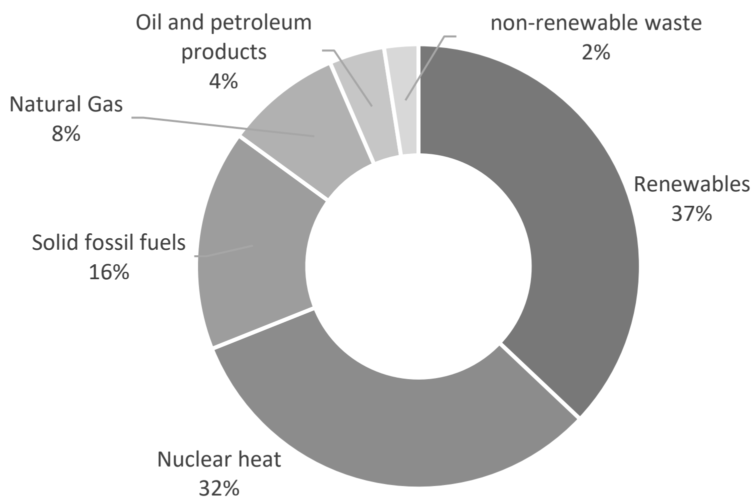

Figure 2 EU Energy Production in 2019. Adapted from Primary energy production by Eurostat, 2022, Energy statistics - an overview. Retrieved 10.12.2022 from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_statistics_-_an_overview#Final_energy_consumption. Copyright by 2022 by eurostat

In 2021, the US total primary energy production amounted to an equivalent of 103,755 Petajoule and the energy consumption to 103,301 Petajoule, hence making the US a net energy exporter (U.S. Energy Information Administration, 2022). The US energy mix for consumption and production is illustrated in the following two graphs.

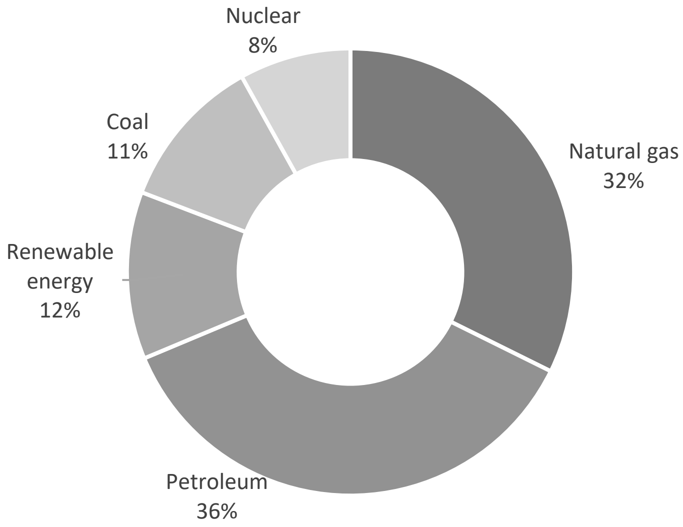

Figure 3 US Total primary energy consumption in 2021. Adapted from Total energy consumption by U.S. Energy Information Administration, 2022, U.S. energy facts explained. Retrieved 10.12.2022 from https://www.eia.gov/energyexplained/us-energy-facts/data-and-statistics.php. Copyright by 2022 by eia

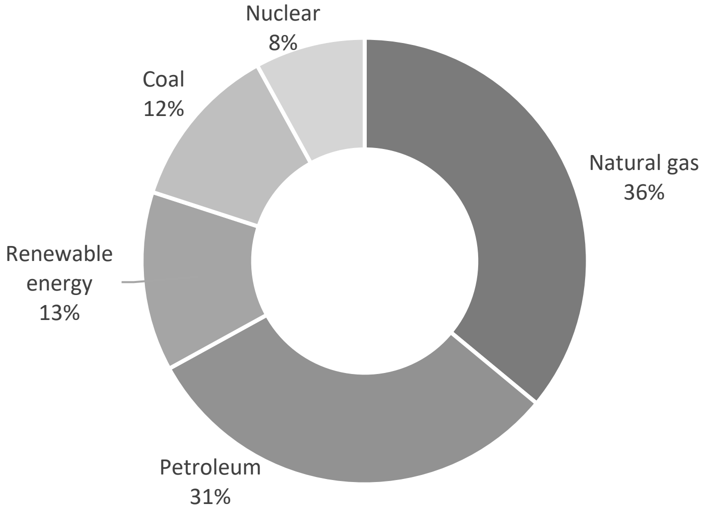

Figure 4 US Total primary energy production in 2021. Adapted from Total primary energy production by U.S. Energy Information Administration, 2022, U.S. energy facts explained. Retrieved 10.12.2022 from https://www.eia.gov/energyexplained/us-energy-facts/data-and-statistics.php. Copyright by 2022 by eia

In 2021, Canadian energy consumption amounted to 12,314 Petajoule. On a per capita basis this exceeds US consumption and is almost triple the EU average. Canada is a significant energy exporter with a net export of more than 10,000 Petajoule in 2021 (iea, 2023).

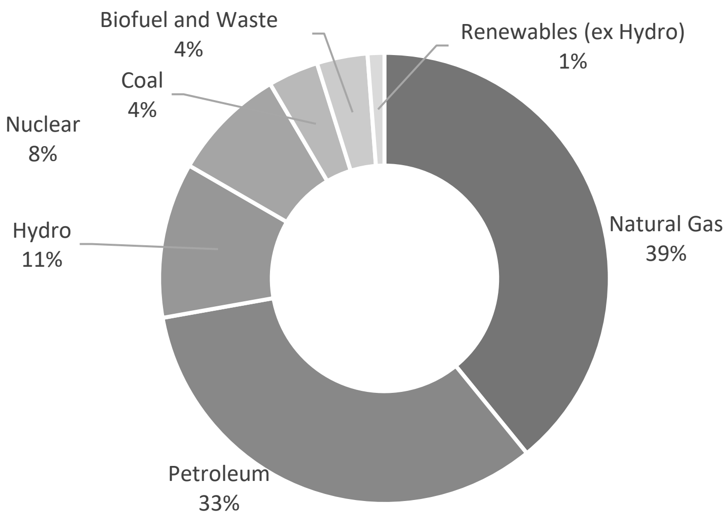

Figure 5 Canada Total Available Energy in 2021. Adapted from World Energy Outlook special report by iea, 2020, The Oil and Gas Industry in Energy Transitions. Retrieved 10.12.2022 from https://www.iea.org/reports/the-oil-and-gas-industry-in-energy-transitions. Copyright 2020 by eia

The graph below displays the worldwide energy mix for 2018 to put things into a larger, global context. Comparing the worldwide energy production mix to the one in Canada and in the US, it becomes apparent that all of them rely on fossil fuel to an extend of more than two thirds of the total energy mix. However, the share of coal in Canada and the US is a lot smaller than in the worldwide mix, which is largely compensated by natural gas. In the EU, the share of fossil fuels in the energy production is less than a third, with renewables accounting for the largest share. Admittedly, more than half of EU's energy needs is produced elsewhere, resulting in a flawed comparison, as Canada and the US are net exporters.

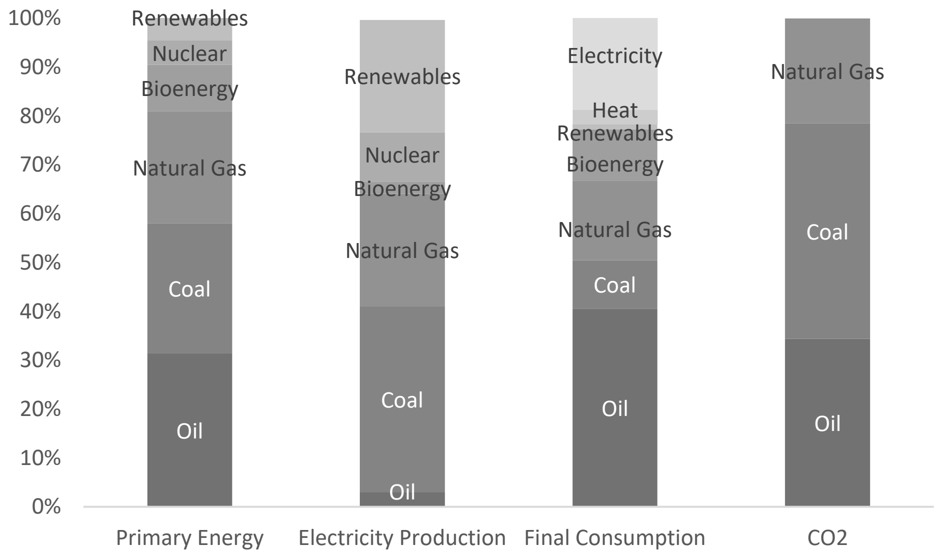

Figure 6 Global Energy Mix in 2018. Adapted from World Energy Outlook special report by iea, 2020, The Oil and Gas Industry in Energy Transitions. Retrieved 10.12.2022 from https://www.iea.org/reports/the-oil-and-gas-industry-in-energy-transitions. Copyright 2020 by eia

1.3. Hypothesis Development

The study of Fonseka et al., (2019) serves as a leading paper for this thesis, having also investigated the effects within the energy sector. However, Fonseka et al., (2019) investigated the energy sector in China and in this paper the author would like to investigate the energy sector within regions, i.e., Europe, the US and Canada. Due to a variety of differences in China versus the other three regions, the link between Environmental Performance and cost of equity is potentially different, therefore, a further investigation on the effects is conducted. Illustraded below are the most crucial differences between China and the other three regions:

