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# **The relationship between stock returns and climate change concerns in different regions**

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**ABSTRACT:**

The purpose of this thesis is to examine the relationship between climate change concerns and stock returns in different regions. The chosen regions for the evaluation are the USA, Europe, and the Nordic countries. The sample consists of data for the period 1.1.2010-31.5.2024. For the examination, two simple linear regression models are constructed. These Models aim to elaborate how the Media Climate Change Concern (MCCC) index affects the returns of stock indices in different regions. In addition, with thematic climate change concern indices, it is possible to locate which type of concerns have the most significant effect on returns. Lastly, additional analysis is performed by analyzing how the relationship has evolved as attention towards climate change has strengthened.

This thesis is motivated by the growing importance of sustainability and climate change as critical global challenges that impact economic systems and financial markets. Traditional and behavioral finance theories, which elaborate the basis of stock price formation on the market, provide a theoretical background for this thesis. Also, the importance of climate risks for investors and the consistent development of sustainability justifies the materiality of climate change concerns. Furthermore, supporting the objective of this thesis.

The results of this thesis are mainly aligned with the presented hypotheses. The increase of climate change concerns has a negative impact on the stock returns in most of the regions. Also, in the USA, Finland, and Sweden evidence is found that the negative impact on the returns is strongest for the transition risk related climate change concerns. Whereas, in Europe, Denmark, and Norway the climate change concerns linked to physical risks have the strongest negative impact on the stock returns. These results confirm a recognizable relationship between climate change concerns and stock returns. The regional differences would indicate that the importance of climate change concerns varies depending on the region, which can be further traced back to the sustainability differences of the regions. This has important implications for the risk management of investors. While providing information on the importance of climate change concerns to policymakers and companies.

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**KEYWORDS:** climate change, climate risk, socially responsible investing (SRI), sustainability, ESG, stock returns, investor attention, risk management, the Paris Agreement, the Nordics

**TIIVISTELMÄ:**

Tämän tutkielman tarkoituksena on tarkastella ilmastonmuutoshuolien ja osaketuottojen välistä yhteyttä eri alueilla. Tutkimuksen kohteeksi valitut alueet ovat Yhdysvallat, Eurooppa ja Pohjoismaat. Tutkittavaksi ajanjaksoksi on valittu 1.1.2010–31.5.2024. Tutkimusta varten laadittiin kaksi lineaarista regressiomallia, joiden avulla analysoitiin Media Climate Change Concern (MCCC) -indeksin vaikutusta osakeindeksien tuottoihin eri alueilla. Lisäksi ilmastonmuutoshuolien teemajaottelun avulla pystyttiin tunnistamaan, millaisilla huolenaiheilla on merkittävin vaikutus osaketuottoihin. Lopuksi tutkielmassa suoritettiin lisäanalyysi, jossa tarkasteltiin, miten tämä suhde on kehittynyt ajan kuluessa, kun ilmastonmuutokseen kohdistuva huomio on kasvanut.

Tämä tutkielma saa motivaationsa kestäväen kehityksen ja ilmastonmuutoksen kasvavasta merkityksestä, mitkä keskeisinä haasteina vaikuttavat laajasti talouteen sekä rahoitusmarkkinoihin. Teoreettisena taustana tutkielmassa hyödynnetään sekä perinteisiä että käyttäytymistieteellisiä rahoitusteorioita, jotka selittävät osakehintojen muodostumisen perusteita markkinoilla. Lisäksi tutkielman taustana käsitellään ilmatoriskien merkitystä sijoittajille sekä kestäväen kehityksen jatkuvaa edistymistä. Nämä teemat sekä aiheeseen liittyvät tutkimustulokset luovat rungon tutkielmassa esitettyihin hypoteeseihin.

Tutkielman tulokset tukevat pääosin esitettyjä hypoteeseja. Ilmastonmuutoshuolien lisääntyminen vaikuttaa negatiivisesti osaketuottoihin useimmilla alueilla. Lisäksi havaittiin, että Yhdysvalloissa, Suomessa ja Ruotsissa ilmastonmuutoshuolien negatiivinen vaikutus tuottoihin on voimakkain siirtymäriskeihin liittyvillä huolilla. Kun taas Euroopassa, Tanskassa ja Norjassa osaketuottoihin voimakkaimmin vaikuttavat ilmastonmuutoshuolet liittyvät fyysisiin riskeihin. Nämä tulokset vahvistavat, että ilmastonmuutoshuolilla ja osaketuotoilla on tunnistettava yhteys. Alueelliset erot taas viittaavat siihen, että ilmastonmuutoshuolien merkitys vaihtelee alueittain, mikä voidaan liittää alueiden eroihin kestäväen kehityksen osalta. Tällä on tärkeitä vaikutuksia sijoittajien riskienhallintaan sekä tämä tarjoaa tietoa ilmastonmuutoshuolien merkityksestä päättäjille ja yrityksille.

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**AVAINSANAT:** ilmastonmuutos, ilmatoriski, vastuullinen sijoittaminen (SRI), vastuullisuus, ESG, osakkeiden tuotto, sijoittajien tarkkaavaisuus, riskien hallinta, Pariisin ilmastopöytäkirja, Pohjoismaat

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## 1 Introduction

Climate change is one of the greatest global threats of our time. It is going to influence our life on the planet in many ways and some of the consequences can already be discovered all over the world. Climate change has caused problems such as rising sea levels, extreme weather disasters, water shortages, and the increased risk of floods and drought. In a constant effort to avoid these impacts, various measures have been taken to prevent them. The consequences of climate change and mitigation efforts can be detected to influence the financial market and especially the stock market.

On the stock market, the influence of climate change is illustrated as climate risk. This represents all the risks investors face linked to the development of climate change. According to Giglio et al. (2021), climate risk consists of two main aspects, that are physical and transition risk. Transition risk includes risks related to the profitability of companies (Giglio et al., 2021). This consists of the risks of implementing new climate change inspired regulations or introducing a carbon tax, which can cause companies to have additional expenses or stranded assets. Physical risk includes the risks of the actual deterioration of company production assets due to climate change (Giglio et al., 2021). Physical risk can be further divided into acute and chronic physical risks (Venturini, 2022). An example of an acute physical risk to a company could be a climate disaster destroying a manufacturing facility.

As the significance of climate change has emerged, there has been a clear shift towards sustainability. In general, this can be seen as policy changes, new regulations, and different environmental movements. These public efforts seem to concentrate on unifying the actions taken against climate change and encouraging all participants to reduce emissions (Hale, 2016). On a global level, the Paris Agreement 2015 has been one of the most important turning points in creating a common goal with efforts against climate change. This shift can be detected on the stock market as the development of guidelines and rating systems that help investors incorporate climate change into decision-making processes. This important participation in the sustainability of investors

is usually referred to as socially responsible investing (SRI). The main idea is that SRI is a strategy that incorporates environmental, social, and governance aspects in the selection process of securities (Eurosif, 2021). This has further resulted in the classification of stocks. “Green stocks” represent environmentally friendly and sustainable stocks. Whereas all other stocks are usually referred as “brown stocks”, which represent the opposite or just conventional stocks. The popularity of the SRI strategy has been constantly growing during recent years. According to a US SIF report, 13 percent of total assets under professional management in the USA were using sustainable investing strategies at the end of the year 2021 (US SIF, 2023). This illustrates how important investors perceive sustainability in their investment decisions. Also, this shift has piqued the interest of researchers to gain more information about the effect of climate risk on the stock market which has caused a flood of literature in this area during recent years.

The existence of climate risk is widely acknowledged and according to Krueger et al. (2020), investors have ranked climate risk as the fifth most important risk while considering investing. However, the dynamics behind the pricing of this risk remain partially unclear. There have been suggestions that climate risk would represent an anomaly, be an additional source of systematic risk, or a diversifiable risk related to a specific company (Venturini, 2022). The uncertainty starts with the pricing timing of climate risk. According to Venturini (2022), climate risk can be priced on an ex-post (after) or ex-ante (before) basis. It is more common that physical risks are priced on ex-post basis as the occurrence might be unexpected. As for an ex-ante basis pricing, fairly adverse evidence has been found in existing literature. Pástor et al. (2022) report finding a green stock premium, which has increased during the last decade. According to Faccini et al. (2023), the pricing of climate risk is more concentrated around the pricing of transition risks related to climate policy uncertainty. In different industries, the pricing seems to be at different levels, as the food stocks seem to underestimate the pricing of the risk (Hong et al., 2019), whereas in the energy sector, the prices of renewable energy stocks are positively impacted by climate risk (Dutta et al., 2023). On the other hand,

Bolton and Kacperczyk (2021) reported that higher carbon risk is positively compensated for. This is supported by the hedging assumptions (Faccini et al., 2023; Pástor et al., 2021). As green stocks are not as strongly exposed to climate risks, those stocks should provide a hedge to investors (Engle et al., 2020). Therefore, green stocks would produce a lower expected return when compared to brown stocks, which is rational as this difference would work as an expense for the gained insurance.

The behavioral aspects of investors have caused the registered importance of climate risks being linked to the attention levels of investors. The attention level toward climate change can be increased by the realization of physical and transition risks or public conversation related to the topic. According to El Ouadghiri et al. (2021), an increase in public attention towards climate change has a positive effect on sustainability stock indices. This would mean that investors take climate risk increasingly into account when they are reminded of the existence of this risk. Also, Santi (2023) reports that increased attention toward climate change shifts investors' selection toward more sustainable options. Both El Ouadghiri et al. (2021) and Santi (2023) believe that this reaction caused by the increased attention levels can be traced back to the disinvestment of conventional stocks.

The pricing of climate risk and preference changes of investors have been detected to cause performance differences between green and brown stocks. According to Pástor et al. (2021), green stocks have positive ESG betas in an asset pricing equilibrium model. This indicates that major changes related to climate risk would have a positive influence on green stocks. However, the study shows that green stocks have negative CAPM alphas which implies a lower expected return due to the possibility of avoiding climate risk (Pástor et al., 2021). Still, during times of increased climate risk green stocks seem to outperform brown stocks. Also, Ardia et al. (2023) found that green stocks outperform brown stocks when there is an unexpected growth in climate change concerns. According to Choi et al. (2020) during abnormally warm weather high emission stocks underperformed lower emission stocks. On the contrary, Bauer et al. (2022) report a

reversal of this effect during the year 2022, when brown stocks seem to outperform green stocks. Also, El Ghoul et al. (2023) reported underperformance of socially responsible funds. However, these both could be related to the possible hedging against climate risk.

The response of the stock market and investors to climate change can be traced back to traditional and behavioral finance theories. According to the efficient market hypothesis introduced by Fama (1970), stock prices should reflect accurately all existing information, which means that developments related to climate risk should be incorporated into the pricing. This would mean that climate risk should be incorporated into the fundamental price of stocks. Arguments for the investor response towards climate risk are supported by the modern portfolio theory, as there should be an effort to maximize the risk and return ratio. As climate change causes additional risk, investors should find ways to mitigate this risk, to improve the ratio. In research, it is reported that high ESG performance portfolios seem to have lower volatility (López Prol & Kim, 2022). On the other hand, the reaction could be traced back to a more realistic view of investor behavior. Raut et al. (2023) argue that the personal sense of responsibility plays a role in the decision processes and some investors have developed a preference to participate in the mitigation of climate change. In the group of retail investors, it is possible that personal values drive decisions, whereas with institutional investors reputation might be more important. Also, the growing trend of sustainable investing could be caused by herd behavior. According to Shi et al. (2024), investors tend to trade similar stocks, which is accelerated by growing trends. This has been detected in the Chinese stock market as herding towards carbon neutrality. In reality, the stock market reaction to climate risk could be caused by a combination of these reasons.

The relationship between climate risk and the stock market seems to be affected by regional differences. Some countries only participate in the mandatory actions whereas others can be considered as sustainability leaders. The stage of sustainability in a certain country can depend on regional differences. According to Afzali et al. (2024),

corporations that operate in areas of higher climate change denial are proven to have lower environmental performance. Therefore, the attitudes of local communities can affect the progress of sustainable development. Also, Di Giuli and Kostovetsky (2014) report that companies headquartered in states characterized as Democratic are more socially responsible compared to companies in Republic states. When it comes to sustainable investing, it is mainly concentrated in the US and Europe. Especially, in Europe the conditions are favorable for sustainability, which constantly promotes the development of socially responsible investing. The EU has implemented different requirements that ensure transparency about sustainability efforts (Eurosif, 2021). Sustainability is even better in the Nordic countries, and they have been even referred to as the world sustainability leaders (Strand, 2024). The Nordics have been spotted at the top of multiple sustainability rankings. Also, it is well known that stakeholders put a lot of weight on the responsibility of companies which accelerates the transition toward a more sustainable society. As the relationship between climate risk and the stock market is partially connected to investor sentiment and attention, it can be assumed that regional differences can alter this relationship.

### **1.1 Purpose of the study**

The purpose of this thesis is to examine the relationship between climate change concerns and stock returns in different regions. The level of climate change concerns is modeled by the Media Climate Change Concern (MCCC) index constructed by Ardia et al. (2023). The MCCC index models how the attention and sentiment towards climate change vary across time. This makes it possible to examine whether stock returns are influenced by the increasing climate change concern levels. The chosen regions (countries) for this evaluation are the US, Europe, and the Nordics, which include Finland, Sweden, Norway, and Denmark. The stock return of each region is illustrated with the return of a broad-base index that represents the whole stock market of the region.

As the stage of sustainability and attitudes toward climate change differ regionally, it could be assumed that also the magnitude of the impact of climate change concern on the stock returns could differ regionally. Therefore, this thesis aims to evaluate the possible differences between regions and extend the knowledge of the influence of climate change. According to Gong et al. (2023), there is evidence that climate risk premium has regional differences. As most of the published research is based on the US market. Therefore, this thesis attempts to present more information on the Nordics and Europe. This has an important contribution as those regions can be considered to be sustainability leaders (Strand, 2024). This could help determine whether the efforts aimed toward sustainability make a difference between regions. The chosen research design for this thesis concentrates on how climate change concerns affect the whole stock market in a specific region. Because of the chosen research design, the indices used in the thesis are conventional stock indices, and the formation of the chosen indices does not include strict sustainability metrics.

The examination in this thesis is constructed of a main analysis and an additional analysis. The main analysis examines the effect of climate change concerns over the whole sample. The analysis should provide a view of how the general level of climate change concerns affect stock returns in different regions. Also, providing information on exactly what type of climate change concerns have the most significant effect on stock returns. In the additional analysis, the aim is to examine whether the effect of climate change concerns has changed over time. Therefore, there is an evaluation of different periods before and after the Paris Agreement. This should provide insight into whether the growing public interest in climate change has strengthened the relationship. In the following sections, the hypotheses of this thesis are presented with the results of supporting literature. The main hypotheses are the same for all the regions, which means that the direction of the impact is expected to be the same in all the regions. However, we expect the magnitude of the effect to alter depending on the region.

Firstly, in the examination of the impact of the aggregate MCCC index on the stock returns, it is expected that the climate change concern levels impact negatively the stock returns in all the regions. According to existing literature, when the climate change concern level increases it impacts the return of green stocks positively (Ardia et al., 2023; El Ouadghiri et al., 2021; Pástor et al., 2021; Santi, 2023). As our sample includes conventional stock indices, the effect is expected to be negative in all regions. The increase in climate change concerns causes the disinvestment of conventional stocks as they contradict investor preference (El Ouadghiri et al., 2021; Santi, 2023). According to Ardia et al. (2023), climate change concerns seem to have a stronger impact on brown stocks as investors seemingly discipline brown stocks. However, it is expected that the sustainability of the region influences the effect. Therefore, the negative impact is expected to be least pronounced in the Nordic countries, which can be labeled as sustainability leaders (SDSN, 2023; Strand, 2024). Based on this literature, we assume the following hypothesis on the relationship between stock return and climate change concerns.

H1: The increase in climate change concern levels has a negative impact on stock return.

H1a: The negative impact is least pronounced in the Nordics.

In the examination of the impact of the thematic MCCC indices on the stock returns, it is expected that the increase in concerns with transition risk related themes has the largest negative impact on the stock returns. This assumption is based on the existing literature highlighting the importance of transition risks to investors. This view of investors has been confirmed by a survey conducted by Stroebe and Wurgler (2021). The results of the survey reported that investors believe transition risks to be the most important climate risk over the next five years. According to Faccini et al. (2023), while researching the pricing of climate risk, only evidence of the pricing of transition risk was found. Also, Ardia et al. (2023) conducted a similar evaluation with the MCCC index and resulted in the conclusion that transition risk related concerns have the biggest negative impact. In all the regions, it is expected that the transition risk related concerns

are most relevant. Based on this argumentation, the following hypothesis number two is formed.

H2: The increase in climate change concerns with transition risk related theme has the most negative impact on stock return.

In the additional analysis of the effect of climate change concerns, during periods before and after the Paris Agreement, it is expected that the effect of concerns on the stock returns has strengthened after 2015. This means that if the climate change concern level increases, the stock returns are more negatively impacted after the Paris Agreement. This assumption is based on the growing trend of investors including climate risks in their asset selection process. According to Krueger et al. (2020), the importance of climate risk has increased during the recent years, and it has been ranked as the fifth most important risk. Also, Bolton and Kacperczyk (2021) reported that carbon risk premium has increased after the Paris Agreement. Meaning that the importance of climate risks has increased. In general, the existing literature indicates that when the attention level toward climate change increases, it should increase the importance of climate risk perceived by investors (El Ouadghiri et al., 2021; Santi, 2023). Therefore, it is assumed that the growing attention toward climate change and the implemented mitigation efforts are constantly strengthening the effect of climate change concerns on stock returns. However, this strengthening is expected to be strongest in the USA, as other regions are generally more sustainable (Strand, 2024). Based on this evidence, the third hypothesis of this thesis is formed in the following manner.

H3: The negative effect of climate change concerns has strengthened after the Paris Agreement.

H3a: The negative effect has strengthened most clearly in the USA.

The objective of this thesis is to provide support to the three hypotheses by conducting an empirical analysis. In addition, to confirming the hypotheses for each region, we

expect to be able to provide evidence that the magnitude of the effect varies among different regions. Possibly indicating that the effect of climate change concerns is stronger in other regions, possibly depending on the sustainability of the region. Therefore, the results are expected to contribute regional information on how the increase of climate change concern levels affects the stock return. In addition, elaborating which type of concerns are the most significant for the stock returns. From the examination of periods before and after the Paris Agreement, the aim is to address how the relationship has changed over time. The contribution of these results would be to help investors in risk management and provide useful information for policymakers. More specifically, the results could contribute to risk management, as to whether some of the climate risk could be reduced with geographic diversification.

## **1.2 Structure of the study**

The structure of the thesis is presented in this chapter. At the start of the thesis, there is an introduction, which provides a brief overview of the topic. After that, there is a chapter regarding the dimensions of sustainable investing. It focuses on the development of sustainability and socially responsible investing in general. Also, it provides an overview of the climate risk factors and introduces the measurement used for sustainability. The third chapter concentrates on the theoretical background, by presenting the relevant financial theories for the thesis. In chapter four, the existing research related to the topic is presented. In chapters four and five the data and methodology used in the thesis will be addressed and further, the empirical results are presented. In the final chapter, there is a discussion of the findings and conclusions.

## **2 Dimensions of sustainable investing**

This chapter focuses on the different aspects of sustainability related to investing. It should provide a brief overview of the historical developments around sustainability. After this, the focus is aimed towards socially responsible investing and how it is implemented on the stock market. In addition, we will cover the basic structures of climate risk and ESG. This will provide an understanding of the metrics of how risks and sustainable performance are defined. Lastly, the characteristics of sustainability in the Nordic countries are discussed to gain a perspective on regional aspects.

### **2.1 Shift towards sustainability**

During the recent years, there has been a noticeable shift towards sustainability in our society. This can be detected from the growing news media coverage, policy changes, and different climate movements (e.g. Earth Hour) that have been able to draw more attention to these climate related issues. This has helped all the participants to align efforts towards a common goal, therefore making the influence of the actions taken much more effective. All these developments have helped the transition towards a more sustainable investing environment.

One of the most significant turning points of sustainability can be said to be the Paris Agreement. In December 2015, the United Nations updated the previous agreement on climate change to create the Paris Agreement. In this agreement, a limit of global warming was decided to be 2 °C, and all the participants were required to take action to succeed in this target. According to Hale (2016), the goal was to support the progress of creating conditions that would increasingly encourage all participants to reduce emissions. As a consequence of the Paris Agreement, the objective related to sustainability has been unified among many countries. Essentially, all the countries were coming together to try to mitigate climate change with their own different policy shifts aimed toward the common target.

According to Peake and Ekins (2017), this development included behavioral and technological aspects. General behavioral changes could help incorporate climate aspects into the decision-making processes of corporate executives and investors. The significant role of investors is highlighted because a lot of funding is needed to make this transition to a sustainable economy possible. Especially, the technological developments during the transfer towards renewable energy have required both public and private funding (Peake & Ekins, 2017). Therefore, favorable circumstances needed to be created with policy shifts to ensure the capital flow and motivation toward this transition.

Another noticeable unification of incorporating climate change into decision-making processes has been the development of different guidelines for sustainable investing such as Principles of Responsible Investing (PRI) and parameters to measure the sustainability of investments such as the environmental, social, and governance (ESG) factors. The global investor association Principles of Responsible Investing (PRI) is built on six ESG-related principles. The PRI began to grow in 2006 and currently over 4,000 investment managers have signed the principles. According to Majoch et al. (2017), the association does not directly have mandatory requirements for the implementation of these principles and therefore, leaving execution options to the investors. Fundamentally, the association wants to support and encourage investors to make more sustainable ownership and investment choices.

From the point of view of companies, environmental policies play a considerable role in motivating the transition towards more sustainable operations. Regulations are often aimed toward emission levels because for a long-time carbon dioxide ( $CO_2$ ) emissions have been considered to be the primary source of human accelerated climate change (Nordhaus, 1993). Companies are responsible for emissions on three levels set by the standards of the Greenhouse Gas Protocol (2004). Firstly, Scope 1 illustrates the emissions created by the sources owned by the company as the direct emissions. Secondly, the emissions created by the consumed electricity are illustrated as Scope 2

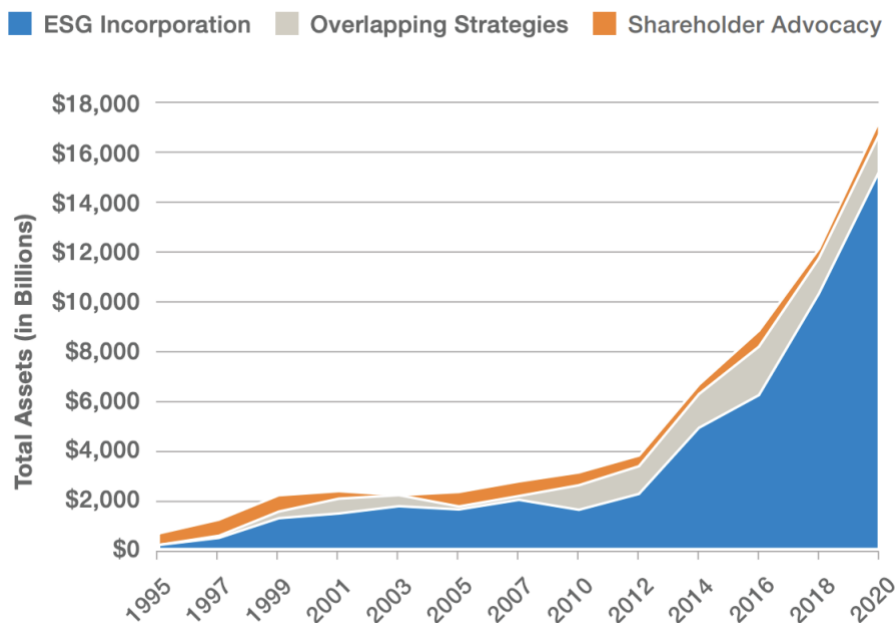
indirect emissions. Lastly, Scope 3 represents indirect emissions caused by other activities of the company, for example outsourcing.

These firm-level emissions are influenced by the regulations and policies implemented in the region. Ben-David et al. (2021) discovered that companies headquartered in countries with strict regulations are proven to move emission-creating activities to countries with more loose environmental policies. However, these companies are still reported to have lower pollution levels globally (Ben-David et al., 2021). Therefore, emission regulations slowly incentivize companies toward more sustainable operations. In addition, the reporting requirements of companies have been updated to support sustainable development. During the start of 2023, the Corporate Sustainability Reporting Directive (CSRD) entered into effect for EU-companies (European Commission, 2024). As companies are forced to report their actions, it makes them more accountable. Furthermore, the necessary levels of emissions and the levels of environmental friendliness are discovered, and it provides investors information about which investments are sustainable.

The development towards sustainability can be in different stages in different countries and even in different areas in the country. This is partly due to cultural differences, different geographical locations, political leanings, and the stage of social capital and trust which all have an impact on the operating environment of the company. For example, Di Giuli and Kostovetsky (2014) reported that companies headquartered in states that can be characterized as Democratic are more socially responsible compared to companies in Republic states. In addition to this, the local attitude towards climate change plays a role. According to Afzali et al. (2024), companies that operate in higher climate change denial US counties are proven to have lower environmental performance scores. These attitudes in local communities create obstacles to sustainable development and increase the risk of larger environmental costs for society (Afzali et al., 2024). This emphasizes the importance that every individual participates in the shift towards sustainability, not only large entities.

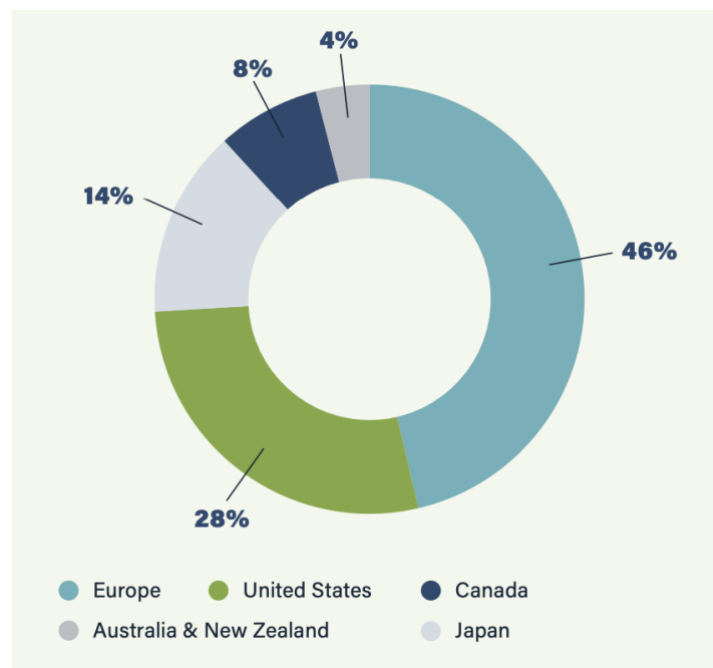
## 2.2 Socially responsible investing

As a response to these global challenges, concepts such as sustainable development and corporate social responsibility have evolved. As a way for investors to participate in this effort directly by themselves, socially responsible investing has emerged. Some argue that the need for socially responsible investing was accelerated by the global financial crisis of 2008, as stakeholders started to pay more attention to responsibility and accountability in the market participants (Scholtens & Sievänen, 2013). Socially responsible investing (SRI) is a strategy defined as incorporating environmental, social, and corporate governance aspects in the selection process of securities and investor advocacy (Eurosif, 2021; US SIF, 2023). It enables investors to gain long-term returns and simultaneously strengthen the well-being of society by influencing corporate behavior (Eurosif, 2021). US SIF (2023) explains that different types of motivations have been the reason for the growth of sustainable investing. Motivation varies from personal values and ethical goals to demands of clients and mission to achieve superior financial performance (US SIF, 2023).



**Figure 1.** Sustainable investing in the US 1995-2020 (US SIF, 2020)

During the last decade, socially responsible investing has grown substantially worldwide. According to a review published by the Global Sustainable Investment Alliance (2022) approximately \$30.3 trillion is globally in assets invested by applying the ESG criteria in the investment asset selection process. In Figure 1 it can be seen that the US markets in socially responsible investing started to grow most rapidly after 2012 and the trend has continued ever since (US SIF, 2020). As for non-US markets, there has been a 20% increase in sustainable investment since 2020 (Global Sustainable Investment Alliance, 2022). The biggest class of SRI is equities, representing almost a 46,5% portion (Eurosif, 2018). Most of the socially responsible investments are undertaken by institutional investors (Eurosif, 2018). However, the importance of retail investors in the continuity of SRI has been widely recognized. Both of these are connected as retail investors typically participate in investing through SRI funds (Scholtens & Sievänen, 2013).



**Figure 2.** Regional proportions of global sustainable investment assets 2022 (Global Sustainable Investment Alliance, 2022)

Among different regions, most of the global sustainable investing is largely concentrated in Europe and the US, as seen in Figure 2. The proportion of Europe has increased significantly during the last two years. According to the review of the Global Sustainable

Investment Alliance, after the UN Principles for Responsible Investment and the Sustainable Development Goals, Europe has been considered to be a leader in many aspects of social responsibility and continued to show an example by implementing new actions to improve the current state of the world.

The conditions in Europe are favorable for sustainability which promotes the development of socially responsible investing. One of the crucial aspects in creating these conditions is the legislation and regulations that support the transition towards a more socially responsible direction. In the European region, the EU is mainly responsible for these, and it has been a great advocate for social responsibility. The EU has implemented requirements that ensure transparency about sustainability in corporations and investment products offered by financial institutions (Eurosif, 2021). One of the recent actions taken has been the framework for financial advisers as in the Sustainable Finance Disclosure Regulation (SFDR). The framework ensures that financial advisers and market participants communicate sustainability information accurately to investors (European Commission, 2024). With these actions, the risk of greenwashing is mitigated, and investors can be more aware of the state of sustainability of their investments. In addition, one strength in sustainable development is the general awareness of environmental challenges in Europe. In a survey conducted by European Investment Bank (2019), it was presented that 78% of Europeans are concerned about climate change whereas in the USA only 63% of the respondent citizens were concerned. This creates an increased social and cultural pressure to operate and invest in a socially responsible manner in the European region.



**Figure 3.** Socially responsible investing strategies in Europe (Eurosif, 2018)

Socially responsible investing is usually implemented with different SRI investment strategies. In Figure 3, the graph presents the popularity differences between SRI strategies during two years in Europe and the compound annual growth rates (CAGR) for each one (Eurosif, 2018). Exclusions remain as the dominant strategy. However, in the growth figures, it can be seen that investors increasingly want to enhance sustainability through their own engagement and therefore increasing the popularity of strategy engagement and voting (Eurosif, 2018). Different strategies enable the investors to choose the best way for them to invest socially responsibly. These strategies can be used independently or in a combination of multiple strategies.

The main idea of the strategy best-in-class is that it takes into consideration how companies perform in ESG in a particular industry. Investors choose the industrial sector they want to invest in and pick the companies with the best ESG scores (Eurosif, 2018). This strategy sets the ESG performance in proportion and acknowledges the possible efforts with ESG. Naturally, financial evaluation is implemented for all investment equities. The benefit of this strategy is to consider the impact of the industry on what level of ESG performance is even possible for the companies. For example, software and manufacturing companies have different premises to try to minimize emissions.

Sustainability themed investing strategy focuses on selecting assets that are related to a specific area of sustainability. These themes can be for example water management, sustainable transport, renewable energy, and energy efficiency. Most popular among investors have been climate change and water-themed assets (Eurosif, 2018). The strategy of norms-based screening is based on investors selecting assets that are in line with the preferred international standards and norms. These can focus on aspects such as labor standards, human rights, and environmental protection. There has been a significant decrease in the popularity of norm-based screening as seen in Figure 3. However, the most popular base for the norms has been the UN Global Compact (Eurosif, 2018).

The most popular SRI investing strategy is exclusions with engagement and voting being the second most popular. Exclusion is the oldest socially responsible investing strategy (Eurosif, 2018). The aim is to consistently exclude companies and industries that are not socially responsible. Common areas to exclude are weapons, tobacco, and animal testing. However, there is a contradiction about whether the exclusion strategy can be labeled as an SRI strategy when used alone. According to Eurosif (2018) disinvesting in these harmful industries cannot be considered to have a strong enough impact and therefore, it should be combined with an attempt to impact through engagement and voting. As a strategy engagement and voting concentrate around the active management by investors. Investors' objective is to constantly influence and monitor the companies they invest in. Ensure that the company is constantly working towards more sustainable business operations.