First, all regions started different climate policies. In China it is called the Climate revolution, in the EU it was named the European Green Deal, in the US it is the Green New Deal (Lu, 2021) and in Canada it is The Pact for a Green New Deal (MacArthur et al., 2020). One notable difference between China and the other blocs with regards to fighting the climate crises is the role of legislations in China. The “rule of law” is only secondary as the target responsibility lies within the government that aims to prevent foreign influence and losses of control. Another distinction is the enforcement of policies on a local level. China is a much more centralistic country were policies that are set by the central government are more easily enforced on a local level. Whereas, in the EU, the US and in Canada federalism is much more prevalent. In the western regions the States respectively countries in the bloc also have the authority to make laws and be more progressive in the energy transition (Lu, 2021). One more apparent difference is the form of government, inter alia democracy versus autocracy. In many democracy indices as in the one of Julius-Maximilians-Universität Würzburg (2020) or Wisevoter (2023) most European nations and Canada are ranked in the top 20 and the United States is ranked shortly after. In contrast, China is placed as one of the last nations, insinuating an authoritarian state. A final notable difference are cultural differences and how these may affect investor behaviors or market perceptions of environmentally stronger or weaker firms. Hofstede initially introduced 4 cultural dimensions (Hofstede, 1984) and later he added one more dimension to the list (Hofstede, 1991). Today, the dimensions are constantly updated and adapted to allow comparing certain cultural behaviors among countries. In these dimensions countries get assigned a score from 0 to 100. In the “Power Distance” dimension China scores significantly higher. This might indicate that Chinese investors respond more positively when companies align with government initiatives whereas in the other regions investors are influenced by a more diversified set of factors. The low Chinese score in “individualism” could express that Chinese individuals follow societal norms and government directives on sustainability. In the western countries investors might show a more varied response based on their individual beliefs. “Motivation towards Achievement and Success” shows similar scores. The difference in the “Uncertainty Avoidance” score could be a proxy for the risk levels that investors are wanting to take. Given the data Chinese investor might be more open to risk, US and Canada might consider a more moderate risk level and European investor might be more conservative in their risk strategy. The “Long Term orientation” in China may imply that investors are valuing more environmentally friendly companies due to their potential long-term benefit. On the other hand, European, US and Canadian investors might also value other factors such as short-term gain, i.e., quarterly profits. A similar point can be made for “Indulgence” where Chinese investors might put less emphasis on short-term gains whereas the other regions might have a higher share of mixed preferences. (The Culture Factor Group, 2023)

	Power Distance	Indivi-dualism	Motivation towards Achievement and Success	Uncertainty Avoidance	Long Term Orientation	Indul-gence
China	80	43	66	30	77	24
Canada	39	72	52	48	54	68
USA	40	60	62	46	50	68
EU27-Min	11	42	5	23	32	13
EU27-Median	53	69	43	75	51	42
EU27-Mean	52	86	45	72	53	59
EU27-Max	100	559	100	100	71	448

Table 1 Hofstede Cultural Dimension Scores for China, Canada, USA and EU (equally weighted by country). Adapted from Country Comparison Tool, 2023, The Culture Factor Group. Retrieved 11.12.2023 from https://www.hofstede-insights.com/country-comparison-tool. Copyright by 2023 by The Culture Factor Groupeia

Given the importance of the energy sector and its sub-sectors the author would like to investigate the effect of Environmental Performance on the cost of equity. Fonseka et al. (2019) already investigated this effect for the Chinese energy sector, however due to the afore mentioned differences between China and the EU, Canada, and the US the author aims to conduct an analysis on those regions using the Environmental Performance as the independent variable. Given the set of parameters the author aims to answer the following research question:

Does Environmental Performance affect the implied or realized cost of equity in the energy sector, if yes how and to what extend does this effect vary among the sub-sectors of the energy sector?

2. Theoretical and empirical background

2.1. Theoretical background

In this section the author provides theoretical examples of investor base, risk mitigation & Over Investment Hypothesis that illustrate why ceteris paribus companies with a high Environmental Performance have a lower cost of equity.

2.1.1. Investor base

In the asset pricing theory by Sharpe (1964) investor base would need to be an undiversifiable risk to affect a firm’s cost of equity. However, using the framework in Lambert et al. (2007), the authors show a link between the disclosure of accounting information and cost of equity that are in line with the (one-factor) CAPM. Applying that framework to common ownership in Ni & Yin (2023) the authors showed that common ownership could offer reduced cost of equity financing for certain firms through:

> strategic actions and collaborations [that] allow firms to tap into larger new markets, enjoy economies of scale, and internalize negative externalities, which enables firms to reduce the covariance of cash flows of focal firms with cash flows of industry peers, and therefore reduces the non-diversifiable covariance risk, leading to a lower cost of equity capital. (p. 11-12)

At the same time studies argue that a larger investor base reduces the cost of equity. In the study by Heinkel et al. (2001) the authors introduced an equilibrium model on investor preferences where they pointed out that some investors solely invest in environmentally responsible firms, therefore only non-green investor would hold shares in non-environmentally responsible firms. Green investors would further motivate increased green investments by the firms, hence increasing the firms' Environmental Performance and thereby creating a higher firm value. For this reason, investors are willing to pay a premium that is shown in the form of a reduced cost of equity. On the other hand, companies with poor Environmental Performance will have a lower investor base, as some investors who are focused only on green firms would simply not invest in environmentally poor performing firms. Non-green investors are then confronted with a lack of risk sharing and to compensate for the risk and to attract investors from the remaining investor base these companies have to pay a premium in the form of a higher cost of equity to the investors (Heinkel et al., 2001). The premium paid by these firms to their reduced investor base is also referred as Neglected Stock Hypothesis (Hong & Kacperczyk, 2009). Hong & Kacperczyk (2009) found that normed constrained investors such as pension funds tend to invest less into "sin" stocks and that also loan syndicates of those companies comprise of fewer banks given the climate change concerns.

Furthermore, using the capital market equilibrium model from Merton (1987) that takes incomplete information into account, El Ghoul et al. (2011) argue that low CSR firms are likely to have a higher information asymmetry. The same argument could be made for firms with a lower Environmental Performance. Now according to the model by Merton (1987) in a world of information asymmetry an investor only considers buying shares if the investor has certain knowledge about the company. Accumulating the knowledge as an investor from the firm involves costs. The higher the asymmetry, the higher the cost of information gathering. Dhaliwal et al. (2009) found that high CSR firms disclose more CSR information than the low CSR companies, as the former companies view the strong scores as a form of advertising. In their cross-country study Lopez-de-Silanes et al. (2020) concluded a similar message when observing that firms with a high ESG performance score are disclosing more information. Therefore, firms with lower ESG performance are disclosing less information, thus the investor cost of acquiring information is higher.

2.1.2. Risk mitigation

Investors perceive "sin" stocks as more risky than other industries due to greater litigation risk. Traditionally, such "sin" stocks included alcohol, gambling, tobacco, and defense, as these stocks produce unwanted social consequences (Hong & Kacperczyk, 2009; Chava, 2014). Due to the climate crises some investors added coal, metals & mining, nuclear and oil & gas stocks to the list, because of the high-carbon intensity of these sectors (Sagbakken & Zhang, 2021). In turn this would mean that companies that manage their environmental risk, enhance their Environmental Performance, thus have a lower perceived riskiness for investors. In addition, companies' efforts in reducing environmental externalities ultimately lead to lower liability exposure, reducing the overall litigation risk.

This is also in line with the findings of Sharfman & Fernando (2008) who argue that firms' improved environmental risk management is rewarded by the financial markets through lower cost of equity, which is essentially driven by lower volatility, thus lower beta.

2.1.3. Over Investment Hypothesis

Increased environmental investments mitigate risk, thus reducing the cost of equity. In contrast to the risk mitigation theory, the overinvestment hypothesis indicates that environmental investments exceeding a certain amount would decrease a firm's value, implying an increased cost of equity (Goss & Roberts, 2011). Utz (2018) has identified differences in the effect of overinvestments depending on the respective region, where emerging economies tend to overinvest so to reach western environmental standards. This is also supported by Yeh et al. (2020) who found no evidence that increased CSR investments lower the cost of equity in the case of China. Additionally, Irawan & Okimoto (2021) found value-enhancing and value-destroying effects of overinvestments that depend on the respective industries.

2.2. Empirical background

Prior research has shown evidence that environmental and social metrics have an effect on the cost of capital. Already 15 years ago, Sharfman & Fernando (2008) found that environmental risk management aids to generate more revenues respectively less costs due to increased resource utilization efficiency. Because of lower perceived riskiness the investigated firms were also able to take on more leverage and shift from equity financing to more debt financing, hence reducing the overall cost of capital (Sharfman & Fernando, 2008). In more recent years an increasing number of institutional investors used ESG or “E” scores to rebalance their portfolio and to mitigate climate risk. To strengthen the climate resilience of their investments, investors focused in particular on the environmental pillar (Boffo & Patalano, 2020).

As stated in the introduction, El Ghoul et al. (2011) had a large impact on the broader interest in investigating the effect of non-financial metrics i.e. CSR scores on the cost of capital. The study found that high CSR firms had lower ex-ante cost of equity. The authors explain these findings by a wider investor base among high CSR companies and a lower perceived risk. Thus, an increase in CSR spending would boost a firm’s value. Therefore, aside from the positive societal impact, it makes sense for managers to pursue increasing CSR activities and to disclose them (El Ghoul et al., 2011). In He et al. (2013) the authors examined the effect of voluntary carbon disclosure and carbon performance on the cost of capital. They found a negative relationship between the carbon disclosure and cost of capital, where the evidence was even stronger in firms with poor carbon emission performance. The authors concluded that for those firms investors required more extensive disclosure as from good carbon performers (He et al., 2013). The Chava (2014) paper explains the increasing importance of Social Responsible Investing, by examining environmental externalities for corporations and their cost of capital. Chava (2014) backed this hypothesis by comparing firms with hazardous chemicals, substantial emissions, and climate change concerns to firms without these concerns. In this study it was concluded that investors require significantly higher returns from firms with poor environmental externalities. The Trinks et al. (2017) study found that greenhouse gas emissions positively affect the cost of equity. The evidence became more significant towards the end of the investigated period from 2002-2016, indicating that investor preferences for low-carbon assets have grown. The El Ghoul et al. (2018) paper inspected how corporate environmental responsibility (CER) affects the cost of equity within a single industry. For this purpose, the authors chose manufacturing firms within 30 countries. In accordance to prior studies it was concluded that investments into CER lowers the companies' cost of equity (El Ghoul et al., 2018). Similarly, Yao & Liang (2019) investigated the effect of environmental disclosure and analyst following on the cost of equity for manufacturing firms, however, focusing on the Chinese market. The authors chose the years 2004-2006 as well as 2009-2011. These are the years prior respectively after the Chinese government introduced measured for the mandatory disclosure of environmental information. The authors found that through increased environmental disclosure, analyst following would lead to lower cost of equity. These findings became stronger, after the measure by the Chinese government was introduced in 2008 (Yao & Liang, 2019). The idea of Fonseka et al. (2019) was to examine the effect of environmental information disclosure within the energy sector in China as well as to investigate whether the effect varies across different energy types. Interestingly, the authors found a positive relationship between environmental information disclosure and cost of equity for fossil-fueled thermal power generation as well as oil and gas. A negative relationship was found for renewable sources. Therefore, the authors suggested to expand the mandatory environmental information disclosure for all energy types to reduce costs for low-polluting energy types and incentivize firms to mitigate their effect on the greenhouse gas emissions (Fonseka et al., 2019).

In one of the most recent studies Y. Chen et al. (2023) investigated ESG performance and evaluated its effect on the cost of equity. The study included Chinese A-Share companies over the period from 2010 until 2020. The authors not only found that higher ESG performance directly reduces the cost of equity but also that the market risk beta was reduced for those firms, hence indirectly reducing cost of equity as well.
In a second report of the Energy Transition Risk and Cost of Capital Program Zhou et al. (2023) investigated the difference in cost of equity and debt capital for the energy and utilities sectors with a further differentiation for companies operating in the coal mining, oil & gas and renewables sectors. In their analysis, the regional focus was on China, Europe and North America. Globally coal mining was the sector with the highest cost of equity, but

renewable fuels did not have the lowest costs. The authors identified differences within the sub-sectors depending on the carbon-intensity of the respective companies. What is more, the effect of the cost of equity depending on carbon-intensity varied gravely among the regions. While European sustainable companies were widely rewarded with lower cost of equity, the effect was less prevalent for North American firms and mostly not observable for Chinese companies. One of the reasons for this divergence are different policies in climate friendly actions, where Europe is leading and contrastingly in China fossil fuel power is still growing.

Based on this literature the author tested the following two hypothesis:

H1: *Environmental Performance affects the cost of equity within the energy sector.*

H1a: *The effect of Environmental Performance on the cost of equity varies depending on the respective energy sub-sector.*

3. Methodology

3.1. Sample Selection

The author used “The Refinitiv Business Classification” in short TRBC to obtain panel data of public companies headquartered in the regions Europe, Canada, and the United States for the period 2017 to 2019. 2017 was picked as the starting year, because environmental data prior to this year is scarce. Furthermore, the final year is 2019 as the Covid-19 pandemic influenced the subsequent years which would distort the data. The sample consists of publicly listed companies that fall in the TRBC Economic Sector Energy. Subsequently, additional information was collected by classifying the companies into the TRBC Industry Groups: Coal, Oil & Gas (including Oil & Gas Related Equipment and Services), Renewable Energy and Uranium. In total, the sample consists of 363 companies and 1089 observations.

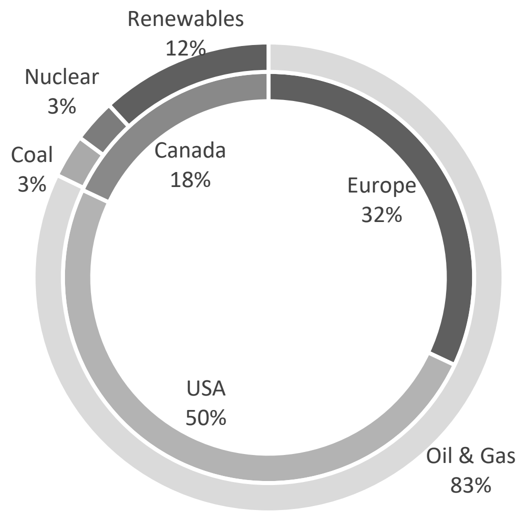

Figure 7 Geographic & Industry Distribution of the Sample

The financial data was gathered from Capital IQ and the factor loadings used in the Fama-French multi-factor model were obtained from the Kenneth R. French data library. The environmental disclosure score used as a control variable was collected from Bloomberg. Further information on the collection of Environmental Performance data will be provided in the following chapter.

3.2. Estimating Environmental Performance

To measure Environmental Performance this paper uses a proxy score as there exists no general framework of applicable criteria. The dependent variables *Environmental Performance* and its three categories *Environmental Emissions, Environmental Innovation* and *Resource Use* were obtained from Refinitv EIKON. The Environmental Performance Score is one of three pillars of the ESG score and it is calculated using a subset of 68 metrics. The score range starts at 0 illustrating poor relative Environmental Performance as well as an insufficient degree of transparency in reporting environmental data publicly and it ends at 100 indicating excellent relative Environmental Performance and a high degree of transparency in reporting environmental data publicly.

Pillars	Catagories	Themes	Data points
Environmental	Emmission	Emissions	TR.AnalyticCO2
		Waste	TR.AnalyticTotalWaste
		Biodiversity*	
		Environmental management systems*	
	Innovation	Product innovation	TR.EnvProducts
		Green revenues, research and development (R&D) and capital expenditures (CapEx)	TR.AnalyticEnvRD
	Resource use	Water	TR.AnalyticWaterUse
		Energy	TR.AnalyticEnergyUse
		Sustainable packaging*	
		Environmental supply chain*	

Figure 8 ESG materiality matrix. Reprinted from Environmental, Social and Governance Scores from Refinitiv by Refinitiv (May 2022). Retrieved from https://www.refinitiv.com/content/dam/marketing/en_us/documents/methodology/refinitiv-esg-scores-methodology.pdf

No data points available that may be used as a proxy for ESG magnitude/materiality mainly due to insufficient disclosure

3.3. Estimating Cost of Equity

In this section the author will elaborate on the methods used to estimate the cost of equity. The cost of equity is the rate of return demanded by a firm's equity investors while the cost of capital is the return expected by all investors of a firm. Furthermore, the cost of capital determines the rate at which future cash flows are discounted. In other words, a lower cost of capital, ceteris paribus, leads to a higher valuation of a company (Sharfman & Fernando, 2008). In the following chapters the author uses three models to estimate the cost of equity. The first model uses implied returns, and the others observe realized returns to derive the cost of equity.

3.3.1. Implied Returns

To derive implied returns the author relied on the model by Claus & Thomas (2001).

$$P^*{}_t = B_t + \sum_{i=1}^{5}\left(\frac{FEPS_{t+1} - R_{CT} *\ B_{t+i-1}}{(1+R_{CT})^i} + \frac{[FEPS_{t+5} -\ R_{CT} * B_{t+4}] * (1+g_t)}{(R_{CT} - g_t) * (1+R_{CT})^5}\right)$$

where:

FEPS = Forecasted/Future Earnings per Share

g_t = Long-term growth rate

B_t = Future book value → $B_{t+i-1} = B_t + EPS_{t+1} – DPS_{t+1}$

DPS_{t+1} = Future Dividend per share → $DPS_{t+1} = EPS_{t-1} * DPR$

DPR = Dividend Payout Ratio

R_{CT} = Implied Cost of Equity according to the Claus & Thomas Model

P^*_t = Share price at time t

This model is an expectation model that uses analysts' forecasts on earnings per share while maintaining a constant dividend pay-out ratio and a constant long-term growth rate for all companies in the sample (Claus & Thomas, 2001). Several different papers relied on the Claus & Thomas model when estimating the implied cost of equity (Chen & Silva Gao, 2011; Bose, 2014; El Ghoul et al., 2011; El Ghoul et al., 2018). The author first collected analyst forecasts of EPS for the first three years to then derive year 4 and year 5 by multiplying the previous year EPS forecast by the constant long term growth rate (Claus & Thomas, 2001). However, due to insufficient data in year 3, the author applied the same approach to derive year 3 data as for year 4 and 5. The long-term growth rate was set at 1.5% and the dividend payout ratio was assumed to be 40%, as suggest on the Damodaran Online database (Damodaran, 2022). The aim in this thesis for using implied returns is to investigate how the Environmental Performance of a company affects the return of an investor.

3.3.2. Realized Returns

On the other hand, realized returns explain why companies with a high or low Environmental Performance obtain lower or higher yields. Here we observe their cost of equity.

3.3.2.1. Cross-sectional panel data

The next approach aims to explain the cost of equity using the Capital Asset Pricing Model (CAPM) (Sharpe, 1964).

$$E(R_i) = R_f + \boldsymbol{\beta}_i * (E(R_m) - R_f)$$

where:

R_i = expected rate of return for equity investors

Rf = risk-free rate

$\boldsymbol{\beta}_i$ = systematic risk (market risk)

$(R_m - R_f)$ = Equity Risk Premium

The risk-free rate was approximated using the 30-year government bond of the respective region in year t. The equity risk premium was downloaded from the Damodaran Online database with the same value for every region for a year t. The beta was estimated using the 2-year weekly data from Capital IQ.