Socially responsible investing is not that well-defined as an investing strategy and there are many ways to perform it. However, at the center of it is incorporating ESG aspects in the selection process of assets. Still, Sandberg et al. (2009) have raised questions about the problems in the heterogeneity of socially responsible investment. Differences can be found in definitions, terminology, strategy, and practice. Standardization would be desirable to unify the objectives of investors and further strengthen the impact. However,

it can be said that socially responsible investing is a multidimensional way of investing and in the end, the meaningful implementation of it is the responsibility of the investors.

### **2.3 The structure of climate risk**

Driving these previously presented movements is the acknowledgment of the risks related to climate change. In climate finance literature, it has been presented that climate change creates a climate risk in the financial market which affects the return on investment (Faccini et al., 2023; Venturini, 2022). This is important to investors whose main goal is to be constantly trying to maximize profits. According to a survey conducted by Krueger et al. (2020), the general perception of investors is that climate risk influences portfolio risk and return. Climate risk can cause additional expenses for companies and create price alterations in different assets. Directly to companies' own processes, the climate risk causes additional expenses such as growth in financing and equity costs (Chen & Gao, 2012). As a consequence of these effects, the investors take climate risk increasingly into consideration in their investment processes. The more you are exposed to risk factors the bigger impact it has on financial performance. As for a more detailed understanding of climate risk, it can be divided into two categories that are physical and transition risk.

Physical risk illustrates the risks of immediate deterioration of company production assets due to climate change (Giglio et al., 2021). The subject of the physical risk can be for example the properties and facilities owned by the company or the deterioration of real-estate values. For instance, this risk can materialize as a climate disaster that destroys the company's assets and causes damage to the business. Furthermore, physical risk can be categorized into two types, namely acute and chronic physical risks (Venturini, 2022). An example of an acute physical risk can be a wildfire caused by extreme drought and abnormally warm weather. Acute risks such as climate disasters and sudden extreme weather conditions can be hard to predict and prepare for. Whereas chronic physical risks can be predicted because they usually materialize gradually. Such

as rising sea levels create a progressive threat, that can be calculated and therefore forecasted. In addition, the company's exposure and vulnerability affect the level of physical risk (Venturini, 2022). Exposure illustrates the locational distribution of entities and assets that could be exposed to climate hazards. Whereas vulnerability focuses on the company's ability to adapt to different materializing hazards.

Transition risk has a multidimensional effect on company profitability and processes. This risk is related to decisions about the economy to become more sustainable, which can cause other companies to have competitive advantages and others to have stranded assets (Giglio et al., 2021). An example of this type of risk could be the introduction of a carbon tax by the government. This can cause industries that use fossil fuels to have growing expenses and suffer losses. Transition risk does not always have a clear and specific effect, as the actions taken to enhance the shift towards a more low-carbon economy have several different consequences through multiple different channels.



**Figure 4.** Transition risk components (Giglio et al., 2021; Semieniuk et al., 2021; Venturini, 2022)

As for a more detailed breakdown of transition risk, climate finance literature suggests that it contains policy risk, technology risk, and preference change components as seen in Figure 4 (Giglio et al., 2021; Semieniuk et al., 2021; Venturini, 2022). First, two of the components can be said to be intertwined. The policy component includes public actions taken to mitigate climate change. For example, introducing new sustainability standards

and regulations. These actions usually create incentives to accelerate the development of new sustainable technologies for companies. New innovations can save costs and accelerate the incorporation of low-carbon technologies (Semieniuk et al., 2021). On the other hand, investments and commitments companies need to put into these new developments can create additional expenses. The last aspect of transition risk is the preference change of investors and consumers (Venturini, 2022). This illustrates the risk of a strengthened desire to invest capital in climate friendly companies and consume products created by green companies. This preference is motivated by investors' and consumers' own sentiments and attention toward climate change. However, this can create an opportunity for environmentally friendly companies to benefit from, and create a competitive advantage compared to conventional companies (Semieniuk et al., 2021).

In the existing literature, Giglio et al. (2021) state that there is a clear connection between transition and physical risks. This correlation between the two can be noticed without the risk materializing simultaneously. The growth in the frequency of climate disasters and other appearances of physical risks causes a requirement for new mitigation actions which increases transition risks. Therefore, a materialization of physical risks increases the probability of transition risk. On the contrary, when additional regulations are appointed, it can help the mitigation of climate change and possibly reduce the appearance of physical risk.

To understand better how climate risk is priced on the financial market, investors need to have a clear view of the nature of the risk. There has been a lot of research debating whether physical or transition risks are more imminent for investors. It has been demonstrated that investors believe that especially transition risks are constantly materializing and therefore priced in the financial markets (Krueger et al., 2020). Stroebl and Wurgler (2021) find similar results, that investors perceive transition risks, especially regulatory risks, to be the most significant risk for businesses. Whereas

physical risk is commonly believed to be the most important risk within the next 30 years (Stroebel & Wurgler, 2021).

## 2.4 ESG

As mentioned before, investors are constantly participating in the actions to mitigate climate change and there has been a growing trend to direct investments toward more sustainable options. For, investors to easily recognize and evaluate these sustainable investment targets, the ESG rating system was created. The ESG stands for environmental, social, and governance. Similarly, as companies have received credit ratings illustrating their ability to meet debt obligations, the ESG rating describes the nature of the company’s environmental impact, social responsibility, and corporate governance. Ratings give a vast amount of information to the investors in a condensed form which simplifies the assessment of the potential risks linked to the investments. Currently, the leading ESG rating providers can be said to be MSCI and Sustainalytics. These companies provide ESG ratings for companies worldwide.

MSCI ESG Score									
ENVIRONMENT PILLAR				SOCIAL PILLAR				GOVERNANCE PILLAR	
Climate Change	Natural Capital	Pollution & Waste	Env. Opportunities	Human Capital	Product Liability	Stakeholder Opposition	Social Opportunities	Corporate Governance	Corporate Behavior
Carbon Emissions	Water Stress	Toxic Emissions & Waste	Clean Tech	Labor Management	Product Safety & Quality	Controversial Sourcing	Access to Finance	Board	Business Ethics
Product Carbon Footprint	Biodiversity & Land Use	Packaging Material & Waste	Green Building	Health & Safety	Consumer Financial Protection	Community Relations	Access to Health Care	Pay	Tax Transparency
Financing Environmental Impact	Raw Material Sourcing	Electronic Waste	Renewable Energy	Human Capital Development	Privacy & Data Security		Opportunities in Nutrition & Health	Ownership	
Climate Change Vulnerability				Supply Chain Labor Standards	Responsible Investment			Accounting	
					Chemical Safety				

■ Universal key issues applicable to all industries

Figure 5. ESG ratings key issue framework (MSCI, 2024)

Figure 5 presents an example of general key issues used in constructing the ESG rating for a company (MSCI, 2024). MSCI divides the different pillars into differently themed subcategories. Among all the rating agencies the environmental aspect concentrates on the climate effects of the company. For example, measuring emission levels or the company's carbon footprint. Social responsibility focuses on how the company affects the surrounding society such as equality, diversity, and fair working conditions. The last aspect concentrates on the governance practices of the company, which evaluates corruption, executive pay, and authority distribution. Even though all three aspects of ESG represent important themes that all corporations should consider in their actions. Still, the environmental aspect is playing the leading role and making the environmental impact of the company often the most highlighted rating aspect. According to research conducted by Krueger et al. (2020), specifically climate-related risks are included in the top concerns of investors.

The agencies that provide ESG ratings play a crucial role in the stock market because investors are increasingly relying on their information and making strategic decisions based on the ratings (Chatterji et al., 2016). Due to this increasing weight of ratings in the investment decision processes, there have been comparisons between different agencies. Berg et al. (2022) found significant differences in ESG ratings between different rating providers. In the article, the primary creator of divergence was traced to be the measurement differences, including definition variation and alternations in the analyzed data. Also, the ESG ratings are closely linked to the extent of disclosure. Based on this Christensen et al. (2022) confirmed that disagreement among ESG ratings increases when ESG disclosure expands. As the amount of information grows, there is more information to disagree over. Christensen et al. (2022) argue that in the absence of information, rating agencies are more likely to rely on similar rules of thumb and are more likely to agree. However, the researchers believe that over time there will be more standardized metrics, and consensus will be found (Christensen et al., 2022).

As the importance of ESG ratings has grown, it is natural that it has implications on company value. Fatemi et al. (2018) argue that ESG strengths would increase the company's value. Whereas deficiencies in ESG would decrease the value. In addition, Fatemi et al. (2018) report that announcements related to ESG would have a direct effect on the company value. However, frequent announcing of ESG strengths would cause a much minor increase in value and therefore weaken the positive influence on the company value. In the study, the authors explain this to be a consequence of the public perception of the company trying to justify its actions or polish its public appearance.

In addition, there have been implications of ESG ratings playing a role in stock price reactions. Gao et al. (2022) state that ESG mitigates the risk of stock price crashes. Therefore, focusing on the ESG performance could stabilize the stock price developments. In the paper, the authors state that the mitigation effect is reached by drawing the attention of green investors (Gao et al., 2022). In other words, this highlights the importance of company ESG performance and the investors' preference towards it. However, investing in high ESG performance stocks is much harder in the presence of ESG rating disagreement. According to Billio et al. (2021), the disagreement between rating agencies mitigates the effects that ESG investors have on the return of stocks. Therefore, not all the possible effects of ESG performance can be currently detected in the financial performance of stocks. Still, considering the benefits, that good ESG ratings can create, all companies have the incentive to pay attention to their performance in this area.

## **2.5 Sustainability in the Nordic countries**

Environment, social, and governance aspects have been noticed to be at different levels in different regions. Some countries are the sustainability leaders whereas others participate only in mandatory actions. Also, other countries emphasize different aspects of sustainability more. According to Kvasničková Stanislavská et al. (2023), the sustainability reports of developed countries have focused more on topics such as

“sustainable production” and “supply chain emissions” whereas developing countries pay more attention to themes such as “education” and “human rights”. These differences could be caused by cultural differences, the pressure created by stakeholders, the attitude of the government, or the financial opportunities. As a solution, the constantly evolving sustainability reporting provides information to estimate the level of sustainability efforts in different regions.

It has been stated that the Nordic countries are the world sustainability leaders (Strand, 2024). In the sustainable development report (SDSN, 2023), the Nordics were all ranked in the top 5 countries in Europe based on the SDG index score. In addition to this, the Nordics have been spotted at the top of multiple other sustainability rankings (Strand, 2024). In the Green Growth Index (GGGI, 2019), the Nordics were ranked the highest globally. All of this indicates that in the Nordic countries, stakeholders put a lot of weight on the responsibility of companies which accelerates the transition. Strand (2024) explains that the sustainability success of the Nordics is ensured by the close cooperation of stakeholders and the general commitment to sustainability that has been incorporated into the Nordic socio-economic structures. Also, the high tax levels in the Nordics cause corporations and society to work closely together which can harmonize sustainability efforts (Strand, 2024).

The public administration plays a significant role in the transition towards a green economy in the Nordic countries. Therefore, the policies must be aligned to support technology development and innovation in a sustainable direction. Khan et al. (2021) study the policy documents in the Nordics and find aspects that support green growth and the transformative green economy approaches. In addition, it is observed that during this transformation the importance of human well-being is recognized in the Nordics (Khan et al., 2021). With these actions, the state actors are able to actively influence the direction of the economy. This can work especially in the Nordics as they have been known to have interventionist state institutions. As for successfully transitioning to a green economy, it requires stakeholders, investors, and corporations

to work towards a common goal. This should be possible as it is a general perception that a green economy should increase competitiveness and reinforce growth as the demand for green services and products intensifies (Khan et al., 2021). However, there is still debate on whether it is effective to aim the development towards a generally green economy or whether the support should be aimed towards a specific target such as a low-carbon economy (Khan et al., 2021).

One of the current accelerators of Nordic sustainability has been the incorporation of new sustainability reporting standards. The Corporate Sustainability Reporting Directive (CSRD) became effective at the beginning of 2023 (European Commission, 2019). The directive will apply for the 2024 financial year and the first reports should be published in 2025. The standard gives corporations specific rules about what environmental and social information needs to be reported (European Commission, 2019). These rules make sustainability reporting more relevant and unified. As a result, it guarantees that investors and stakeholders are extensively informed about the impact that the company has on the environment and other sustainability issues. This provides companies with better opportunities to communicate their own sustainability efforts. Also, this standardization can possibly mitigate the risk of greenwashing as all participants have better access to information on the true state of the company's sustainability. Therefore, this standard is beneficial to all parties involved and it can incentivize them to participate even more in the sustainability efforts.

Investor participation in sustainability in the Nordics has increased through the popularity of socially responsible investing. In general, socially responsible investing can be carried out with screening and shareholder engagement. The Nordic countries do have slightly different starting points in socially responsible investing, as Finland is the newest in this field. In addition, different drivers have shaped the development of SRI in the Nordic countries. The drivers are important to recognize, as most of the Nordic countries do not have an explicit framework for SRI. According to Scholtens and Sievänen (2013), drivers for SRI are still similar in all four countries. These can be listed as the role

of institutional investors, national pension funds, religious movements, and the popularity of different types of investment strategies. Also, the researchers noticed that the pension industry has a clear impact. More specifically, for Norway, SRI development has been strongly driven by the Norwegian Petroleum Fund and other pension funds that are regulated (Scholtens & Sievänen, 2013). As for Finland and Sweden, religious institutions have been key actors (Scholtens & Sievänen, 2013). A closer inspection is taken on the SRI in Finland, Sweden, Denmark, and Norway.

The four countries are mainly viewed as being similar in many aspects, but in the history of sustainability, there are still some different features among the countries. Finland is often introduced as a relative newcomer when compared to other Nordic countries (Scholtens & Sievänen, 2013). Especially, in socially responsible investing, the first activity can be spotted in 1999. However, Finland is still one of the leading countries in sustainability. According to a market settlement carried out by Finsif (2022), investors in Finland choose sustainable options based on values, sustainable development, and better risk management. The most important focus in the future was named to be the diversity of nature (Finsif, 2022). For sustainable investing, the future challenge can be said to be the increasing regulation and implementation of the regulation, as growing competence in the area is needed. In Finland, most popularly investors prefer to implement sustainable investing with ESG- integration and exclusion.

In Sweden, the development was very early in the field of socially responsible investing as the first ethical funds can be traced to the 1960s (Scholtens & Sievänen, 2013). Therefore, it can be called one of the pioneers of SRI. According to Eurosif (2018), the SRI market in Sweden is currently very advanced, and many of the large institutional investors have a framework for sustainable investment. In Sweden, it is common for institutional investors to use many SRI strategies simultaneously. The most commonly implemented SRI strategy is engagement and voting (Eurosif, 2018). Many platforms have been founded to ensure green financial solutions and constant developments in sustainable finance. For example, the Stockholm Sustainable Finance Centre (SSFC) and

Stockholm Green Digital Finance (SGDF). Sustainable investment practices still lack of specific legal framework. However, in Sweden, this has been compensated by Swesif's assessments of the sustainability of investment funds (Eurosif, 2018). This kind of declaration of sustainability has accelerated the sustainability efforts of funds.

Historically the Norwegian financial industry has been considered to be leaders for SRI and it has influenced the development of SRI globally (Eurosif, 2018). This has been made possible by the large size of the Norwegian financial sector. In Norway, the first activity of socially responsible investing was seen in the late 1980s (Scholtens & Sievänen, 2013). With a strong foundation of SRI, many large investors have persistent sustainability policies and behave as SRI issue advocates. Sustainable investment is strongly affected by the Norwegian Government Pension Fund Global which is managed based on the government guidelines (Eurosif, 2018). For the Norwegian government, climate change has remained one of the important focus areas. Therefore, the government provide an example of socially responsible investment decisions. Also, Norway has its own SIF association, which aims to increase the knowledge of incorporating ESG into investment decisions. In Norway, the EU is the main source of regulatory changes that have been currently aimed towards improved disclosure and transition to a low carbon economy (Eurosif, 2018).

Despite the smaller size of Denmark, their financial markets are well developed. As for socially responsible investing in Denmark, it can be traced back to the 1990s when the first ethical funds were spotted (Scholtens & Sievänen, 2013). The development has been influenced by the investors' demands for the formalization of SRI. In 2018 the Danish Government published standardized guidelines for responsible investment. The guidelines were based on the OECD's Responsible Business Conduct for Institutional Investors and OECD's Guidelines for Multinational Enterprises (Eurosif, 2018). Curiously, based on a survey 39 % of the investors already have procedures in place that match with the guidelines. As for, socially responsible investing the exclusion strategy remains distinctively the most popular strategy with the norms-based screening strategy coming

second (Eurosif, 2018). The incorporation of ESG themes in investment decisions has been most advanced among listed equities. According to Eurosif (2018), 41% of Danish investors informed of assessing their portfolio's carbon footprint and 44% took into consideration particularly environmental issues. Also, for the investment community, 39 % of investment company respondents have more than one resource dedicated to responsible investing and ESG information.

### **3 Theoretical background**

This part of the thesis concentrates on the structures and characteristics of the stock market. The aim is to help understand how different changes and risk factors might be able to influence the price evolution of different types of stocks. This is illustrated by presenting the most relevant financial theories related to the topic. Theories related to the motivation for sustainable investing can be found both in traditional finance and behavioral finance. The reasons linked to traditional finance theories are mainly focused on the relationship between risk and return whereas behavioral finance concentrates on the personal characteristics of investors. Different characteristics can make investors experience non-financial utility from sustainable investments or make them more prone to herd behavior which further increases the trend of SRI.

#### **3.1 The efficient market hypothesis**

The efficient market hypothesis was first introduced by Fama (1970), who presented foundations for how stock prices are constructed on the stock market. The concept of efficient markets consists of the idea that market prices reflect all the existing information accurately and investors cannot create excess return by analyzing the information. Fama (1970) presents that the efficiency of the markets can be described by three different levels, based on how well the market prices reflect information. This theory gives guidelines for understanding the behavior of the stock market and how the stock prices develop after new information is discovered.

The first level of market efficiency introduced by Fama (1970) is the weak form. This efficiency level requires that the current stock price includes all the historical information. This includes information about previous developments of the stock price, previous stock prices, trading volumes, and profits (Fama, 1970). This means that by analyzing the historical data of the stock, the investors should not be able to create excess return, as the price should already include all this information. The second level is rated as a semi-

strongly efficient market. This indicates that the stock price should include all the other easily available information, and the accurate pricing of this information should be immediate (Fama, 1970). For instance, when the corporate executives announce recent business developments or annual reports. The last level introduced by Fama (1970) is strongly efficient markets which indicates that all insider information is reflected in stock prices. This means that no market participants should have a certain advantage over any of the meaningful information. When all these levels are fulfilled the stock price should reflect the company's accurate value.

According to Fama (1970), for the efficient market theory to be completely accurate, the following market conditions are needed. The first assumption about the conditions is being able to trade equities without transaction costs and therefore making the markets frictionless. Secondly, all market participants should be able to access all available information without additional expenses. Finally, every market participant is constantly rational and agrees on how the most recent available information affects the existing stock price, and toward which direction the stock price is going to develop in the future. Still, it is stated, that even without all of these conditions being fulfilled in reality, the stock markets can act efficiently (Fama, 1970). Therefore, the theory can be applied in the evaluation of how different informational developments influence stock returns.

As mentioned earlier, it has been acknowledged that the rationality of investors has a part in creating market efficiency. However, there are still investors who do not trade rationally as stated in the previous chapter, and their trading transactions are considered to be more random (Degutis & Novickyte, 2014). Based on this notion, Degutis and Novickyte (2014) divide investors into two categories. Noise traders who do not base their trading decisions on information. And proficient investors who evaluate their investment decisions precisely. Even though these different investors participate in the markets, the effects seem to be reversed. Proficient investors can benefit from the mispricing of equities caused by noise traders and further eliminate the appearance of mispricing from the stock market (Degutis & Novickyte, 2014).

Even though the efficient market theory has been the foundation of classical finance for a long time. In literature, the efficient market theory has been constantly under inspection. Jegadeesh and Titman (1993) present evidence that by buying past winner stocks investors are able to generate excess return. Even though, according to the efficient market hypothesis, investors should not be able to do this. In the article, this is traced back to an anomaly called momentum, which has been caused by the delayed price reaction to relevant information (Jegadeesh & Titman, 1993). In addition, the changing investment criteria and introduction of corporate sustainability metrics bring new difficulties in forming accurate stock prices. According to Bofinger et al. (2022), firms' ESG performance and corporate sustainability strengthen the misevaluation of a firm's market value. This results in already overvalued firms being even more overvalued. Whereas an undervalued firm's valuation gradually moves closer to the true value, making their pricing more accurate. This impact of misevaluation can possibly be traced back to the trend of sustainable investing or the benefits investors gain from the risk-decreasing effects of corporate sustainability (Bofinger et al., 2022). Therefore, this indicates that stock price developments could be explained with both traditional and behavioral finance theories.

### **3.2 The modern portfolio theory**

In the traditional finance literature, it is presented that the main goal of rational investors is to maximize their returns on the stock market. This allegation is supported by the modern portfolio theory which was first developed by Markowitz (1952). The main objective of this theory was to establish principles of profit maximizing asset allocation. As a foundation for the theory Markowitz (1952) assumes that investors aim for profits and try to avoid variance as much as possible. He suggested that portfolio construction should be a choice of the mean-variance ratio to the desired level. The theory works as a framework how to maximize the expected return with the smallest possible variance by selecting uncorrelated stocks for the portfolio. Furthermore, this framework led to the discovery of the efficient frontier which illustrates the maximum expected rate of

return with a certain level of risk. The graph of efficient frontier provides a selection of different possible portfolios with different weights of assets which from investors can choose the portfolio that suits their risk preferences. The theory is based on the importance of diversification. Therefore, how assets move relative to each other is highlighted to investors. It is emphasized that the portfolio should be constructed as an entity rather than selecting individual assets by their unique characteristics (Markowitz, 1952).

This theory has remained a cornerstone of portfolio construction for decades. However, the theory has several deficiencies that complicate the effortless appliance of the theory on the stock market. Elton and Gruber (1997) argue that the framework is constructed for a single decision period, which makes it harder for investors to utilize it because in reality they are faced with a multiperiod nature. This problem could be fixed by treating reality as a series of single periods. However, that solution would require that return and variance should be independent of other periods which is not the case (Elton & Gruber, 1997). Therefore, it is important to keep in mind the reality investors face when applying theories to the stock market. All in all, this theory illustrates how investors incorporate the threat of increasing risk in their investment decisions.

The modern portfolio theory has also been adapted to responsible investing. Pedersen et al. (2021) performed a valuation on how ESG affects the size of required return by forming the ESG-efficient frontier. Therefore, providing investors with additional information on how to take ESG performance into consideration while maximizing the risk and return of the portfolio. ESG performance provides new non-financial information that can affect the risk-return tradeoff differently. The ESG performance of the company has both benefits and costs which need to be realistically evaluated. According to Pedersen et al. (2021), responsibility preferences can be detected as a decrease in the Sharpe ratio when a portfolio with better ESG performance is chosen. However, when the ESG performance is even further increased there is only a slight decrease in the portfolio Sharpe ratio (Pedersen et al., 2021). Similarly, López Prol

and Kim (2022) found lower volatility and even lower returns among portfolios with high ESG performance. To conclude, ESG performance creates new dimensions to consider with portfolio construction when aiming for maximized risk-return tradeoff.

### **3.3 Behavioral finance perspective**

When examining the effects of certain risks on the stock market it is important to understand the underlying reasons for investor decisions. Where traditional finance makes the presumption of complete rationality of investors and a consistent tendency to maximize the return on investments, the behavioral finance takes a more realistic stance on the behavior of investors (Ritter, 2003). According to Ritter (2003), psychology literature has documented that people are proven to be prone to make systematic errors in decision making processes. Investors can be overconfident, or their personal experiences can distort the weight put on certain pieces of information (Ritter, 2003). This can cause irrational investment decisions and behavioral biases. Also, De Bondt (1998) elaborates that irrational behavior can cause changes to trading habits, risk management, and perceptions about market prices and values.

Currently, there are many tools and guidelines available for investors to help determine the accurate value of investments and how certain risks would affect the return on their investments. However, not all investors are financial professionals and these complicated valuation tools can be hard to use (De Bondt, 1998). As a result, investors might base the valuation of an investment on a general impression of the company's value. This creates a dilemma because even if the company seems to have a good reputation, it might not indicate that investing in company stocks is profitable. As De Bondt (1998) points out, this kind of optimistic behavior can lead to the overvaluation of assets. In addition, forecasting the direction equity prices are going to take is often based on the previous fluctuations of the equity price (De Bondt, 1998). This might not have any rational justifications as price developments should reflect new information. Still, investors make conclusions based on their personal expectations.

In literature, it has been noticed that investors have a subconscious tendency to treat outcomes differently (Ritter, 2003). Investors seem to experience losses much heavier than the same-size profits. These experiences further shape the future decisions and preferences of investors. According to Kahneman and Tversky (1979), investors have been noticed to avoid losses which has an impact on how investors perceive different risk levels. This loss aversion behavior has been tested in a situation where an investor has to choose among two options with the same expected result. Investors chose the option with a certain loss rather than an option with a smaller risk of losing a bigger amount (Burton et al., 2013).

The rationality cannot be assumed even with the most common investment advice. For example, diversification is the easiest way to reduce risk among investments as it reduces the effect of a realized idiosyncratic risk on the investment (Barber & Odean, 2013). Even though many investors are risk averse and aware of this simple way to reduce investment risk levels they do not implement it. Barber and Odean (2013) explain this by characterizing that it is common for uneducated investors to feel safer while investing in domestic assets that have the same communicative language and familiar culture. On the other hand, investors might believe they can avoid the risk with other means than diversification. De Bondt (1998) argues that some individual investors believe in other risk mitigating techniques such as effective trading expertise. Investors seem to believe that they can avert risk realization by selling quickly. This is based on an illusion of liquidity. This example illustrates that not all investors are able to process information about risk with the same capacity.

Also, investment decisions are not always driven by only financial information. In literature, Pasewark and Riley (2010) show that another leading factor of investments can be investors' personal values. Social responsibility causes investors to search for investments that represent the values they think are important. This has been noticed when examining the investors' decisions between two investment alternatives that have a similar return, but the other alternative is in contradiction with the investor's values

(Pasewark & Riley, 2010). This tendency has been widely noticed as more sustainable investment options have become available and investors have been very eager to use the opportunity. Raut et al. (2023) argue that social motivation and sense of responsibility play a significant role in the growing popularity of ESG stocks. Investors have developed a green preference as they want to participate in the mitigation of climate change.

### **3.3.1 Market participants**

Investors can be mainly sorted into two different groups. It is important to understand the characteristics of these groups to be able to evaluate their role in the perception of climate risk. There are institutional and retail investors who both influence the stock market. This influence results from trading behavior that is typical to the specific market participants. Among both groups, there are own characteristic downsides. Still, the two investor groups are closely intertwined as many individuals choose to invest through the institutions.

Retail investors invest in equities directly by themselves with their own capital. As they trade equities in smaller volumes, they hold much smaller parts of a company. In addition, trading in smaller amounts and values, the effect of transaction expenses is much bigger (Barber & Odean, 2013). This could occasionally affect their trading decisions. It can be assumed that not all retail investors are professionals and without proper knowledge, they are more prone to make irrational investment choices. Barber and Odean (2013) state that many things can influence investment decisions with retail investors. For instance, living location and place of work can affect the development of portfolio structure. Investors might invest in local entities or even in their own employer's company. This causes trouble with diversification. Another example is that the media has been able to increase investors' willingness to buy stocks of frequently mentioned companies (Barber & Odean, 2013). Even though this might not have an actual financial reason to be affecting portfolio construction.

The growth of institutional investing has been noticeable, and many individuals are more likely to choose the option to invest through different institutions (Kalcheva et al., 2020). These institutions can be for example banks, pension funds, hedge funds, and insurance companies. Institutions have massive resources and a cluster of financial professionals. For inexperienced investors, this alternative is much more effortless to carry out, as investing in equities requires knowledge and commitment. Investors would need to be constantly updated on the latest market developments and news regarding equities. According to Kalcheva et al. (2020), individuals might have determined that it is more profitable to depend on the skills of investment professionals. Behind these investing institutions are investment managers who complete the investment selection processes. Managers choose investment targets based on planned strategies and guidelines. Potter (1992) mentions that these decisions can be assumed to be superior when compared to retail investors' decisions because the dedication towards information searching about investments is more extensive.

In addition, institutional investors have a significant role due to their large volume and responsibility for the stewardship of these investments. Among institutions, there can be variations in management which can be either passive or active. Differences in active management can be illustrated by preferences in time horizons and trading methods or styles. Bushee (2004) labels three groups among institutional investors as “transient”, “dedicated” and “quasi-indexer”. Transient institutions trade their equities more frequently and have small shares in companies. Dedicated institutions maintain steady holdings and have stronger positions in companies. Quasi-indexer institutions are a combination of these two, they maintain steady holdings and have small shares in individual companies. As for investment portfolios under passive management, managers invest automatically in companies that are included in a certain equity index. The interest in this option has increased substantially and has kept growing (Bebchuk et al., 2017).

As institutional investors can hold many shares of a certain company on behalf of individual investors, the shareholding is distinctly concentrated. This phenomenon can be quite beneficial if the responsibilities of investment stewardship are fulfilled. These responsibilities consist of attending meetings of shareholders, voting rights implementation, and monitoring the management (Nguyen & Shiu, 2022). With more concentrated ownership, there will be a bigger weight on the opinion presented by institutional investors. If the responsibilities are not fulfilled, an agency problem might be created. This problem illustrates that if both shareholders and companies are utility maximizers, there is a reason to believe in the possibility of management not always operating in the best interests of the shareholders (Jensen & Meckling, 1976).

The causes of the agency problem are linked to the underlying structure of institutional investors. However, Bebchuk et al. (2017) state that there is a need to add transparency related to stewardship. Investment managers would need to inform their relationships with the companies they have invested in. As the stewardship of investments is time consuming, the creation of agency problems can be partly caused by the lack of incentives aimed toward managers (Bebchuk et al., 2017). Especially, with the increase of index funds, the management compensation has decreased. Investment managers would get nothing to cover the efforts put into this comprehensive governance. This would mitigate the influence investors can have on the sustainability of their investments.

### **3.3.2 Theory of herd behavior**

The growing popularity of sustainable investing has been detected as a new trend in the stock markets. This trend seems to have an accelerating effect on herd behavior which causes investors to favor trading similar stocks (Shi et al., 2024). Herd behavior can unify the objectives of investors and furthermore allocate more capital toward sustainable investment options. This could assist sustainable development by possibly increasing the attention paid to corporate sustainability and ESG related issues. On the other hand, this kind of market inefficiency can complicate how socially responsible endeavors are

incorporated into the valuation of stocks (Shantha, 2019). Therefore, the phenomena could be said to have multiple sides.

In general, herd behavior illustrates the tendency for individuals to mimic the actions of other individuals (Scharfstein & Stein, 1990). According to Scharfstein and Stein (1990), in the stock market, this can be noticed as managers mimic the investment decisions or even whole portfolio compositions of other managers. This imitation can be implemented even while simultaneously ignoring the fundamental information and own private intuition. The behavioral bias can be detected in many different market participants, as it is typical for retail investors, portfolio managers, and even for whole investment institutions (Shi et al., 2024).

Herd behavior has been a widely researched topic but still there is inconclusive evidence about the sources behind it (Spyrou, 2013). However, basic argumentation for this behavior stems from psychological and social aspects that are characteristic of human beings. Scharfstein and Stein (1990) argue that portfolio managers participate in herd behavior to alleviate concerns about their reputation. If managers presented bold speculations that differentiated from the market consensus, they could suffer negative reputation effects or even get fired (Spyrou, 2013). As they make similar decisions as other portfolio managers, it creates an illusion of shared blame if the choices are not successful or sustainable. In addition, herd behavior can be temporarily caused by advice announced by investment professionals or newsletters (Scharfstein & Stein, 1990). The motivation for this can be the belief that other market participants have more extensive access to information, which causes investors to neglect their own assessment. Also, investors have been noticed to imitate the trading choices of others with the justification of extracting additional information from the actions of other market participants (Lux, 1995).