To see whether the Environmental Performance of a company explains the company's stock return, the author used a multi-linear regression model with a similar setup as in Fama & MacBeth, 1973. This model corrects for various risk factors which are further explained below. The regression model was setup as follows:

$E(R_i) = \boldsymbol{\beta 0} + \boldsymbol{\beta 1}$ ENV + $\boldsymbol{\beta 2}$ GWTH + $\boldsymbol{\beta 3}$ RISK + $\boldsymbol{\beta 4}$ SIZE + $\boldsymbol{\beta 5}$ LEV + $\boldsymbol{\beta 6}$ LIQ + $\boldsymbol{\beta 7}$ ENV_D + ε

where:

Dependent variable:	$E(R_i)$	= Cost of Equity
Independent variable:	ENV	= Environmental Performance
Control variables:	GWTH	= Growth expectations
	RISK	= Business risk
	SIZE	= Firm Size
	LEV	= Leverage
	LIQ	= Liquidity
Moderating variable:	ENV_D	= Environmental Disclosure

The author introduced five control variables and a moderating variable complying with previous empirical papers to check for effects that might influence the cost of equity of the firms. GWTH is defined as Shareholders' equity divided by the company's market value (Li Yun et al., 2018), which controls for different growth expectations of the investors. The RISK measures business risk through total asset turnover (Li Yun et al., 2018) and controls for the efficient use of assets to generate sales. The author further controls for firm SIZE through the natural logarithm of total assets (El Ghoul et al., 2011; Gupta, 2018; Yao & Liang, 2019), as smaller companies are associated with higher risks than larger ones (El-Gazza, 1998). LEV is measured through the book value of total liabilities divided by total assets (Li Yun et al., 2018). Higher leverage, all else being equal, results in a higher cost of equity, as the risk increases. Finally, the author controls for LIQ which is determined through the Bid-Ask Spread. High illiquidity increases risk, leading to higher cost of equity (Verrecchia, 2001). Environmental disclosure is measured through the environmental disclosure score retrieved from Bloomberg and is used as a moderating variable.

3.3.2.2. Portfolio framework

In the following model the author formed two portfolios. Companies were ranked according to their Environmental Performance score, and the portfolios were rebalanced every calendar year from 2017 until 2019. The portfolio returns were calculated through aggregated monthly stock returns of the individual companies in the portfolio. The high-ranked portfolio (HIGH) consists of companies with an Environmental Performance score above the 50^{th} percentile and vice versa for companies in the low-ranked portfolio (LOW). Additionally, a difference portfolio LOW-HIGH is formed that is constructed through subtracting excess returns of HIGH energy firms from the LOW ones. Companies without an Environmental Performance score in a given year are omitted from the analysis in that year. This portfolio formulation follows the approach of previous papers in this field (Derwall et al., 2005; Lee & Faff, 2009; Humphrey et al., 2012). Using portfolios instead of single firms to investigate the relationship between Environmental Performance and the cost of equity will result in less noisy estimates (Humphrey et al., 2012).

The author further extends the analysis by only scanning the companies in the lowest quartile (25^{th} percentile) as well as companies that fall into the highest quartile (above 75^{th} percentile) ranked by their Environmental Performance. These portfolios are stated as 25^{th} and 75^{th} portfolio. Again the author constructed a difference portfolio 25^{th} – 75^{th} (in line with Humphrey et al., 2012).

The author aims to determine the one-factor, three-factor and four-factor alpha in each of the seven portfolios: TOTAL, HIGH, LOW, LOW-HIGH, 25^{th}, 75^{th}, 25^{th}-75^{th}. The factor loadings obtained from the Kenneth R. French data library are monthly data referring to developed markets. To determine the one-factor alpha the author used the same model (CAPM) as in the previous chapter which is:

$$E(R_i) = R_f + \boldsymbol{\beta}_i * (E(R_m) - R_f)$$

The market return is a value-weighted return of the developed market region minus the US one month T-bill rate. Subsequently, the author extended the model by adding two factors, resulting in the following equation:

$$E(R_i) = R_f + \boldsymbol{\beta}_1 * (E(R_m)-R_f) + \boldsymbol{\beta}_2 \, SMB + \boldsymbol{\beta}_3 \, HML$$

where:

SMB = Small minus Big

HML = High minus Low

The SMB factor considers risk stemming from long-term outperformance of small stocks over big stocks measured by their market performance. The additional risk might be caused due to less liquidity of small stocks (Fama & French, 1992). The Kenneth R. French data library defines big stocks as those that fall under the top 90% within the developed market region in June for any given year. Small stocks make up the bottom 10%.

HML adjusts for the spread in returns of value and growth stocks. This factor claims that value stocks, i.e., high book-to-market stocks, outperform growth stocks, i.e., low book-to-market stocks, in the long-term (Fama & French, 1992). The methodology of the Kenneth R. French data library follows the approach of subtracting the growth portfolio from the value portfolio. The thresholds for growth and value stand at the 30^{th} and 70^{th} percentile. Next, the author added a fourth factor leading to the following equation:

$$E(R_i) = R_f + \boldsymbol{\beta}_1 * (E(R_m)-R_f) + \boldsymbol{\beta}_2 \, SMB + \boldsymbol{\beta}_3 \, HML + \boldsymbol{\beta}_4 \, MOM$$

where:

MOM = Monthly Momentum

When looking at the past performance of stocks, the MOM refers to the winners and losers (Carhart, 1997). In the Kenneth R. French data library MOM was calculated by subtracting the average monthly return of the losers from the average return of the winners, while the thresholds of the losers and winners stood at the 30^{th} and 70^{th} percentiles.

4. Results

The previous chapter explained the data selection and the sample as well as the various research models used in this thesis. This chapter is dedicated to present the findings of previously discussed models. First the author will present the descriptive statistics followed by the regression analysis results.

4.1. Descriptive statistics

4.1.1. Descriptive statistics of implied returns

Even after the model was adapted (year 3 FEPS were approximated analogous to year 4 and 5) the model did not provide resilient data. Out of 1089 observations from 2017 until 2019 483 lacked data in at least one of the following variables: FEPS in year 1, FEPS in year 2, book value per share, share price. Out of the remaining complete observations 169 of them had negative data in at least one of their variables. The total number of complete and non-negative observations stood at 437. However, when the author conducted the iterative calculations to derive the implied cost of equity via the Claus & Thomas model the majority of the results were not meaningful. Consequently, the author could not proceed since the information requirement of this model was too high respectively the data availability was too low.

4.1.2. Descriptive statistics of cross-sectional panel data

Table 1 depicts the descriptive results of the sample for the cross-sectional time-series analysis. While the environmental pillar score range starts at 0 with a maximum of 100, the average energy firm reached a score of approximately 30. In the period from 2017 until 2019 the average return for equity investors stood at 6.6% and the median return at 6.1% according to the CAPM. Figure 9 shows a strong positive correlation among the various environmental scores and negative correlation between the cost of equity and each of the environmental (sub-) scores. Additionally, in line with previous literature there is a strong positive correlation between Environmental Performance and environmental disclosure suggesting that environmentally high performing firms disclose more information.

Variables	N	Min	Max	Mean	Median	SD
Y CoE	1089	-25,9%	29,2%	6,6%	6,1%	5,2%
X_1 ENV	1089	0,0	95,4	33,8	29,5	27,9
X_2 GWTH	1089	-6,1	679,2	18,1	0,7	70,5
X_3 RISK	1089	0,0	6,1	0,7	0,4	0,8
X_4 SIZE	1089	1,5	12,7	7,4	7,4	2,1
X_5 LEV	1089	0,0	2,4	0,5	0,5	0,3
X_6 LIQ	1089	0,0%	35,2%	0,8%	0,2%	2,6%
X_7 ENV_D	1089	9,5	77,0	40,8	36,1	13,3

Table 2 Descriptive statistics of cross-sectional panel data

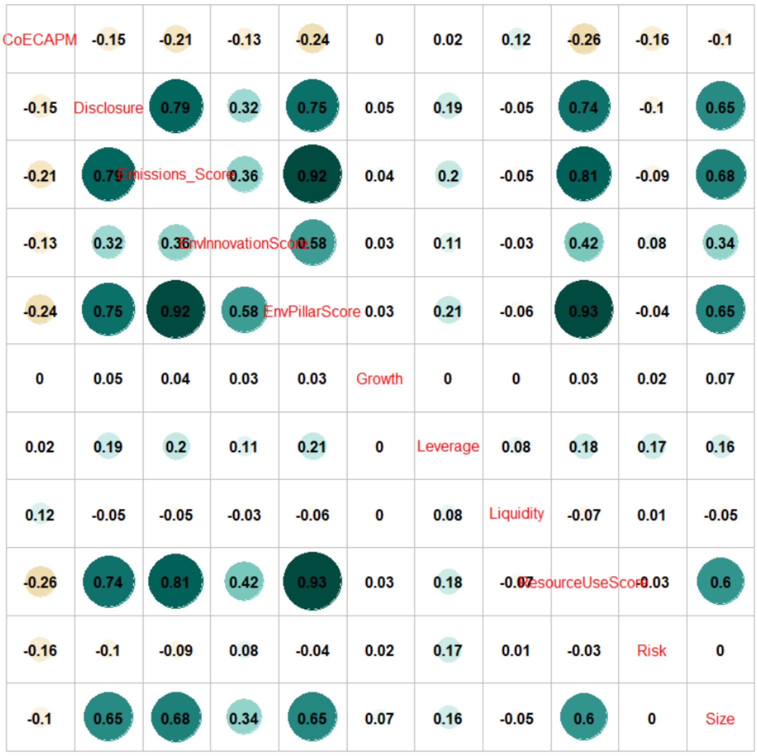

Figure 9 Regression Matrix of the cross-sectional panel data

4.1.3. Descriptive statistics of portfolio analysis

In table 2 the author shows the portfolio excess returns of all seven constructed portfolios. Additionally, each year's Environmental Performance median score is presented. This metric was decisive on whether a company was placed the HIGH respectively LOW portfolio. The median and mean Environmental Performance scores increased on a year-by-year basis.

Variables	N	Min	Max	Mean	Median	SD
Pfl. xs. return (Total)	36	-12,8%	12,6%	-0,1%	0,8%	5,6%
Pfl. xs. return (HIGH)	36	-11,7%	12,3%	0,0%	0,6%	5,3%
Pfl. xs. return (LOW)	36	-14,4%	15,2%	-0,3%	0,7%	6,4%
Pfl. xs. return (LOW-HIGI	36	-3,3%	5,8%	-0,3%	-0,6%	1,9%
Pfl. xs. return (25^{th})	36	-14,5%	16,5%	-0,3%	-0,8%	6,6%
Pfl. xs. return (75^{th})	36	-11,1%	12,9%	0,1%	0,1%	4,9%
Pfl. xs. return (25^{th}-75^{th})	36	-9,3%	5,6%	0,4%	0,7%	3,0%
ENV (2017)	363	0,0	95,4	33,8	29,5	27,9
ENV (2018)	363	0,0	95,2	34,9	31,6	27,6
ENV (2019)	363	0,0	96,3	35,3	33,3	26,8
r_f	36	0,0%	0,2%	0,1%	0,1%	0,1%
$E(R_m) - R_f$	36	-8,2%	7,5%	0,9%	1,6%	3,2%
SMB	36	-2,5%	1,9%	-0,3%	-0,5%	1,1%
HML	36	-4,5%	4,2%	-0,7%	-0,7%	1,8%
MOM	36	-8,7%	7,6%	0,3%	0,0%	3,3%

Table 3 Descriptive Statistics of the portfolio analysis data

4.2. Regression analysis

In the following sections the findings of the Claus & Thomas (2001) model using implied returns and the regression analysis of the cross-sectional panel data as well as of the portfolio analysis are presented.

4.2.1. Implied Return Model

The model introduced by Claus & Thomas (2001) is an expectation model using analyst forecasts. Due to demanding requirements in forecasted EPS data and Environmental Performance figures, the author could not derive meaningful results from this model. Out of the 1089 observations, 437 observations had non-negative FEPS & non-negative share prices. However, the iteration process of the Claus & Thomas (2001) model did not lead to practical data using the remaining data points.

4.2.2. Regression of cross-sectional panel data

The five regression results presented in this chapter show whether the Environmental Performance has a significant negative impact on the cost of equity. This analysis is controlled by the variables GWTH, RISK, SIZE, LEV, LIQ and moderated by ENV_D. The regressions were performed on the whole energy sector as well as on each one of the four sub-sectors (Oil & Gas, Coal, Renewables and Nuclear) individually.

The first regression, shown in table 4, was performed on the whole energy sector. The regression data shows a significant negative relationship between ENV and the cost of equity at a confidence level of 95% as the p-value of $1.36 * 10^{-9} \leq 0.05$ and the t-value $|6.12|$ is > 1.96, therefore, the null hypothesis can be rejected. An increase of 1 in the ENV score leads to a decrease of 0.05% in the cost of equity. Furthermore, RISK has a significant inverse effect on the cost of equity, that means the more sales a company generates in comparison to its assets, the more efficient it is, decreasing business risk and cost of equity. With a t-value of 2.12 and a p-value of 0.03, LEV has a significant positive effect on the cost of equity. Hence, equity investors were compensated for higher LEV. A t-value of 2.8 and a p-value of 0.01 underpin the significant effect of LIQ on the cost of equity. In this paper the LIQ's proxy is the Bid-Ask spread. Therefore, the positive relationship indicates that a higher bid-ask spread, that is higher illiquidity, increases the cost of equity. On the other hand, GWTH, SIZE and ENV_D had no significant impact on the cost of equity as the t-values < $|1.96|$ and the p-values > 0.05.

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.094684 -0.021985 -0.003296  0.020007  0.142068 

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)    
(Intercept)     8.313e-02  8.106e-03  10.255  < 2e-16 ***
EnvPillarScore -4.961e-04  8.058e-05  -6.156 1.36e-09 ***
Growth          5.303e-10  1.904e-09   0.278  0.78074    
Risk           -8.744e-03  1.658e-03  -5.273 1.87e-07 ***
Size            5.560e-04  1.051e-03   0.529  0.59716    
Leverage        1.471e-02  6.951e-03   2.116  0.03476 *  
Liquidity       6.920e-04  2.458e-04   2.815  0.00504 ** 
Disclosure      8.230e-05  1.612e-04   0.510  0.60990    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03408 on 601 degrees of freedom
  (395 observations deleted due to missingness)
Multiple R-squared:  0.1449,    Adjusted R-squared:  0.1349 
F-statistic: 14.55 on 7 and 601 DF,  p-value: < 2.2e-16
```

Table 4 Regression All industries 2017-2019

The table 5 shows the regression output on the oil & gas sector. Similar to the previous table, a significant negative relationship is observed between ENV and the cost of equity, where an increase of 1 Environmental Performance score leads to a decrease of 0.05% in cost of equity. The t-value of -5.42 > $|1.96|$ and the p-value of $9.14*10^{-8} < 0.05$. Analogous to the regression on the whole energy sector, the regression on the oil & gas sector is significantly impacted by RISK, LEV and LIQ. RISK shows a significant negative relationship regarding cost of equity with an absolute t-value of 5.65 and a p-value of $2.6 * 10^{-8}$. LIQ and LEV both show a significant positive relationship regarding the cost of equity with t-values > |1.96| and p-values < 0.05. GWTH, SIZE and ENV_D have no significant effect on the cost of equity.

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.091314 -0.021615 -0.002574  0.019140  0.140673

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)     9.533e-02  8.778e-03  10.860  < 2e-16 ***
EnvPillarScore -4.717e-04  8.705e-05  -5.419 9.14e-08 ***
Growth          7.334e-10  1.842e-09   0.398  0.69071
Risk           -9.345e-03  1.653e-03  -5.652 2.60e-08 ***
Size           -7.399e-04  1.090e-03  -0.679  0.49773
Leverage        1.969e-02  7.508e-03   2.622  0.00898 **
Liquidity       6.398e-04  2.382e-04   2.686  0.00746 **
Disclosure      7.815e-06  1.660e-04   0.047  0.96247
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.03296 on 529 degrees of freedom
  (298 observations deleted due to missingness)
Multiple R-squared:  0.1841,    Adjusted R-squared:  0.1733
F-statistic: 17.06 on 7 and 529 DF,  p-value: < 2.2e-16
```

Table 5 Regression Oil & Gas 2017-2019

In the regression of coal-related enterprises, ENV has no significant effect on the cost of equity. The p-value of 0.29 is larger than 0.05 and the t-value of 1.11 is smaller than 1.96. Thus, the author fails to reject the null hypothesis. Out of the control variables and the moderating variable, LEV has a positive and LIQ and negative significant impact. The p-vales stand at 0.01 and 0.04 and the absolute t-values at 3.10 and 2.28 respectively. The sample size consistent of 30 companies out of which only 3 had environmental data, therefore, limiting the explanatory power of the results.

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.029902 -0.010621 -0.000802  0.009622  0.041865 

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)  
(Intercept)     0.0446990  0.1297449   0.345   0.7370  
EnvPillarScore  0.0007944  0.0007130   1.114   0.2889  
Growth          0.0015107  0.0022349   0.676   0.5130  
Risk           -0.0337806  0.0294929  -1.145   0.2764  
Size            0.0046794  0.0238619   0.196   0.8481  
Leverage        0.1169571  0.0376966   3.103   0.0101 *
Liquidity      -0.7243080  0.3176910  -2.280   0.0435 *
Disclosure     -0.0022921  0.0015472  -1.481   0.1666  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02087 on 11 degrees of freedom
  (8 observations deleted due to missingness)
Multiple R-squared:  0.8086,	Adjusted R-squared:  0.6869 
F-statistic: 6.641 on 7 and 11 DF,  p-value: 0.003046
```

Table 6 Regression Coal 2017-2019

In the regression on renewable energy companies, the result shows no significant relationship between ENV and the cost of equity. The p-value of 0.35 > 0.05 and |t| of 0.93 > 1.96. Therefore, the author fails to reject the null hypothesis. The control and moderating variables show no significant effect on the cost of equity, as the p-values are all above 0.05 and all absolute t-values below 1.96.

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.081481 -0.021517 -0.000581  0.023104  0.105163 

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)     2.076e-02  3.710e-02   0.560    0.579
EnvPillarScore -3.643e-04  3.908e-04  -0.932    0.357
Growth         -6.753e-06  2.045e-05  -0.330    0.743
Risk            4.511e-03  9.183e-03   0.491    0.626
Size            5.805e-03  6.749e-03   0.860    0.395
Leverage        1.469e-02  2.444e-02   0.601    0.551
Liquidity      -1.007e+00  7.411e-01  -1.358    0.182
Disclosure      2.791e-04  8.009e-04   0.348    0.729

Residual standard error: 0.03918 on 42 degrees of freedom
  (73 observations deleted due to missingness)
Multiple R-squared:  0.1155,	Adjusted R-squared:  -0.03193 
F-statistic: 0.7834 on 7 and 42 DF,  p-value: 0.6049
```

Table 7 Regression Renewables 2017-2019

The regression on nuclear energy companies does not show significant results. Aside from other factors, this is also due to the small sample in this industry and the lack of data. Therefore, the author fails to reject the null hypothesis.

```
Residuals:
ALL 3 residuals are 0: no residual degrees of freedom!

Coefficients: (5 not defined because of singularities)
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     0.252524         NA      NA       NA
EnvPillarScore -0.001855         NA      NA       NA
Growth         -0.001420         NA      NA       NA
Risk                  NA         NA      NA       NA
Size                  NA         NA      NA       NA
Leverage              NA         NA      NA       NA
Liquidity             NA         NA      NA       NA
Disclosure            NA         NA      NA       NA

Residual standard error: NaN on 0 degrees of freedom
  (16 observations deleted due to missingness)
Multiple R-squared:      1,     Adjusted R-squared:    NaN
F-statistic:   NaN on 2 and 0 DF,  p-value: NA
```

Table 8 Regression Nuclear 2017-2019

4.2.3. Multi factor models

In this chapter the author will present the findings of the multi factor models. First, the results of the one-factor model will be examined, followed by the three-factor and four-factor models. In each factor model section all seven portfolio (TOTAL, HIGH, LOW, LOW-HIGH, 25th, 75th, 25th-75th) regression results will be reviewed.