Herd behavior among investors can be said to be a sign of market inefficiency, as the trading is not based on newly available information. Herd behavior is believed to create

excess volatility in the stock market and be the possible reason behind market instabilities (Scharfstein & Stein, 1990; Spyrou, 2013). Investors seemingly tend to think as a group, creating widely spread optimism or panic. According to Spyrou (2013), economists have suggested that this behavior can be linked to the creation of stock market bubbles where stock prices deviate from their intrinsic value. In addition, Bogdan et al. (2022) state that herd behavior becomes more pronounced during times of crisis which was registered during the COVID-19 pandemic. In times of unstable market conditions, the anxiety of investors can drive investors to rely on better informed market participants. However, Shantha (2019) argues that with a cognitive evaluation of past investment choices, investors can reduce their own behavioral biases.

Even with the possible risks of market inefficiencies, herding towards environmentally friendly investment options can be considered as a positive side effect. According to Shi et al. (2024) herding towards carbon neutrality seems to be detectable on the Chinese stock market. This is linked to the importance of climate concepts and the possibility to mitigate the risk of policy uncertainty (Shi et al., 2024). This trend increases the capital flow toward environmentally friendly options. However, these inefficiencies play still a significant role in how accurately different risks can be priced on the market and whether the stock prices can illustrate the fundamental value accurately. It has to be taken into account while evaluating climate risk, whether the pricing is truly created by the pricing of the risk or is it caused by a behavioral bias.

These behavioral aspects of investors indicate how investors can be motivated to participate more in sustainable investing. This motion is supported by the theories of traditional finance related to the risk perception of investors. Sustainable investing is something to be actively considered by investors because of the change in risk levels caused by climate change. However, because of the characteristic deficiencies of investors, the transition to sustainable investing and taking climate risks into consideration is not as straightforward. Therefore, the effects of increasing climate risks need to be evaluated.

## **4 Previous research**

The existing research related to the effects of climate risk on the stock market is presented in this chapter. Firstly, we will concentrate on the available literature regarding climate risk and the pricing of it. After this, the focus will be more on the behavioral aspect of investors, as how the general attention and sentiment towards climate change affects the stock market. Lastly, there will be an evaluation of the existing evidence of performance differences between green and brown stocks. This should provide an extensive overview of the recent evidence about the role of climate change on the stock market.

### **4.1 Climate risk**

Climate change related risks can be detected entering stock prices in the form of climate risk. This climate risk is formed with aspects of physical and transition risks. As a theoretical foundation, it has been detected that investors want compensation for the risks that they face in the stock market. This view is consistent with the modern portfolio theory which indicates that there should be a tradeoff between risk and return. However, there is still ambiguity about how climate risk is incorporated into stock prices. According to a review conducted by Venturini (2022), researchers have ongoing debates about the dynamics behind the pricing and whether it is priced efficiently or even at all. Suggestions have been made that climate risk might represent an anomaly, an additional source of systematic risk, or a specific risk that could be eliminated with diversification (Venturini, 2022). Methods to evaluate the pricing of the risk differ among studies. Some studies use extensive illustration of a company's sustainability behavior whereas other studies focus specifically on the emissions to illustrate corporate sustainability. Therefore, some of the climate risk pricing research focuses on examining the carbon risk, which is a more specific part of climate risk.

One way of evaluating the pricing of climate risk is to take a closer look at when the risk is incorporated into the stock prices. Venturini (2022) introduces the categorizing of ex-post and ex-ante basis of climate risk pricing. Ex-ante basis refers to pricing climate risks in advance and investors being able to detect what kind of risks a certain asset is exposed to. The risk is recognized, and compensation is included in the stock price. However, this way of pricing climate risk can be very difficult because the available knowledge is limited to the investors and even the professionals are not unanimous. Forecasting of risks is especially hard for physical risks. For instance, the correct pricing of acute physical risk in advance has proved to be extremely difficult due to the uncertainty of materialization (Venturini, 2022). As another timing, the ex-post basis pricing happens after a certain risk has materialized. Therefore, this pricing can be considered to be a market reaction to the materialization of a specific risk. According to Venturini (2022), pricing seems to happen on an ex-post basis especially when the materialization is unexpected. The reaction is not always similar and for instance, it can be excessive or even delayed. The wrong estimation of these risks and the timing of risk pricing can cause major differences between expected returns and realized returns in stocks.

The appearance of climate risk has already been acknowledged over a decade. Chen and Gao (2012) break down climate risk as how the risk affects company operations. For company operations, the realization of these risks can impact future cash flows. Especially, when there is a possibility of growing capital expenditures as companies have to adjust their own operations to match the continuously changing regulations and legislation (Chen & Gao, 2012). In addition, potential shifts in supply and demand impact the performance of the company. There is uncertainty about the prospects of how well the company will be able to respond to the changing demands of consumers in the future (Chen & Gao, 2012). These aspects have a linear effect on the financial performance and stability of the company. According to Chen and Gao (2012), climate risk is priced by the financial market as increases in the cost of equity and debt financing.

During recent years, there has been a rapidly growing amount of literature aimed to prove the possible pricing of climate risks on the stock market. A considerable number of studies have found evidence that climate risk is priced on the stock market. Pástor et al. (2022) report finding evidence of a green stock premium which has further increased during the last decade. In addition, studies have confirmed that climate risks are being priced in the stock valuation depending on the exposure to the risks (Engle et al., 2020). Furthermore, this pricing of the climate risk has been shown to create performance differences between green and brown stocks (Ardia et al., 2021; Pástor et al., 2021). However, some studies have found more specific results about which type of risk is being priced. Faccini et al. (2023) found that only transition risks related to climate policy uncertainty are priced on the US stock market. Also, Li et al. (2024) highlight the importance of transition risk and found that the stocks, that do not respond to the risks they face, are valued at a discount.

The conducted research has provided a more comprehensive view of how climate risk is being priced in different industries. In the food industry, Hong et al. (2019) find that food stock prices tend to underestimate the effects of climate risks. Even though, climate change poses an imminent risk to food production, as droughts become more common. Therefore, these findings suggest that food stocks are inefficient in the pricing of climate risks. Whereas, in other sectors, it is common that the effects of climate risks are constantly embedded in prices. According to Dutta et al. (2023), the prices of green energy stocks increase significantly during times of increased climate risk and when a shift toward renewable energy can be noticed in the energy sector. In addition, the popularity of technology sector stocks increases during increased risk attention which is possibly caused by the hedging opportunity against climate risk (Dutta et al., 2023). As for more polluting sectors, Gong et al. (2023) present evidence that a clear climate risk premium can be found in fossil energy stocks. The premium is tightly linked to the level of climate risk and therefore, regional differences can be recognized (Gong et al., 2023). This illustrates that other industries are more sensitive to climate risk and some industries are able to price it more efficiently.

It is common that climate risk is frequently associated with the emission levels of companies and some research papers mainly focus on the carbon risk. Bolton and Kacperczyk (2021) report higher returns for stocks of companies that have higher carbon emission levels. This is consistent with the assumption that investors demand compensation for the carbon risk they face (Bolton & Kacperczyk, 2021). Similarly, Hsu et al. (2023) report that stocks related to higher emission levels create higher profitability. However, the future expected return of these stocks should be lower as new stricter regulations come into force and carbon risk increases (Hsu et al., 2023). According to Huij et al (2023), there is evidence that during times of increased carbon risk, the stocks with higher exposure to carbon risk have lower returns. Clearly, exposure to carbon risk is an important aspect of climate risk. However, this prioritization could underrate other aspects of the environmental efforts of companies. Therefore, many studies use other measures to get a more comprehensive view of the exposure to climate risk (Faccini et al., 2023; Li et al., 2024; Pástor et al., 2021). For example, the measure of ESG ratings takes into account a more adverse selection of efforts that reflect the company's attitude towards the climate risk.

The possibility of hedging climate risk is often provided as an explanation for the pricing of the risk (Engle et al., 2020; Faccini et al., 2023; Pástor et al., 2021). As green stocks are not as strongly exposed to climate risks, they should provide a hedge to the investor (Engle et al., 2020). Therefore, green stocks would be an opportunity to minimize the effects on return if the climate risk materializes. The lower expected return works as an expense for gaining insurance (Engle et al., 2020). Whereas brown stocks are significantly exposed to climate risk and the expected return must compensate for the risk investors face (Pástor et al., 2021). This supports the explanation that climate risk pricing is connected to whether stocks provide a hedge against it. However, creating a successful hedge against climate risk does not mean only investing in green stocks. According to Faccini et al. (2023), there are important environmentally friendly innovators among brown stocks, which could mean that the realization of a climate risk creates a positive shock to these kinds of company stocks.

## 4.2 Public attention and sentiment

The importance of climate risk can be linked to the attention and sentiment of investors towards climate change. Investors are constantly reminded about the stage of climate change by the publicly addressed issues and various environmental consequences, such as extreme weather events and periods of abnormal temperatures. Also, the attention can be increased with the implementation of policies, and regulations in the effort to try to mitigate the effects of climate change. These published guidelines provide incentives and direction for companies and investors to make more environmentally friendly financial decisions. The perceived importance of climate risks depends on the attention and sentiment that is created in society. Investors are a significant part of this.

Investors seem to view different aspects of the climate risk with a different importance level. In a survey conducted by Stroebel and Wurgler (2023) over the next five years finance professionals and public sector regulators believe that the regulatory risk is the most important climate risk. This is related to the continued efforts to achieve a low-carbon economy. Whereas with a longer horizon of 30 years, professionals consider the physical risk to be the most important aspect of climate risk (Stroebel & Wurgler, 2023). This indicates that the physical consequences of climate change are publicly perceived to materialize after a longer period of time. In addition, Stroebel and Wurgler (2023) found that finance professionals have a common belief that stock prices do not illustrate climate risks enough. This could partly explain why stock returns change during periods of high attention to climate change.

The materiality of climate risk can be measured by how much investors take it into consideration while making investment decisions. According to Krueger et al. (2020), there has been an increase in importance during recent years, and it can be ranked as the fifth most important risk to consider while investing. This increase could be caused by the belief that the materialization of climate risks is becoming more likely. This is confirmed by a survey conducted by the CFA Institute (2020) which reports that investors believe climate risks to be a current issue. For instance, it is broadly believed that

regulations have started to affect investments which indicates that transition risk materialization has already started. Krueger et al. (2020) argue that the increase in the importance of climate risk has different reasons behind it. These can be divided generally into financial reasons and non-financial reasons, which both affect investment decisions.

Financial reasons are connected to the performance of the investment. Both institutional investors and individual investors are constantly expected to maximize returns. Therefore, the reason to consider climate risk is directly connected to trying to maximize the value of investments and return. For instance, a significant effect on the financial performance of an investment can be caused by regulations, which can cause stranded assets to the company (Semieniuk et al., 2021). The company won't be able to profit from these assets and therefore investments have lower returns (Krueger et al., 2020). In addition to this, there are non-financial reasons why climate risk is currently important to investors. Investors can have the feeling of social responsibility as mentioned earlier and want to reduce their investment's carbon footprint (Pástor et al., 2021). While this ethical aspect can guide the actions of individual investors, institutional investors have an additional take on this. Krueger et al. (2020) point out that even if institutional investors did not have their own ethical aspects, they would still need to consider their reputation. Consequently, when maintaining a positive reputation, it can attract climate friendly investment clients.

El Ouadghiri et al. (2021) conducted a study that is based on this attention related assumption. In their research, they take into consideration how the continuous attention to environmental issues affects the returns of sustainable indices compared to their conventional parent indices in the USA. Four indices were included in the review, half were sustainable. In the paper, the attention level was measured with two indicators. Firstly, the attention was measured with US media attention based on how much climate change related topics were covered in the articles of major newspapers. Secondly, the attention of individuals was measured with the Google Search volume index (GSVI) with two keywords "climate change" and "pollution". In addition, the researchers included a

Model that examines the effect of attention created by global climate-related natural weather disasters (El Ouadghiri et al., 2021).

In the study, El Ouadghiri et al. (2021) report that an increase in public attention towards climate change has a significantly positive effect on the returns of sustainability stock indices. Whereas, when the attention towards environmental issues is low, there are noticeably lower returns on the sustainable stock indices. From the natural disaster evaluation, the researchers found a significant positive effect on the returns of sustainability stock indices and a detectable negative effect on the returns of conventional stock indices during disasters. This would mean that the occurrence of climate related weather disasters would increase investor attention towards climate change. Also, both direct measures of attention were positively related to the returns on sustainable stock indices. This confirms that investors are taking climate risk into account and when reminded, they shift towards more sustainable investment choices.

Similarly, Santi (2023) reports that the increase in the investors' climate sentiment impacts positively the returns of climate friendly stocks. The effects are examined with the creation of an EMC long-short portfolio which considers the returns of emission minus clean stocks. The attention and sentiment towards environmental issues are measured with climate related social interaction volume on StockTwits, which is a social media platform for investors. Santi (2023) finds that the returns of this created portfolio are much lower during the period of increased climate sentiment. It indicates that investors want to invest more sustainably. Furthermore, Santi (2023) suggests that the real climate impact is priced subjectively by the investors depending on their own sentiments. This could affect the pricing of both climate friendly and emission stocks. However, the effect of sentiment seems to be temporary and in the long-term, the effects are found ultimately to return to normal.

Both El Ouadghiri et al. (2021) and Santi (2023) believe that these effects are on some level traced back to the disinvestment of conventional stocks as they contradict the

updated investor preferences. Meanwhile directing capital towards more sustainable investments. It is argued that the motive driving these preferences depends on the characteristics of the investor. Based on this, El Ouadghiri et al. (2021) suggest that investors could be divided into sustainable, neosustainable, and opportunistic investors. The first two are genuinely interested in climate change and the sustainability of the stocks. Whereas opportunistic investors are interested mainly in the possibility of better returns without specific motivation towards sustainability. Also, Pedersen et al. (2021) suggest that investors could be divided into categories based on their knowledge of ESG information. According to the authors investors are either ESG-unaware, ESG-aware, or ESG-motivated (Pedersen et al., 2021). ESG-unaware investors pursue traditionally mean-variance balanced portfolios and ignore ESG information. Similarly, the main goal of ESG-aware investors is a traditional mean-variance portfolio, but they additionally consider ESG scores. Whereas ESG-motivated investors have distinctive preferences for high ESG scores and want their investment decisions to be as sustainable as possible. Therefore, the characteristics and knowledge of investors can affect how much the increased attention towards climate change can be seen in investment decisions.

In addition, to investor characteristics, the level of exposure affects how investors perceive the increased level of climate risk. When abnormal weather conditions or other physical risks materialize, the amount of attention can differ regionally. According to Alok et al. (2020), fund managers seem to overestimate the effect of climate disasters on stocks that are located in the materialization area. The source of this effect is not traced to an informational advantage, but to the salience bias of fund managers (Alok et al., 2020). In addition, there can be regional differences in the attitude towards climate change. In some regions, there are higher levels of climate change denials. Afzali et al. (2023) reported that corporate actions of environmental responsibility are negatively influenced by the level of denial in the region. Therefore, it is possible that climate change denial can have an even more adverse effect on the regional stance on the importance of climate risk.

### 4.3 The performance of green versus brown stocks

The performance differences between green and brown stocks have been reported for a while and many researchers are interested in the underlying reasons for this difference. “Green” stocks include stocks that can be labeled as environmentally friendly. There can be different premises on which stocks are considered to fulfill this characteristic. For example, stocks can be evaluated with ESG scores, emission levels, or the social responsibility of the company. Conversely, “brown” stocks describe more generally all the other stocks and therefore are not seen as sustainable investment entities. However, the categorization requirements are not always fixed and there is variation among industries. This kind of labeling has been created because of the change in investor preferences. It helps investors to identify the desirable assets. This can be further linked to the performance differences of different kinds of stocks.

Pástor et al. (2021) studied how these preferences among investors affects the pricing and expected returns of different assets. The effects on asset pricing are examined with an equilibrium model. In the study, an ESG factor is introduced as it addresses the level of ESG related concerns. This way the ESG factor is supposed to capture possible changes in the importance of climate change. The asset pricing is presented in a two-factor model which displays the market portfolio and ESG factor together. In this model, ESG beta characterizes the sensitivity and direction of the factor. Also, it measures the stock's possible exposure to climate risk. Explicitly, green stocks have positive ESG betas, and on the contrary, brown stocks have negative betas. This indicates that unexpected and major changes in the ESG factor would have a positive influence on green stocks and help them outperform brown stocks. Therefore, possible changes in attention aimed towards climate change could easily cause a performance advantage to green stocks.