4.2.3.1. One-Factor Model

In the following part the author regressed the excess returns of the seven portfolios on the market beta. Table 9 reports a negative alpha of -1.3%, however, the p-value of 0.07 > 0.05 and the t-statistic of |1.86| < |1.96|. Therefore, at a 95% confidence interval the portfolio's performance was not significantly different from the market proxy. The t-statistic of 6.42 and a p-value of smaller than 0.05 show that the market beta explains the portfolio return.

Regression Statistics	
Multiple R	0,740145496
R Square	0,547815355
Adjusted R Square	0,534515807
Standard Error	0,038992714
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,062627378	0,062627	41,19052	2,48078E-07
Residual	34	0,051694679	0,00152		
Total	35	0,114322057			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,012529157	0,006747561	-1,85684	0,072015	-0,02624185	0,0011835	-0,0262419	0,00118354
$E(R_m) - R_f$	1,285393279	0,200279902	6,417984	2,48E-07	0,878375547	1,692411	0,8783755	1,69241101

Table 9 TOTAL Portfolio

In table 10 the statistical figures provide a similar picture. The negative alpha is not significant as the t-value is smaller than |1.96| and the p-value larger than 0.05. The market proxy shows a t-statistic of 6.42 and a p-value of $2.44 * 10^{-7}$ and therefore, it successfully explains the risk of the HIGH portfolio.

Regression Statistics	
Multiple R	0,740402159
R Square	0,548195357
Adjusted R Square	0,534906985
Standard Error	0,036920965
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	0,056235384	0,056235	41,25376	2,44481E-07
Residual	34	0,04634736	0,001363		
Total	35	0,102582744			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,011175477	0,006389052	-1,74916	0,089287	-0,02415959	0,0018086	-0,0241596	0,00180864
$E(R_m) - R_f$	1,218032118	0,189638692	6,422909	2,44E-07	0,832639929	1,6034243	0,8326399	1,60342431

Table 10 HIGH Portfolio

The alpha in table 11 is -1.5%, but with a t-value of less than |1.96| and a p-value of more than 0.05 it is not significant. The portfolio's return positively correlates with the market beta. The significant relationship in the LOW portfolio is underlined by a t-value of 5.66 and a p-value of $2.41 * 10^{-6}$.

Regression Statistics	
Multiple R	0,69627054
R Square	0,484792665
Adjusted R Square	0,469639509
Standard Error	0,047204151
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,071287486	0,071287	31,99285	2,40931E-06
Residual	34	0,075759883	0,002228		
Total	35	0,147047368			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,015257027	0,008168523	-1,86778	0,070432	-0,03185746	0,0013434	-0,0318575	0,00134341
$E(R_m) - R_f$	1,371388672	0,242456648	5,656222	2,41E-06	0,878657479	1,8641199	0,8786575	1,86411986

Table 11 LOW Portfolio

With a value of -0.4% the alpha of the difference portfolio LOW-HIGH is slightly negative, but at a t-statistic of |-1.26| and a p-value of 0.22 the alpha is not significant. The market proxy does not explain the return of the difference portfolio as the t-value stands at |1.60| and the p-value at 0.12.

Regression Statistics	
Multiple R	0,263890357
R Square	0,069638121
Adjusted R Square	0,042274536
Standard Error	0,01871593
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,00089145	0,000891	2,54492	0,119904228
Residual	34	0,011909725	0,00035		
Total	35	0,012801175			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,004081551	0,00323873	-1,26023	0,216167	-0,01066344	0,0025003	-0,0106634	0,00250034
$E(R_m) - R_f$	0,153356553	0,09613141	1,59528	0,119904	-0,04200598	0,3487191	-0,042006	0,34871908

Table 12 LOW-HIGH Portfolio

In table 13 the alpha stands at -1.6%, lacking significance due to a t-value of |1.87| and a p-value of 0.07. The market risk explains the 75th Portfolio's return with the t-statistic and the p-value being significant at |5.65| and $2.44 * 10^{-6}$ respectively.

Regression Statistics	
Multiple R	0,69602129
R Square	0,484445637
Adjusted R Square	0,469282273
Standard Error	0,048467415
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,075049744	0,07505	31,94843	2,43783E-06
Residual	34	0,079869071	0,002349		
Total	35	0,154918814			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,015665167	0,008387127	-1,86776	0,070435	-0,03270986	0,0013795	-0,0327099	0,00137953
$E(R_m) - R_f$	1,407111509	0,248945205	5,652294	2,44E-06	0,901193983	1,913029	0,901194	1,91302903

Table 13 75th Portfolio

The 25th Portfolio in table 14 has a negative alpha of -0.9% which is not significant at a p-value of 0.07 and a t-value of |1.85|. The portfolio's return is described by the market beta which is supported by a t-value of |7.49| and a p-value of 1.09^{-8}.

Regression Statistics	
Multiple R	0,788996323
R Square	0,622515197
Adjusted R Square	0,611412703
Standard Error	0,0311849
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,054527819	0,054528	56,06985	1,08687E-08
Residual	34	0,033064932	0,000972		
Total	35	0,087592751			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,009989408	0,005396445	-1,85111	0,072857	-0,0209563	0,0009775	-0,0209563	0,00097749
$E(R_m) - R_f$	1,199397034	0,160176304	7,48798	1,09E-08	0,873879619	1,5249144	0,8738796	1,52491445

Table 14 25th Portfolio

The difference portfolio 25th-75th in table 15 shows a slightly positive alpha of 0.6%. This alpha is not significant as the t-value stands at 1.11 and the p-value at 0.27. The market proxy does not support the excess return of the difference portfolio as the t-value of |-1.37| < |1.96| and the p-value of 0.18 > 0.05.

Regression Statistics	
Multiple R	0,228950398
R Square	0,052418285
Adjusted R Square	0,024548234
Standard Error	0,029487661
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	1	0,001635406	0,001635	1,880811	0,179225813
Residual	34	0,029563753	0,00087		
Total	35	0,03119916			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	0,005675759	0,005102743	1,112296	0,273814	-0,00469426	0,0160458	-0,0046943	0,01604578
$E(R_m) - R_f$	-0,207714475	0,151458704	-1,37143	0,179226	-0,51551559	0,1000866	-0,5155156	0,10008665

Table 15 25th-75th Portfolio

4.2.3.2. Three-Factor Model

The regressions from Table 16 – Table 22 show the results in the case of the three-factor model. The seven portfolios were regressed on the market risk, SMB and HML. In table 16 the alpha of the TOTAL portfolio is slightly negative at -0.3%. This result is not supported by the t-statistic and the p-value as they stand at |-0.47| and 0.64 respectively. All three risk factors, the market beta, SMB and HML successfully explain the portfolio's return. The t-statistic is larger than |1.96| and the p-value is smaller than 0.05 for all of them. The alpha of in three factors is positive for all of them being in line with the Fama-French Three Factor model rational. The regression shows that when taking on higher market risk, plus when investing into smaller firms opposed to investing into large cap ones and when investing into value companies i.e., high book.to-market ratio firms, the investor is rewarded with higher returns (Fama & French, 1992).

Regression Statistics	
Multiple R	0,822483423
R Square	0,67647898
Adjusted R Square	0,646148885
Standard Error	0,033997053
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	3	0,077336469	0,025779	22,30389	5,5468E-08
Residual	32	0,036985588	0,001156		
Total	35	0,114322057			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,003014444	0,006467186	-0,46611	0,644292	-0,01618767	0,0101588	-0,0161877	0,01015878
$E(R_m) - R_f$	1,27764643	0,175210742	7,292055	2,74E-08	0,920753828	1,634539	0,9207538	1,63453903
SMB	1,351761397	0,516908979	2,615086	0,013493	0,298852263	2,4046705	0,2988523	2,40467053
HML	0,868290242	0,319353048	2,718904	0,010491	0,217789371	1,5187911	0,2177894	1,51879111

Table 16 TOTAL Portfolio

The alpha in table 17 stands at -0.2%, though it is not significant due to the t-statistic being smaller than |1.96| and the p-value overshooting 0.05. All three factors, i.e., market risk, size risk and value risk have significant positive coefficients with t-statistics above |1.96| and p-values below 0.05.

Regression Statistics	
Multiple R	0,823804208
R Square	0,678653373
Adjusted R Square	0,648527127
Standard Error	0,032095862
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0,069618125	0,023206	22,52698	4,98679E-08
Residual	32	0,032964619	0,00103		
Total	35	0,102582744			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,002192866	0,006105527	-0,35916	0,721834	-0,01462942	0,0102437	-0,0146294	0,01024368
$E(R_m) - R_f$	1,207409839	0,165412562	7,299384	2,69E-08	0,870475476	1,5443442	0,8704755	1,5443442
SMB	1,366892936	0,488002264	2,800997	0,008571	0,372864853	2,360921	0,3728649	2,36092102
HML	0,779045305	0,301494106	2,583949	0,014538	0,164921908	1,3931687	0,1649219	1,3931687

Table 17 HIGH Portfolio

In the regression on the LOW portfolio, the negative alpha of -0.4% is not significant due to a t-statistic of -0.46 and a p-value of 0.64. By contrast the three factors in the model all had a significant positive impact on the alpha, as all share t-statistics greater than |1.96| and p-values below 0.05.

Regression Statistics	
Multiple R	0,796605361
R Square	0,6345801
Adjusted R Square	0,600321985
Standard Error	0,040977904
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0,093313334	0,031104	18,5235	3,78084E-07
Residual	32	0,053734035	0,001679		
Total	35	0,147047368			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,003594797	0,007795138	-0,46116	0,647804	-0,01947297	0,0122834	-0,019473	0,01228338
$E(R_m) - R_f$	1,362824091	0,211187975	6,453133	2,94E-07	0,932648262	1,7929999	0,9326483	1,79299992
SMB	1,631337652	0,623049475	2,618312	0,013389	0,362227401	2,9004479	0,3622274	2,9004479
HML	1,07571319	0,384928018	2,794583	0,008709	0,291640474	1,8597859	0,2916405	1,85978591

Table 18 LOW Portfolio

In the difference portfolio LOW-HIGH the slight negative alpha of 0.1% does not hold as the t-statistic of |-0.46| and the p-value of 0.64 indicate not significant results. At the same time, the three factors fail to describe any outperformance of the LOW portfolio regarding the HIGH portfolio. The t-statistics are below |1.96| and all p-values above 0.05.

Regression Statistics	
Multiple R	0,402898087
R Square	0,162326868
Adjusted R Square	0,083795012
Standard Error	0,018305737
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0,002077975	0,000693	2,067019	0,124201117
Residual	32	0,0107232	0,000335		
Total	35	0,012801175			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,00140193	0,003482261	-0,40259	0,689925	-0,00849506	0,0056912	-0,0084951	0,0056912
$E(R_m) - R_f$	0,155414252	0,094342344	1,647344	0,109274	-0,03675481	0,3475833	-0,0367548	0,34758332
SMB	0,264444715	0,278329995	0,950112	0,349176	-0,30249493	0,8313844	-0,3024949	0,83138436
HML	0,296667885	0,171955868	1,725256	0,094128	-0,05359476	0,6469305	-0,0535948	0,64693053

Table 19 LOW-HIGH portfolio

The portfolio in table 20 shows a slight non-significant underperformance of -0.4%. As the t-statistic of -0.53 and the p-value of 0.60 do not support the result. The three factors, on the other hand, successfully account for the risks in the portfolio as all their t-statistics are above |1.96| and their p-values below 0.05.

Regression Statistics	
Multiple R	0,786930078
R Square	0,619258948
Adjusted R Square	0,583564474
Standard Error	0,04293307
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	0,095934862	0,031978	17,34887	7,21366E-07
Residual	32	0,058983952	0,001843		
Total	35	0,154918814			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,004332801	0,008167066	-0,53052	0,599413	-0,02096857	0,012303	-0,0209686	0,01230297
$E(R_m) - R_f$	1,397649356	0,221264324	6,31665	4,35E-07	0,946948676	1,84835	0,9469487	1,84835004
SMB	1,616450805	0,65277685	2,476269	0,018753	0,286787874	2,9461137	0,2867879	2,94611374
HML	1,031270531	0,403293975	2,557119	0,015498	0,209787587	1,8527535	0,2097876	1,85275347

Table 20 25th Portfolio

In the 75th Portfolio the negative alpha of -0.03% lacks significance due to a t-statistic of -0.53 and a p-value of 0.60. Whereas all three factors help explain the return in the model due to their t-statistics being above |1.96| and their p-values being below 0.05.

Regression Statistics	
Multiple R	0,847210556
R Square	0,717765726
Adjusted R Square	0,691306263
Standard Error	0,027794827
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	3	0,062871074	0,020957	27,12699	6,41468E-09
Residual	32	0,024721676	0,000773		
Total	35	0,087592751			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,002801764	0,00528735	-0,5299	0,599839	-0,01357174	0,0079682	-0,0135717	0,00796822
$E(R_m) - R_f$	1,194676755	0,143246302	8,340018	1,58E-09	0,902893586	1,4864599	0,9028936	1,48645992
SMB	0,990115552	0,42260708	2,342875	0,025516	0,129293101	1,850938	0,1292931	1,850938
HML	0,669845925	0,261092116	2,565554	0,01519	0,138018688	1,2016732	0,1380187	1,20167316

Table 21 75th Portfolio

The alpha in the difference portfolio in table 22 stands at 0.2%, however, lacking significance as shown through the t-statistic of 0.28 and the p-value of 0.78. The three factors in model have p-values of less than 0.05, but their t-values are not greater than |1.96|, therefore, these factors fail to explain the risk in that portfolio.

Regression Statistics	
Multiple R	0,378826329
R Square	0,143509387
Adjusted R Square	0,063213392
Standard Error	0,028897333
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	3	0,004477372	0,001492	1,787255	0,169422228
Residual	32	0,026721788	0,000835		
Total	35	0,03119916			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	0,001531036	0,005497078	0,278518	0,782406	-0,00966614	0,0127282	-0,0096661	0,01272822
$E(R_m) - R_f$	-0,202972601	0,148928294	-1,36289	0,182432	-0,50632961	0,1003844	-0,5063296	0,10038441
SMB	-0,626335253	0,439370165	-1,42553	0,163686	-1,52130299	0,2686325	-1,521303	0,26863249
HML	-0,361424606	0,271448566	-1,33147	0,192443	-0,91434724	0,191498	-0,9143472	0,19149803

Table 22 25th-75th Portfolio

4.2.3.3. Four-Factor Model

In the regression from table 23 until table 29 the author extended the three-factor model by the momentum factor MOM. A positive coefficient in this factor indicates that the returns of positive advancing firms outperform the returns of negative advancing firms (Carhart, 1997). In the four-factor regression of the TOTAL portfolio, the negative alpha of 0.3% is not significant as the t-value of |-0.46|is smaller than |1.96| and the p-value of 0.65 is larger than 0.65. The market beta and the SMB factor are both significant at t-values greater than |1.96| and p-value below 0.05. The HML factor is not significant with a t-statistic of 1.67 and a p-value of 0.10. Also, the MOM factor does not hold, as the t-statistic stands at -0.81 and the p-value shows 0.42.

Regression Statistics	
Multiple R	0,826561561
R Square	0,683204015
Adjusted R Square	0,642327113
Standard Error	0,034180153
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	0,078105288	0,019526	16,71369	2,11912E-07
Residual	31	0,036216769	0,001168		
Total	35	0,114322057			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,002961724	0,006502342	-0,45549	0,651934	-0,01622334	0,0102999	-0,0162233	0,0102999
$E(R_m) - R_f$	1,18573989	0,209442045	5,661422	3,23E-06	0,758580024	1,6128998	0,75858	1,6128998
SMB	1,350053755	0,519697185	2,59777	0,014228	0,290124359	2,4099832	0,2901244	2,4099832
HML	0,672213697	0,401882632	1,672662	0,104458	-0,14743133	1,4918587	-0,1474313	1,4918587
MOM	-0,194065162	0,239226515	-0,81122	0,423425	-0,68197086	0,2938405	-0,6819709	0,2938405

Table 23 TOTAL Portfolio

In the HIGH Portfolio the negative alpha of -0.2% is not significant as the t-statistic is -0.34 and the p-value amount to 0.73. The market beta and the SMB factor are both significant, having t-statistics greater than |1.96| and p-values of less than 0.05. The HML and MOM are not significant as their t-statistics are below the threshold of |1.96| and their p-values above 0.05.

Regression Statistics	
Multiple R	0,828691819
R Square	0,686730131
Adjusted R Square	0,646308213
Standard Error	0,032197016
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0,070446661	0,017612	16,98905	1,79E-07
Residual	31	0,032136083	0,001037		
Total	35	0,102582744			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,002138137	0,006125075	-0,34908	0,72939	-0,01463031	0,010354	-0,0146303	0,010354
$E(R_m) - R_f$	1,112000731	0,197290188	5,636371	3,46E-06	0,709624739	1,5143767	0,7096247	1,5143767
SMB	1,365120216	0,489544281	2,788553	0,008967	0,366688071	2,3635524	0,3666881	2,3635524
HML	0,57549626	0,378565346	1,520203	0,138595	-0,19659285	1,3475854	-0,1965929	1,3475854
MOM	-0,201461008	0,22534656	-0,89401	0,378208	-0,66105835	0,2581363	-0,6610583	0,2581363

Table 24 HIGH Portfolio

In table 25 the alpha of the LOW Portfolio stands at -0.4%, however, this number is not supported as the t-statistic of -0.45 as well as the p-value of 0.66 are not significant. The market beta and the SMB are significant at t-statistics of 5.00 and 2.60 respectively as well as p-values of $2.15*10^{-5}$ and 0.01 respectively. The HML factor as well as the MOM factor are not significant as their t-values are below |1.96| and their p-values above 0.05.