In the study, Pástor et al. (2021) evaluate the expected return levels among green stocks. The expected return among these stocks is estimated to be lower compared to brown stocks. This is explained to be a consequence of the utility investors get from holding sustainable stocks and the possibility to hedge against climate risk (Pástor et al., 2021).

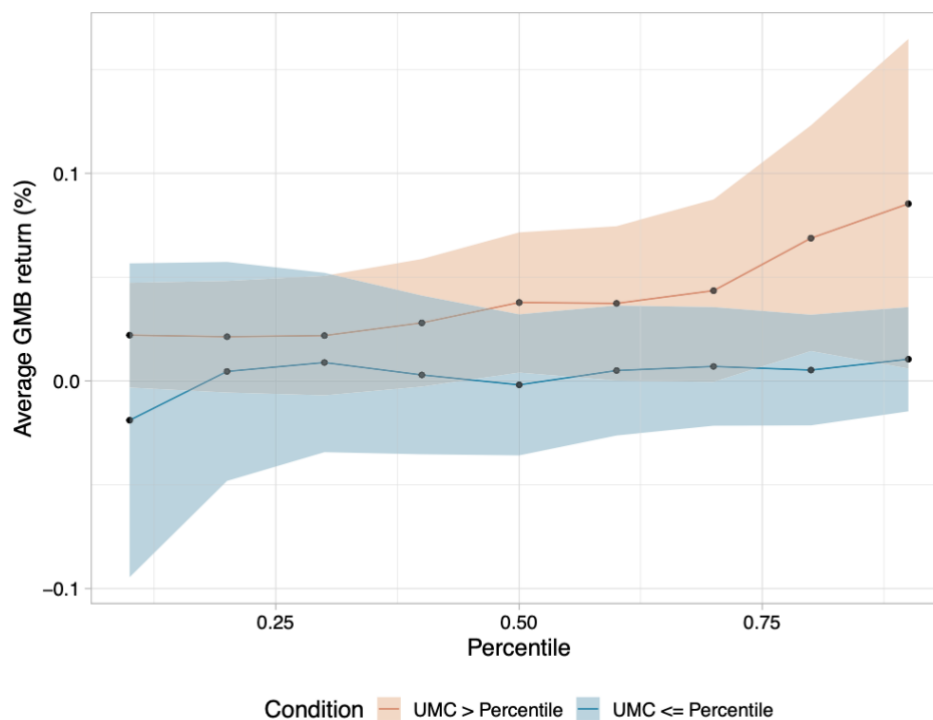
Obviously, investors are interested in the financial prosperity of their investments, but still, investors who prefer sustainable investing are willing to overlook the lower expected return. Whereas investors that invest in brown stocks are detected to want compensation for choosing the riskier option. This is caused by the possibility of climate risk realization or simply general aversion towards brown stocks. This compensation would make outperforming brown stocks much harder.

The lower expected returns are examined by comparing the CAPM alphas among different types of stocks during different preference levels (Pástor et al., 2021). CAPM alpha refers to a constant term of the capital asset pricing model, which illustrates the level of return the asset can create compared to the standard when considering the systematic risk. Negative alpha indicates lower returns. Pástor et al. (2021) find that green stocks have negative CAPM alphas due to the growing popularity of sustainable investing and the possibility of avoiding climate risk. Whereas brown stocks have positive alphas. However, it is reported that due to opposite reactions to the ESG factor, during times when the ESG factor would strengthen, the green stocks would be able to outperform the brown stocks despite lower alphas (Pástor et al., 2021).

Similarly, Ardia et al. (2023) verify predictions that are based on the conclusions that Pástor et al. (2021) came to. The performance of green and brown stocks is under inspection and how it could be linked to common concerns related to climate change. Ardia et al. (2023) study this performance by inspecting the S&P 500 stock daily returns during changes in climate change concerns. First, the researchers created a daily Media Climate Change Concern (MCCC) index by collecting articles from major newspapers and estimating concern scores for each article. Further, the unexpected change was obtained from the MCCC index. This shock component is labeled as unexpected media concerns (UMC). Therefore, the effect of unexpected changes in climate change concerns could be identified. The division into green and brown stocks is based on emission levels adjusted with the revenue. From these premises, the connection between climate concerns and stock performance is evaluated in the paper.

Ardia et al. (2023) found that there is a clear indication of green stocks outperforming brown stocks when there is an unexpected growth in climate change concerns. These results are discovered through the correlation between UMC and the return of the green-minus-brown portfolio. In the constructed portfolio, there are brown stocks as short and green stocks as long. Furthermore, during the inspection of stock returns separately, it was found that unexpected growth in concerns had a stronger impact on brown stocks. Ardia et al. (2023) explain that investors seemingly discipline brown stocks more than they reward green stocks as suggested in the previous chapter.

In Figure 6, the average return of the green-minus-brown (GMB) portfolio is presented at a general level with different levels of unexpected media concern (UMC). Ardia et al. (2023) present the average return of the portfolio on the upright axis and the position of UMC to the current percentile. Redline symbolizes UMC being larger than the percentile. And the blue line symbolizes the UMC being equal to or smaller than the percentile. It can be noticed in the graph, that when the UMC is above the median and the threshold becomes bigger, there can be seen rapid growth in the return of the GMB portfolio. Another discovery is that the red line is constantly going higher. Therefore, the average return of the portfolio is always larger when the UMC is bigger than the percentile. Furthermore, the researchers were able to detect a positive relationship between GMB return and unexpected media concerns (Ardia et al., 2023). This interaction is further examined with multivariate factor analysis. The estimated coefficient for the UMC is consistent with the hypothesis. A one-unit increase in UMC would create a 7.2 basis point positive elevation to the daily return of the GMB portfolio (Ardia et al., 2023).



**Figure 6.** GMB portfolio average return (Ardia et al., 2023)

In addition, Ardia et al. (2023) aimed to obtain information about through which channels the climate change concerns affect the stock price movements. Therefore, the researchers divided the concerns into four thematic categories and labeled them with the nature of climate risk they can be associated with. Business Impact and Societal Debate themes represent transition risk related concerns. Whereas the Environmental Impact theme represents physical risk related concerns. The theme Research consists of topics that can be linked to both physical and transition risk related concerns. The interaction between the return of the GMB portfolio and different thematic concern indices was analyzed. The researchers reported estimation results that indicated that all themes that are associated with transition risk have negative and significant coefficients (Ardia et al, 2023). This means that during unexpected concerns about transition risk, it can be expected that green stocks outperform brown stocks. However, for examining the effect of concerns related to physical risk, it is suggested that more sophisticated methods would be needed.

Also, Bauer et al. (2022) perform a comparison between green and brown stocks by using the emission levels of companies as the measure of greenness. The researchers documented a higher return among green portfolios during the last decade (Bauer et al., 2022). These results are consistent with the earlier studies in this chapter with the assumption that the attention towards climate change has increased continuously during the period. However, Bauer et al. (2022) report a certain level of reversal during the year 2022 which caused brown stocks to outperform green stocks. On the other hand, the results of persistent higher returns of green stocks cause problems with the hypothesis of carbon premium. Bolton and Kacperczyk (2021) have argued that the attention toward climate change can be seen as a carbon premium incorporated into the prices of brown stocks. This would mean that higher emissions cause stocks to perform better. This is argued to be a consequence of investors pricing the carbon risk of the stock and demanding better returns for it (Bolton & Kacperczyk, 2021). Bauer et al. (2022) consider that this could possibly be linked to carbon premium gradually increasing during the last decade and it could be the reason why it did not appear during the evaluation period. Therefore, positively affecting the future return of brown stocks.

Choi et al. (2020) compare the performance of low emission company stocks and carbon intensive company stocks. The performance of stocks is evaluated during different temperature periods as it illustrates the materiality of climate change. The authors report that during abnormally warm weather the high-emission company stocks visibly underperformed the lower-emission stocks (Choi et al., 2020). This indicates that when there is an extrinsic factor that reminds us of climate change it causes the attention to increase, and it can shift the performance differences between the two. Choi et al. (2020) argue this to be linked to the limited attention of investors. Therefore, temporarily forgetting the severity of climate change. The reaction of investors could indicate that the lack of sustainability cannot be compensated with better returns anymore, and investors prefer to eliminate it. Especially, retail investors are noticed to get actively rid of carbon intensive stocks (Choi et al., 2020).

In addition, the performance inspection between green and brown assets has been broadened to the inspection of funds. In the study, El Ghouli et al. (2023) constructed green and brown mutual fund portfolios based on the level of social responsibility. Researchers found that socially responsible funds have a lower raw return, and they exhibited a lower alpha and a Sharpe ratio. However, El Ghouli et al. (2023) highlighted that the underperformance of socially responsible funds was relatively small. In addition, it was discovered that the correlation between the two types of funds was not total, which could indicate possible diversification possibilities with socially responsible assets (El Ghouli et al., 2023). As green assets are found to have possible hedging and diversification opportunities, investing might be beneficial to investors even though there is a lower expected return.

## **5 Data and methodology**

This chapter introduces the data and methodology used to examine the effects of climate change concerns on stock returns in different regions. The aim is to provide an explanation for the chosen dependent and explanatory variables. Including a comprehensive explanation of the chosen data sample. The chosen stock indices are supposed to model the whole stock market for the determined region. The climate change concerns are modeled with an index based on global climate change news. The theory and construction behind this index will be explained. Lastly, there will be a detailed explanation of the methodology and presentation of regression models used in the thesis. This part of the thesis aims to provide an understanding of the foundation on which the examination is built.

### **5.1 Data description**

The objective of this thesis is to empirically examine the effect of climate change concerns on the daily return of stock indices. More specifically, this thesis aims to evaluate how climate change concerns affect the returns in different regions. Whether there is a recognizable difference in the magnitude or direction of this effect. Six different stock indices were chosen, as the data sample for this research. The sample consists of stock indices in the regions of interest. The chosen regions are the US, Europe, and the Nordics. From the Nordic countries, Finland, Sweden, Norway, and Denmark were selected for the sample. Most of the existing research has been conducted on the US stock market (Ardia et al., 2023; El Ouadghiri et al., 2021; Pástor et al., 2021). There has not been a lot of research done about the climate change effects on the Nordic stock market. Even though, the Nordic countries have been called to be pioneers when it comes to sustainability. Therefore, this thesis concentrates on the general effect of climate change concerns on stock returns in different regions and aims to discover new information on the effects in the Nordics.

In the sample, each region is represented by an index that reflects the general stock market movements in that region. The chosen indices are presented in the dependent variables chapter. As for the climate change concerns, this thesis uses the daily Media Climate Change Concern (MCCC) index which was constructed by Ardia et al. (2023). The MCCC index is introduced in a later chapter. Even though the index is based on concerns captured from US sources, it is possible to use it as a globally significant index as climate change is a global and common challenge. For example, mitigation efforts against climate change are based on joint efforts. Therefore, general conversation and all events related to climate change are essential worldwide. Also, it could be assumed that the attention remains approximately at the same level or at least has similar peaks among the developed economies. This is made possible with the modern technology which enables information to travel globally at a rapid speed. In our model, we additionally use relevant control variables to separate the specific effect climate change concerns have on stock returns.

The period chosen for the examination of this thesis is 1.1.2010-31.5.2024. As in the study conducted by El Ouadghiri et al. (2021), the sample period is the most recent period available, and the length is over a decade. Especially, during this period the importance of sustainability and the attention aimed towards climate change has increased consistently (Krueger et al., 2020). This intensifying sentiment towards climate change should be therefore recognizable as the effect on stock index return. Approximately starting from the year 2010, there have been more established movements when it comes to sustainability, and therefore this inspection is reasonable to start after that. Both the stock indices and the MCCC index are used as daily frequency. This is important for the research design as daily returns incorporate more information about financial developments. Whereas monthly returns do not provide the same opportunity to detect the variable's specific impact, as it entails massive amounts of information. Therefore, using daily returns makes it possible to detect all the possible market movements created by the changing levels of climate change concerns and these can be linked more accurately.

### 5.1.1 Dependent variables

The dependent variable in every regression model is the return of the selected index. Indices used in this thesis are selected from broad-base indices that are supposed to represent the general performance of the region's stock market. The indices have mostly similar premises for assembly, including the largest listed companies on the stock exchange. Using the return of these indices should provide a comprehensive view of how climate change concerns impact a specific region. For the US stock market, the chosen stock index is the S&P 500. The S&P 500 -index tracks the price developments of 500 listed large-cap US stocks. For illustrating the stock market of Europe region, the STOXX Europe 600 -index is chosen. The index includes stocks across 17 European countries providing a diversified industry and country allocation. As for the remaining countries the chosen stock indices representing the stock market of each country are OMX Helsinki, OMX Stockholm, OMX Copenhagen, and OBX for the Norwegian stock market. These stock indices are local benchmarks for each country's stock market with similar premises for the assembly as the other indices.

Our analysis is based on stock indices that are listed above. These can be described as conventional stock indices which means that the indices are not constructed based on any sustainability requirements. However, the indices can possibly include some stocks of companies that do put effort into sustainability. The reason behind choosing specifically conventional stock indices is that they are supposed to simulate accurately the price movements of the whole stock market. This should ensure capturing the possible impact differences between regions. In addition, according to Pástor et al. (2022), it can be expected that returns of brown (conventional) assets are more likely to be influenced when climate conditions deteriorate. Therefore, in this type of research design, it is reasonable to use the conventional stock indices to illustrate each market.

In this thesis, the main interest is to detect the possible effect of climate change concerns on the daily returns of stock indices. Therefore, the daily returns for each index are calculated with the following formula:

$$(1) \quad R_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) * 100\% ,$$

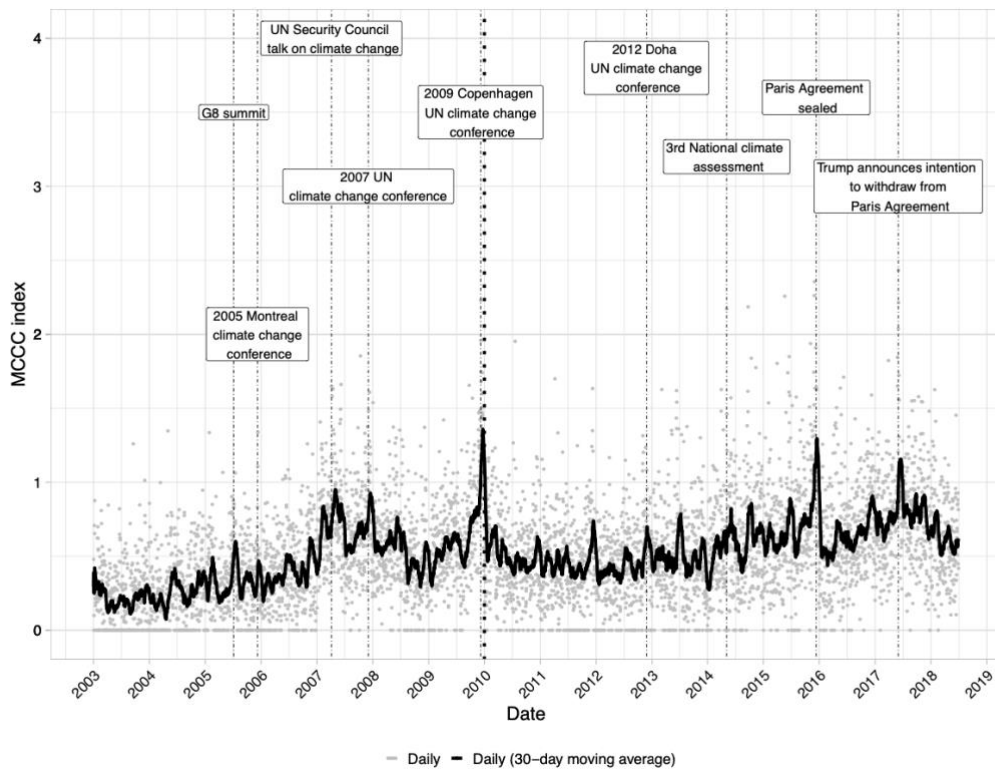
where  $R_{i,t}$  is the logarithmic daily return for each index on the day  $t$  in the country  $i$ .  $P_{i,t}$  and  $P_{i,t-1}$  are the values of the index in each country  $i$  on the days  $t$  and  $t - 1$ . And  $\ln$  represents the natural logarithm.

### 5.1.2 Media Climate Change Concern Index

The main variable of interest is the Media Climate Change Concerns (MCCC) index. During recent years multiple different indices have been developed in an effort to simulate the developments of climate change concerns. Some available indices have been based on news articles whereas others have merely been based on extreme weather events related to climate change. However, climate change is a complex and multidimensional phenomenon. Therefore, in the effort to capture the changes in sentiment and concerns, it is important to take into consideration all the aspects related to it. For the objective of this thesis, the most suitable measurement of climate change concern is the MCCC index created by Ardia et al. (2023).

The MCCC index is formulated through many steps. Firstly, the researchers collected media articles that were related to climate change for each day and defined a “concerns score” for each article (Ardia et al., 2023). The concerns score aimed to illustrate the level of negativity and risk reflected by the article. This is measured with the relative number of words reflecting risk and with the frequency relationship of negative and positive words. A daily aggregate MCCC index is created by combining the data from each news source. Then the index is computed by adjusting for heterogeneity among

sources and after that creating an average for the daily concern level. Also, the researchers set the index in proportion as one article on climate concerns is supposed to increase the concern level, but it is unlikely that 15 articles would increase the concerns by 15 times. The MCCC index was aggregated from the source-specific indices for the period 2010-2018, and it is constantly updated for the most recent observations. However, observations before that period are considered forward-looking and they are used for obtaining the source-specific standard deviation (Ardia et al., 2023). Therefore, helping the researchers only to validate the index.



**Figure 7.** Media Climate Change Concerns Index (Ardia et al., 2023)

The Media Climate Change Concern Index (Ardia et al., 2023) is displayed in Figure 7 as the gray points dotted in the graph. In the bold black line, the 30-day moving average of the MCCC index is presented. This helps to observe possible trends in the development of climate change concerns. In addition, at the largest spikes in the index, there is recognition of major events related to climate change provided in boxes. These spikes in

concern levels can be spotted close to events such as the 2009 Copenhagen UN climate change conference and the Paris Agreement. Based on this, it can be assumed that the index successfully captures the events that should have a major impact on the climate change concern levels. Also, two periods of consistent elevation in concerns can be spotted on the graph. The most recent period of elevated concern can be detected as starting at the end of 2012 and lasting to 2015 when the Paris Agreement was sealed.

Climate change has been recognized to create multidimensional concerns in society. Therefore, Ardia et al. (2023) created additional MCCC indices for each identified climate change theme. The four clusters of topics are Business Impact (B), Environmental Impact (E), Societal Debate (S), and Research (R). These themes are further categorized based on the climate risk their topics represent. The most frequently appearing theme is Business Impact, which includes topics such as Climate summits, Climate legislation/regulations, and Carbon tax (Ardia et al., 2023). Therefore, the theme is associated with transition risk. The second highest prevalence has the theme of Environmental Impact which includes topics associated with acute and chronic physical risk. These are topics such as Ecosystems, Extreme temperatures, and Water/drought (Ardia et al., 2023). Also, the theme of Social Debate can be linked to transition risk, as it includes Political campaigns and Controversies (Ardia et al., 2023). Whereas the theme Research can be linked both to physical and transition risk. The correlation between the theme specific MCCC indices differs in the range from 0,47 to 0,73 (Ardia et al., 2023). The smallest correlation is detected among Business Impact and Environmental Impact. This type of separation of different themes of climate change is important because it has been noticed that some climate risks are more relevant to economic agents than others. Therefore, it can be expected that an increase in a specific thematic concern can have a more significant impact on the stock returns. In this thesis, there will be an inspection of the changing effects of different thematic concerns.

### 5.1.3 Control variables

The control variables for the model are chosen from other factors that are known to affect the stock returns. Most of these are selected based on the existing macroeconomic factor literature. Macroeconomic factors are known to affect both the cash flows of firms and their risk-adjusted discount rates (Flannery & Protopapadakis, 2002). By including these variables in the models, it is possible to isolate the remaining effect that is caused by the developments of climate change concern levels. Some of the control variables are the same in all models for different indices and some are adjusted by the region in which the index under inspection is included. The control variables are presented in this chapter and a brief background on the selection is provided. In addition, the abbreviations for each control variable are presented in this chapter.

The control variable that is identical for every regression model is VIX. VIX is the volatility index maintained by the Chicago Board Options Exchange (CBOE). The function of the VIX is to illustrate the US stock market uncertainty by measuring the implied volatility of the US stock market for the next 30 days. Research has shown that in the US stock market, the VIX has a significant negative effect on stock returns (Whaley, 2009). Also, evidence of a similar relationship between stock returns and VIX has been found in emerging markets (Sarwar & Khan, 2017). Therefore, it can be assumed that VIX is a relevant stock market factor in other markets as well and can be used globally to illustrate market uncertainty. As VIX determines the general investor sentiment on the market, by using it as a control variable, it is possible to separate the effect of general uncertainty from the climate change concern in the stock market.

In addition, to VIX, other known important macroeconomic factors are used as control variables. The remaining chosen macroeconomic factors are mainly based on research conducted by Flannery and Protopapadakis (2002). These control variables have been shown to impact stock returns which makes them relevant variables in the analysis. Two of the chosen variables are inflation indicators, the Consumer Price Index (CPI) and the Producer Price Index (PPI). Higher inflation levels are known to be linked to the increase

of the risk-free rate and further increase in discount rates for stocks. This affects the stock returns as it can shift the expected return differentials between asset classes (Flannery & Protopapadakis, 2002). The CPI and PPI are incorporated in the regression based on local time series data for each country. Therefore, it is possible to control the inflation levels of each country under inspection. As for the larger region of Europe, CPI and PPI variables represent inflation in the eurozone. The fourth control variable chosen is the Monetary Aggregate, more specifically the M1. The effects on stock returns created by the changes in the money supply (M1) can be traced to the changes in liquidity for investors (Celebi & Hönig, 2019). This can be detected as demand changes in stocks on the market. Also, the M1 is linked to interest rates which further affects the firm's cost of capital. Similarly to CPI and PPI, the M1 variable is constructed to represent the money supply in a specific region in each of the regression models. With these customized variables, it should be possible to capture the effects in a specific region.

For these chosen macroeconomic factors, the values are reported on a monthly frequency at the end of each month. However, the objective of this thesis requires the examination of daily stock returns. Therefore, the time series data for the three macroeconomic factors is extended by repeating the announced value during each month and changed as soon as the values are updated. This allows our data for M1, CPI, and PPI to be matched with the daily returns. All the control variables used in the regression are included in the regression as contemporaneous variables. This is suitable for the research design of the thesis, as the stock market is assumed to be efficient. Similarly, Flannery and Protopapadakis (2002) found evidence that macroeconomic factors had contemporaneous effects. Therefore, in this thesis it is assumed that stock returns are affected instantly by the development of different factors.

**Table 1.** Descriptive statistics

	Mean	Median	Standard deviation	Minimum	Maximum	Sum
S&P 500	0.041	0.034	1.078	-12.765	8.968	155.451
STOXX Europe 600	0.019	0.047	1.036	-12.193	8.071	71.339
OMX Helsinki	0.012	0.007	1.148	-10.788	7.131	46.171
OMX Stockholm	0.032	0.033	1.131	-11.805	7.014	119.644
Oslo SE OBX	0.020	0.002	1.165	-8.949	6.293	75.333
OMX Copenhagen	0.050	0.048	1.046	-8.498	7.011	186.314
MCCC	0.815	0.749	0.454	0.000	3.052	
Business Impact	0.667	0.600	0.390	0.000	3.699	
Environmental Impact	0.645	0.563	0.457	0.000	3.717	
Societal impact	0.700	0.608	0.508	0.000	7.404	
Research	0.519	0.433	0.424	0.000	6.909	
VIX	18.418	16.620	7.019	9.140	82.690	
<b>USA</b>						
M1	7361.6	3403.1	7228.4	1674.7	20708.3	
CPI	251.163	243.892	25.846	217.199	313.225	
PPI	116.871	111.900	12.106	100.300	144.300	
<b>EUROPE</b>						
M1	7582908.1	7263975.0	2365496.5	4499855.0	11766718.0	
CPI	103.967	101.130	8.428	91.570	126.310	
PPI	96.427	90.300	15.917	81.700	143.900	
<b>FINLAND</b>						
M1	120334.5	118446.0	37555.3	64815.0	187422.0	
CPI	102.848	100.910	7.576	90.570	122.500	
PPI	108.395	102.700	14.023	92.300	148.000	
<b>SWEDEN</b>						
M1	2728046.7	2531676.0	1031219.9	1454787.0	4653357.0	
CPI	332.263	319.680	29.382	299.790	416.180	
PPI	101.659	93.800	15.498	87.700	143.400	
<b>DENMARK</b>						
M1	1145930.9	1132589.0	260621.6	785962.3	1565551.0	
CPI	102.634	101.000	6.620	91.400	118.500	
PPI	110.159	103.800	18.043	87.000	160.000	
<b>NORWAY</b>						
M1	1748796.1	1858299.0	772712.4	718493.0	2929793.0	
CPI	106.409	104.900	11.761	90.800	133.700	
PPI	86.407	78.800	23.543	58.900	181.600	

The descriptive statistics for the whole data sample are presented in Table 1. From these values, it is possible to draw general conclusions about the performance differences in stock indices. The highest returns over the whole sample have been provided by the S&P 500 and OMX Copenhagen indices. In comparison, the weakest performance is provided by the OMX Helsinki. The standard deviations for all the stock indices are around 1. However, the largest range for returns can be detected for the S&P 500. From the MCCC thematic indices, it is possible to detect characteristics of different concerns. The highest maximum value and standard deviation is for the Societal Impact concern index, which indicates clear fluctuations during the sample. During the sample period, Research seems to be the lowest scoring sustainability concern as it has the lowest mean. The values for VIX indicate significant fluctuations, which means periods of stability and extreme uncertainty. As for statistics for the country specific control variables, the following observations can be made. In Europe, the monetary aggregate (M1) is very high, which reflects the size and activity of the economy. The consumer price index is the

highest and most fluctuating in the USA and Sweden, as they have distinctively the highest values for mean and standard deviation. The producer price index mean is lowest in the USA and Norway. However, Norway has the highest standard deviation for producer price index which indicates clear fluctuations compared to others.

## 5.2 Methodology

The methodology used in this thesis is influenced by many different studies (Ardia et al., 2023; Bolton and Kacperczyk, 2021; El Ouadghiri et al., 2021). The methodology is constructed based on different aspects used by these authors. However, a more general examination is chosen as there are no existing studies with the exact same research objective. Based on the research carried out by Ardia et al. (2023), the aggregate MCCC index and the thematic MCCC indices were retrieved, these represent the climate change concerns in the models. Whereas, based on the research conducted by El Ouadghiri et al. (2021), it was concluded to use market illustrating indices for each country to detect region specific effects. In addition, the objective of this thesis is to detect whether the effect of climate change concerns has changed over time. For this reason, the additional examination was implemented similarly to Bolton and Kacperczyk (2021) by separating subsample periods around the Paris Agreement.

As the research design of this thesis, it is reasonable to use a simple linear regression model with time-series data. This research design includes two different regression models. Model 1 is constructed to detect the effect of the aggregate MCCC index. Therefore, giving a more general view of how the developments in the climate change concern levels affect stock index returns. Whereas Model 2 is an extended version of Model 1, and it includes variables as each of the thematic MCCC indices. This model provides insight into which of the climate change concern themes are most material to investors and have the most significant effect on the stock index returns. These models are presented in further detail below. The regression models are estimated individually for each of the selected regions with the market representing indices. Differences among

the regions are taken into consideration by using controls. All parameters in the models are estimated with the ordinary least squares (OLS) method, as used in the paper of El Quadghiri et al. (2021). With this methodology, it is possible to compare the estimated coefficients between different regions and detect whether the effect is different or stronger in other regions. All in all, this approach provides the opportunity to model the effect of climate change related concerns on the stock returns in each of the chosen regions.

The Model 1 is the simple linear regression formula with the aggregate MCCC index, and the Model 2 is the formula with the thematic MCCC indices, these models are presented below:

$$(1) R_{i,t} = \beta_0 + \beta_1 \ln(MCCC_t) + \beta_2 VIX_t + \beta_3 \ln(M1_{i,t}) + \beta_4 CPI_{i,t} + \beta_5 PPI_{i,t} + \varepsilon_{i,t} ,$$

$$(2) R_{i,t} = \beta_0 + \beta_1 \ln(B_t) + \beta_2 \ln(E_t) + \beta_3 \ln(S_t) + \beta_4 \ln(R_t) + \beta_5 VIX_t + \beta_6 \ln(M1_{i,t}) + \beta_7 CPI_{i,t} + \beta_8 PPI_{i,t} + \varepsilon_{i,t} ,$$

where,

$R_{i,t}$  = the daily return on stock index in country  $i$  in day  $t$

$\ln(MCCC_t)$  = natural logarithm of the MCCC index

$\ln(B_t)$  = natural logarithm of the thematic MCCC index, Business Impact

$\ln(E_t)$  = natural logarithm of the thematic MCCC index, Environmental Impact

$\ln(S_t)$  = natural logarithm of the thematic MCCC index, Social Debate

$\ln(R_t)$  = natural logarithm of the thematic MCCC index, Research

$VIX_t$  = CBOE volatility index

$\ln(M1_{i,t})$  = natural logarithm of monetary aggregate (M1) in region  $i$  in day  $t$

$CPI_{i,t}$  = consumer price index in region  $i$  in day  $t$

$PPI_{i,t}$  = producer price index in region  $i$  in day  $t$

$\beta_0$  = constant

$\beta$  = coefficients

$\varepsilon_{i,t}$  = error term

The basic concept behind these two models is that the dependent variable is the return of an index in a specific region. Whereas the other side of the formula consists of explanatory variables. In this thesis, the main interest is the estimated coefficients for the variables  $\ln(MCCC_t)$ ,  $\ln(B_t)$ ,  $\ln(E_t)$ ,  $\ln(S_t)$ , and  $\ln(R_t)$ . The logarithmic transformation is used for these climate change concern variables as used in other articles (El Ouadghiri et al., 2021). This makes it possible to detect non-linear relationships between variables and makes the changes in the MCCC index more distinctive. The coefficients illustrate the magnitude and direction of the effect on stock index returns when the level of climate change concern shifts. The remaining variables are included in the formula to separate other factors affecting the stock returns. This makes it possible to draw conclusions as the effect of climate change concerns is isolated.

As presented above, the main analysis of this thesis examines whether climate change concerns affect the stock market index returns differently in different regions. As well as what type of concerns are the most material in which regions. In addition, to these examinations, we wanted to examine whether this effect of climate change concerns has remained similar overtime or whether it has gotten stronger during recent years. The aim is to find out whether the effect has different magnitudes over our sample. The Paris Agreement in 2015 is used as a divider of periods. In this thesis, it is suggested that the effect of climate change concern would have been different before and after the Paris Agreement, which can be labeled as one of the remarkable turning points related to climate change.

This examination of the effect of climate change concerns before and after the Paris Agreement is executed with the same methodology as used in the main analysis of the thesis. In this part, the sample is divided into two subsamples that are the length of six years. The period before starts from 2010 at the beginning of our whole sample and stops at the end of the year 2015. The whole year 2015 is included in the before sample as the Paris Agreement took place in December. The subsample for the after period

continues there and stops at the end of the year 2021. For both of these subsamples, Model 1 and Model 2 are estimated as the inspection of the shift in effect. A fairly similar examination around the Paris Agreement was carried out by Bolton and Kacperczyk (2021) by focusing on the carbon risk premium. The additional examination is mainly based on this same motivation, to detect whether the Paris Agreement has increased the attention level of investors and that it can be seen affecting stock returns. This thesis uses a similar approach to Bolton and Kacperczyk (2021). In their article, the subsample after the Paris Agreement was rather short as they aimed to test short-term impact of changed attention. Whereas in this thesis the aim is to detect whether there have been more permanent and long-term changes in the attitude against climate change concerns. Therefore, the inspection is not aimed at an event-based market reaction. Both subsamples were chosen to be six years long, as the whole sample starts from 2010. Also, to ensure better comparability the samples were the same length.

## 6 Empirical results

This part of the thesis presents the empirical results of the analysis of daily stock index returns. The OLS regression results will be introduced and a comprehensive analysis of the significance of these results will be provided. Firstly, the focus will be on the results of the main analysis, which includes the regressions with the aggregate MCCC index and the thematic MCCC indices for each region. After this, we will concentrate on the results provided by the additional examination of how the relationship has altered, by comparing the effect before and after the Paris Agreement. Throughout the chapter there will be an analysis of the results for each region and after that a comparison between the regression results between regions. Based on these, the conclusions will be discussed about the regional differences.