Regression Statistics	
Multiple R	0,800312969
R Square	0,640500849
Adjusted R Square	0,594113862
Standard Error	0,041294928
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0,094183964	0,023546	13,80777	1,41856E-06
Residual	31	0,052863404	0,001705		
Total	35	0,147047368			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,003538694	0,007855838	-0,45045	0,655518	-0,01956078	0,0124834	-0,0195608	0,0124834
$E(R_m) - R_f$	1,265021338	0,253038487	4,999324	2,15E-05	0,748945941	1,7810967	0,7489459	1,7810967
SMB	1,629520457	0,627874835	2,595295	0,014312	0,348961287	2,9100796	0,3489613	2,9100796
HML	0,867057463	0,485536576	1,785772	0,083923	-0,12320091	1,8573158	-0,1232009	1,8573158
MOM	-0,206515306	0,289022749	-0,71453	0,480246	-0,79598109	0,3829505	-0,7959811	0,3829505

Table 25 LOW Portfolio

The difference portfolio in table 26 has a not significant negative alpha of -0.1%, as the t-value stands at -0.39 and the p-value at 0.69. None of the four factors are significant as their t-statistics stand below|1.96| and their p-values are above 0.05.

Regression Statistics	
Multiple R	0,40294864
R Square	0,162367607
Adjusted R Square	0,054286007
Standard Error	0,018598195
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0,002078496	0,00052	1,502269	0,225664768
Residual	31	0,010722678	0,000346		
Total	35	0,012801175			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,001400557	0,003538071	-0,39585	0,694925	-0,0086165	0,0058154	-0,0086165	0,0058154
$E(R_m) - R_f$	0,153020607	0,113962157	1,342732	0,189109	-0,07940674	0,385448	-0,0794067	0,385448
SMB	0,264400241	0,282779001	0,935007	0,357012	-0,31233133	0,8411318	-0,3123313	0,8411318
HML	0,291561202	0,218673437	1,333318	0,192143	-0,15442621	0,7375486	-0,1544262	0,7375486
MOM	-0,005054298	0,130168562	-0,03883	0,969276	-0,27053483	0,2604262	-0,2705348	0,2604262

Table 26 LOW-HIGH Portfolio

The regression in table 27 shows a negative alpha of 0.4% being non-significant as the t-statistic is -0.51 and the p-value 0.61. The market and size factor are both significant as their t-values stand above |1.96| and their p-values below 0.05. The value factor as well as the momentum factor are not significant as their t-values are below |1.96| and their p-values amount to more than 0.05.

Regression Statistics	
Multiple R	0,78881208
R Square	0,622224497
Adjusted R Square	0,573479271
Standard Error	0,043449835
Observations	36

ANOVA

	df	SS	MS	F	Significance F
Regression	4	0,096394281	0,024099	12,76483	2,98022E-06
Residual	31	0,058524533	0,001888		
Total	35	0,154918814			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95,0%	Upper 95,0%
Intercept	-0,004292047	0,008265781	-0,51925	0,607271	-0,02115022	0,0125661	-0,0211502	0,01256613
$E(R_m) - R_f$	1,326603488	0,266242877	4,982682	2,26E-05	0,78359756	1,8696094	0,7835976	1,86960942
SMB	1,615130759	0,660639432	2,444799	0,020375	0,267747754	2,9625138	0,2677478	2,96251376
HML	0,879698853	0,510873489	1,72195	0,095044	-0,1622345	1,9216322	-0,1622345	1,9216322
MOM	-0,150016833	0,304104917	-0,49331	0,625273	-0,7702429	0,4702092	-0,7702429	0,47020923

Table 27 75th Portfolio

In the 25th Portfolio in table 28 the negative alpha of -0.2% is not significant with a t-value of -0.52 and a p-value of 0.60. The market beta and the SMB beta are both significant at t-values above |1.96| and p-values below 0.05. The third and fourth factor are not significant as their t-values are below the threshold of |1.96| and above the p-value of 0.05.

Regression Statistics	
Multiple R	0,851770319
R Square	0,725512676
Adjusted R Square	0,690094957
Standard Error	0,027849306
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	0,063549651	0,015887	20,48446	2,427E-08
Residual	31	0,0240431	0,000776		
Total	35	0,087592751			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-0,002752235	0,005297978	-0,51949	0,60711	-0,01355753	0,0080531	-0,0135575	0,00805306
$E(R_m) - R_f$	1,108332466	0,170649197	6,4948	3,03E-07	0,760291134	1,4563738	0,7602911	1,4563738
SMB	0,988511258	0,423438891	2,334484	0,026224	0,124901947	1,8521206	0,1249019	1,85212057
HML	0,485636073	0,327445945	1,483103	0,148143	-0,18219434	1,1534665	-0,1821943	1,15346648
MOM	-0,1823202	0,194916989	-0,93537	0,356826	-0,57985602	0,2152156	-0,579856	0,21521562

Table 28 25th Portfolio

In the last regression on the difference portfolio the alpha stands at 0.1%, however, this value is not significant as the t-statistic stands at 0.28 and the p-value at 0.78. None of the four factors are significant as all their t-values are below |1.96| and all their p-values are higher than 0.05.

Regression Statistics	
Multiple R	0,37972644
R Square	0,144192169
Adjusted R Square	0,033765352
Standard Error	0,029348015
Observations	36

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	0,004498675	0,001125	1,305771	0,289536542
Residual	31	0,026700485	0,000861		
Total	35	0,03119916			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,001539812	0,005583089	0,275799	0,784532	-0,00984697	0,0129266	-0,009847	0,0129266
$E(R_m) - R_f$	-0,218271022	0,179832672	-1,21375	0,234012	-0,58504218	0,1485001	-0,5850422	0,14850013
SMB	-0,626619501	0,446226227	-1,40426	0,17018	-1,53670389	0,2834649	-1,5367039	0,28346489
HML	-0,39406278	0,345067428	-1,14199	0,262203	-1,09783244	0,3097069	-1,0978324	0,30970688
MOM	-0,032303366	0,205406434	-0,15727	0,876055	-0,45123255	0,3866258	-0,4512326	0,38662582

Table 29 25th-75th Portfolio

5. Discussion

5.1. Summary & Implications

Sustainable Finance is more prevalent than ever with also more and more interest from the investors' side. For this reason, this paper examines whether increased environmental performance affects the cost of equity of a company, therefore the return for the investors. Numerous studies have worked on this topic before, but their scope was vast and comprised of all industries and several regions. Thus, the focus of this study lies on the energy sector as this sector globally is most crucial in solving the environmental crises, because it is connected to the majority of CO_2 emissions. Additionally, the energy sector is heavily regulated, follows its own rules, therefore justifying a study on its own. Last but not least, the energy sector has a major impact on the overall economy, accounting for a large portion of its growth, even if that growth has decoupled itself from energy use to some extend in recent years. This thesis follows the lead paper of Fonseka et al. (2019) that examined the effect of environmental information disclosure (EID) on the cost of equity in the case of the Chinese energy sector. However, in this paper the author investigated the effect of Environmental Performance on the cost of equity for all listed energy companies located in Europe, the US or Canada. The author believes that the Western regions could lead to new results as they differ China in their climate policies, the form of government and cultural differences that might affect investor behavior. Similarly to Fonseka et al. (2019), the author examined whether the effect differs among the energy types: Oil & Gas, Coal, Nuclear, Renewables. In this paper three different models were applied, the first model using implied returns and the second and third model using realized returns, where the second model used cross-sectional panel data and the third one followed a portfolio approach.

The first model implemented the formula from Claus & Thomas (2001), an expectation model using analyst forecast. Due to demanding requirements, the author could not derive results from this model. Hence, the research question was addressed using the models with realized returns. The cross-sectional panel data analysis supports the hypothesis of lower cost of equity for energy companies with a higher Environmental Performance. The significant result in table 3 is further controlled through the variables GRWTH, RISK, SIZE, LEV, LIQ, ENV_D. This holds as well for the Oil & Gas sub-sector. This is in line with (El Ghoul et al. (2018), however opposite to what Fonseka et al. (2019) found. In their study fossil-fueled companies experienced higher cost of equity when the Environmental Information Disclosure was higher.

The analysis on the remaining three sub-sectors (Renewables, Nuclear and Coal) was not significant. An explanation for non-significant results within the Renewables sub-sector might be that investors pay more attention to environmental scores in relation to high-polluting industries or companies. The reason behind nonsignificant outcomes in the Nuclear and Coal sub-sectors is likely to be the lack of public companies i.e., data in the investigated region. Within Coal only 25 data points on the Environmental Performance were collected across all regions and years and for Nuclear the number of data points only resulted in 7 entries. Though, the risk mitigation hypothesis could as be used as an explanation for the lack of investor interest, as investors might perceive Nuclear and Coal as “sin” industries.

While the second model posted some significant results, the outcome of the portfolio framework was surprising. All regressions within that model were not significant. Even when comparing the highest quartile of companies’ Environmental Performance to the lowest quartile, the regression was not significant, regardless of the model used i.e., One- Three or Four-Factor model. Thus, in the third model the author did not observe excess returns of companies in the LOW portfolio. This implies that according to the multi-factor model, the hypothesis of Environmental Performance affecting cost of equity was not supported. This is in line with the results of (Humphrey et al., 2012), who also used a portfolio framework to investigate whether Corporate Social Practices (and ESG data) influence the risk-adjusted performance of portfolios comprising firms and found no evidence.

5.2. Limitations and future research

Even though the author excluded the year 2020 due to extraordinary effects influenced by the Covid-19 pandemic, there might be other limitations to whether the period of 2017-2019 is representative. A shortcoming was the lack of ESG scores. More and more companies receive ESG scores every year, however, in this paper about a third of all listed companies did not have an ESG score in the Refinitiv database. More extensive environmental data might lead to different outcomes.

Therefore, future research could tackle more recent years with hopefully less missing data. Other papers could also extend this research by investigating different sectors, geographies, or the entire market as a whole. Thereby, a variety of different environmental metrics is available to investigate their effect. Additionally, to the cost of equity, an examination of the cost of debt becomes apparent, to see whether debt investors include Environmental Performance metrics into their investment decision.

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