### 6.1 Results for the main analysis

The regression results estimated for Model 1 by using the OLS are reported in Table 2. The analysis was carried out for the whole sample 01.01.2010-31.05.2024 and regression results were obtained for each region separately with regional controls. The estimation sample included 3705 observations for each region. The coefficient of interest is the coefficient for the variable  $\ln(MCCC_t)$ , which reflects the effect the aggregate MCCC index has on the stock returns of a specific region. In this thesis, it is assumed that in all regions the coefficient for  $\ln(MCCC_t)$  should be negative as presented in the first hypothesis. For Model 2, the OLS estimation regression results are reported in Table 3. Similarly, as for Model 1, the analysis was carried out for the whole sample, and the Table is assembled with the same structure. With Model 2, our interest is mainly focused on the coefficients estimated for each variable of the MCCC thematic indices,  $\ln(B_t)$ ,  $\ln(E_t)$ ,  $\ln(S_t)$ , and  $\ln(R_t)$ . This analysis makes it possible to elaborate which of the climate change concerns are most influential for the stock returns. In this thesis, it is hypothesized that transition risk related concerns have the largest effect on stock returns. Most importantly, transition risks that are linked to the themes of Business

Impact and Social Debate. With the results presented in the Table 3, we aim to provide support for the hypothesis 2. In both Tables, the coefficient probabilities are reported inside the parentheses below the results. Coefficients marked with asterisks \*, \*\*, and \*\*\* display significance at the 10%, 5%, and 1% levels, respectively.

**Table 2.** The OLS regression results with the aggregate MCCC index

Variable	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	0.117 (0.579)	-2.552* (0.078)	-1.255 (0.137)	-0.445 (0.688)	-0.073 (0.969)	0.185 (0.846)
<i>ln_MCCC</i>	-0.061* (0.076)	-0.024 (0.481)	-0.061 (0.102)	-0.039 (0.291)	0.011 (0.753)	-0.003 (0.940)
<i>VIX</i>	-0.028*** (0.000)	-0.023*** (0.000)	-0.021*** (0.000)	-0.021*** (0.000)	-0.016*** (0.000)	-0.017*** (0.000)
<i>ln_M1</i>	0.194*** (0.000)	0.274** (0.022)	0.211** (0.023)	0.081 (0.340)	0.035 (0.854)	0.006 (0.950)
<i>CPI</i>	-0.003 (0.621)	-0.020** (0.011)	-0.011* (0.096)	-0.002 (0.248)	-0.001 (0.953)	0.001 (0.897)
<i>PPI</i>	-0.003 (0.827)	0.007** (0.013)	0.003 (0.287)	0.004 (0.266)	0.000 (0.987)	0.000 (0.963)
<i>R-squared</i>	0.031	0.021	0.016	0.016	0.011	0.011

In general, the OLS estimation regression results for the Model 1 in the Table 2 are mainly what is expected. Hypothesis 1 is supported in all other regions except in Denmark. Also, the hypothesis 1a is supported by the results in Denmark and Norway. The general statistical significance of the results is low, as probabilities for the coefficient  $\ln(MCCC_t)$  are high. Only for the USA, the  $\ln(MCCC_t)$  coefficient is significant at the 10% level. Also, the coefficient for climate change concern for Finland has a significance close to the same level. However, the highest significance for the USA could have been expected as the MCCC index is primarily aimed to illustrate the climate change concern levels in the USA even though it is globally applicable. As for the R-squared reported at the bottom of Table 2 is generally low, especially for the Nordics. Therefore, indicating that the model would have a low goodness-of-fit, which means that a rather low proportion of the

variation of the dependent variable is explained by the chosen independent variables. For the chosen model, this can be acceptable as there are countless other factors that additionally drive stock market returns. For example, the three factors suggested by Fama and French (1970). In this thesis, the model seems to work as the retrieved regression results include significant and accurate coefficients that have been successfully estimated. However, with the value of R-squared, it is possible to reflect which proportion of the variation is influenced by these coefficients. Still, this examination provides results that can be used to compare the effects in different regions.

The coefficients for the control variables give insight into whether our estimation is able to detect accurate influence with the dependent variable. For all the regions, the coefficient for the variable VIX is highly significant at the 1% level and negative. This is expected as the return should decrease when the uncertainty increases. This is consistent with the results obtained by Whaley (2009). As for the M1, the coefficient is positive for all regions, and statistically significant for USA, Europe, and Finland. This means that when the money supply increases the stock index returns in these regions are positively affected. As for the coefficients for the two inflation measures, the magnitude and direction differed slightly for different regions. The coefficient for the CPI is negative for all other regions except for Norway. The largest magnitudes and significance are with coefficients for Europe and Finland. As for the coefficient for the PPI, it is negative only in the USA. For Europe, Finland, and Sweden the coefficient is positive. For Denmark and Norway, the PPI seems to have no effect on the stock index returns.

In Table 2 it can be seen that in the USA region, the coefficient for  $\ln(MCCC_t)$  is -0.061 (0.076). This means that the stock index return is decreased by 6.1 basis points when climate change concerns increase by 1%. These results are consistent with the research conducted by Ardia et al. (2023), which showed that the stock returns of brown firms are negatively affected when climate change concerns unexpectedly increase. The sample of this thesis includes conventional stock indices to illustrate general market

movements, and these stock indices are not based on any specific sustainability criteria. Therefore, it is possible to assume the stock indices to be closer to brown stocks. Similarly, as used in the research conducted by El Ouadghiri et al. (2021). They compared the performance of the S&P500 and S&P500 sustainability indices and based this approach on the assumption that the conventional indices include more brown stocks (El Ouadghiri et al., 2021). Therefore, in this thesis, it is possible to confirm the results being consistent with the research performed with the brown and green stock comparison.

Also, for the region of Finland, the coefficient for  $\ln(MCCC_t)$  is the exact same size as in the USA but it is not as statistically significant. However, it indicates that the Finnish stock market is sensitive to global climate change concerns and that these issues have gained a lot of attention in Finland. After Finland, the biggest negative effect of climate change concerns can be detected in Sweden. The coefficient for  $\ln(MCCC_t)$  for Sweden is -0.039 (0.291), which means that if climate change concerns increase by 1 %, the stock index return would decrease by 3.9 basis points. When comparing Sweden and Finland as regions, the effect of VIX is the exact same size and the Model 1 has the same level of goodness-of-fit, which makes these regions good comparisons. Sweden seems to have the same sensitivity to the overall level of stock market uncertainty (VIX), whereas the climate change concerns are not as important as in Finland. For Europe, the effect of climate change concerns is even smaller. The coefficient for  $\ln(MCCC_t)$  for Europe is -0.024 (0.481), which means that if climate change concerns increase by 1 %, the stock index return would decrease by 2.4 basis points. Even though in Europe, the sensitivity to VIX is larger when compared to Finland and Sweden. Still, in all the regions, Finland, Sweden, and Europe, the estimated effect of climate change concern supports hypothesis 1 presented in this thesis. However, the results for Finland and Sweden contradict hypothesis 1a, which expected that the effect of climate change concerns would be least pronounced in the Nordics.

In Norway, the coefficient for  $\ln(MCCC_t)$  is -0.003 (0.940), which is statistically insignificant. However, it provides slim support to hypothesis 1, that climate change

concerns affect the stock index returns negatively. In Norway, this would be interpreted that stock index returns would decrease by 0.3 basis points when the climate change concerns increase by 1 %. The effect is significantly smaller compared to other regions. The smaller effect for the stock returns in Norway can be detected for VIX as well. This could mean that the Norwegian stock market is not that sensitive to uncertainty and climate change concerns. As for the estimated coefficient for  $\ln(MCCC_t)$  for Denmark is the only positive. The coefficient seen in Table 2 is statistically insignificant and small. Further, the inspection would be needed to draw conclusions about whether the Danish stock market is affected by climate change concerns. However, these results for both Norway and Denmark provide support to hypothesis 1a, which would mean that the negative impact is least pronounced in these Nordic countries.

**Table 3.** The OLS regression results with the thematic MCCC indices.

<i>Variable</i>	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	0.174 (0.422)	-2.574* (0.090)	-1.376 (0.123)	-0.607 (0.605)	-0.386 (0.842)	0.269 (0.787)
<i>ln_B</i>	-0.036 (0.404)	-0.027 (0.519)	-0.034 (0.466)	-0.021 (0.650)	0.030 (0.485)	0.013 (0.781)
<i>ln_E</i>	-0.005 (0.887)	-0.038 (0.264)	-0.019 (0.607)	-0.019 (0.608)	-0.021 (0.541)	-0.039 (0.308)
<i>ln_S</i>	-0.013 (0.720)	0.036 (0.321)	0.009 (0.812)	-0.005 (0.894)	-0.003 (0.925)	0.045 (0.271)
<i>ln_R</i>	-0.001 (0.987)	0.002 (0.962)	-0.024 (0.569)	0.005 (0.903)	0.003 (0.945)	-0.017 (0.686)
<i>VIX</i>	-0.028*** (0.000)	-0.023*** (0.000)	-0.022*** (0.000)	-0.021*** (0.000)	-0.016*** (0.000)	-0.017*** (0.000)
<i>ln_M1</i>	0.202*** (0.000)	0.277** (0.026)	0.236** (0.015)	0.096 (0.288)	0.050 (0.797)	-0.001 (0.989)
<i>CPI</i>	-0.004 (0.611)	-0.020** (0.010)	-0.013* (0.055)	-0.002 (0.221)	0.000 (0.982)	0.001 (0.901)
<i>PPI</i>	-0.004 (0.798)	0.008** (0.010)	0.003 (0.272)	0.004 (0.269)	0.000 (0.980)	0.000 (0.927)
<i>R-squared</i>	0.031	0.021	0.016	0.016	0.011	0.011

In Table 3, the estimated regression results for Model 2 with the thematic MCCC indices are reported. This estimation makes it possible to identify which of the concern themes are most influential on stock returns in each of the regions. Generally, when comparing the regression results from Model 2 with the results estimated for Model 1, the control variable coefficients seem to remain at a fairly similar level. However, the coefficient for M1 has a larger magnitude in Model 2 for all other regions than in Norway. For the coefficients of inflation measures, CPI, and PPI, the changes are minimal. Similarly, as in the previous Table, in Table 3 most of the coefficients for the control variables are statistically significant. Whereas the significance of the estimated coefficients for the thematic MCCC indices in Model 2 is very low. Still, we are able to make some conclusions about which themes are most influential while comparing different regions. The R-squared for Model 2 is identical to Model 1 in all the regions.

As seen in the first column in Table 3, the stock returns in the USA are negatively influenced by all the thematic MCCC indices. Consistent, with the results provided by Ardia et al. (2023), the biggest impact on stock returns is caused by the concerns linked to themes of Business Impact and Social Debate. In our Model 2, the estimated coefficient for Business Impact is -0.036 (0.404) and for Social Debate -0.013 (0.720). This means that if climate change concerns related to Business Impact increase by 1 %, the stock index return is decreased by 3.6 basis points. Similarly, the same effect with Social Debate is a decrease of return by 1.3 basis points. These results support our hypothesis 2, that the climate change concerns linked to transition risks have the most significant effect on the stock returns. Both themes Environmental Impact and Research have noticeably smaller impacts, with Environmental Impact having a slightly bigger impact.

In addition, in Finland and Sweden, the concerns related to Business Impact have the strongest impact on the stock returns. In Finland, if concern related to Business impact increases by 1%, the stock return would decrease by 3.4 basis points. This effect is really close to the magnitude estimated in the USA. In Sweden the effect is smaller, the stock

return would decrease by 2.1 basis points if the Business Impact concerns increase by 1%. These results provide support to hypothesis 2 in Finland and Sweden. This supports the survey results provided by Stroebel and Wurgler (2021), which report that investors perceive transition risks as the most important climate change risk. In Europe, the coefficient for Business Impact is -0.027 (0.519) which is close to the coefficients in Finland and Sweden. Therefore, indicating that transition risk related concerns have a detectable effect on the stock returns. However, in Europe, the coefficient for Environmental impact is -0.038 (0.264) which is even larger. This would mean that in Europe climate change concerns related to physical risks have a stronger effect on stock returns than transition risks do.

In Table 3, we see that in both Denmark and Norway, the coefficient for Business Impact is positive. This means that if Business Impact related climate change concerns increase by 1%, it would mean a 3 basis points increase in returns in Denmark and a 1.3 basis points increase in returns in Norway. Therefore, indicating that stock returns are positively influenced by the increase in climate change concerns related to transition risk. However, as the MCCC index is aimed at the USA, it is possible that the concerns of business impact are not perceived as imminent in these countries. Business Impact includes topics such as legal actions and government programs, which can have an effect globally, but not specifically in these countries. It would mean that in Denmark and Norway, global concern levels are not as important, and these regions are not as susceptible.

On the contrary to this, the relevancy of physical risks can be seen in Denmark and Norway. The coefficient for Environmental Impact is -0.039 (0.308) in Norway and -0.021 (0.541) in Denmark. In Norway, the effect of Environmental Impact is close to the level in Europe, which means that if concerns related to Environmental Impact increase by 1% the stock index return would decrease by 3.9 basis points. Especially, when compared to the coefficients of concerns related to transition risk, it seems that in Norway and Denmark, the concerns related to physical risk have a greater influence on the stock

returns than the transition risk related concerns. This contradicts hypothesis 2 and no support for this can be found in Norway and Denmark. In addition, in Finland and Sweden, the concerns related to Environmental Impact have more influence on the stock returns when compared to the USA. In both Finland and Sweden, if concerns related to Environmental Impact increase by 1% the stock index return would decrease by 1.9 basis points. Whereas in the USA this decrease would have been 0.5 basis points. It can be concluded that physical risk related concerns have a greater influence in all other regions than in the USA.

In general, the estimated coefficients for Social Debate and Research vary across regions. For both thematic concern variables, the effect seems to be positive in some regions and negative in some regions. As mentioned earlier, the coefficient for Social Debate in the USA is consistent with the existing research. However, in Europe, Finland, and Norway the estimated coefficient is positive. Even though other coefficients in Finland seem to follow the same pattern as in the USA. The effect is even more noticeable for Europe and Norway as their coefficients for Social Debate are 0.036 (0.321) and 0.045 (0.271). This means that if Social Debate concerns increase by 1%, in Europe the stock returns react positively by 3.6 basis points and in Norway by 4.5 basis points. Therefore, contradicting our hypothesis that stock returns are affected negatively when climate change concerns increase, especially when concerns related to transition risks increase. Even for the regions, Denmark and Sweden, which have negative coefficients for the Social Debate, the coefficients are very small. Again, this contradicting the hypothesis that transition risk related concerns have the largest effect. However, the Social Debate includes topics that are even more localized to the USA than Business Impact. Therefore, it is possible that in other regions than in the USA the theme of Social Debate does not increase the investor perceived climate change concern level.

As seen in Table 3, the coefficient for the theme Research is positive in half of the regions. In Europe, Sweden, and Denmark this would mean that stock returns increase as the concerns related to Research increase. However, these coefficients are rather small and

are statistically insignificant. Therefore, it is possible that in reality, the Research related concerns do not influence stock returns. In Finland and Norway, the coefficient for Research is negative and the effect magnitude is larger. The estimated coefficient for Research in Finland is -0.024 (0.569), which is much larger than the USA coefficient of -0.001 (0.987). This does not contradict our hypothesis in Finland, as the Research theme includes topics related to transition and physical risk.

In our main analysis, we concentrated on how climate change concerns affect stock returns in different regions. Additionally, we focused on whether different themed climate change concerns have different effects on the stock returns. Hypothesis 1 assumed that an increase in climate change concerns would have a distinctive negative effect on stock returns. Evidence to support this hypothesis was found in all other regions except Denmark. The hypothesis 2 assumed that concerns related to transition risk would have the largest negative impact on stock returns as those concerns increase. Only the estimation results in the USA, Finland, and Sweden supported this view. More specifically, the evidence was mainly found related to Business Impact related concerns.

## **6.2 Comparison before and after the Paris Agreement**

In addition to the main analysis carried out in this thesis, we wanted to examine whether the relationship between stock returns and climate change concerns has changed during our sample. For example, whether the effect of climate change concerns is constantly getting stronger when compared to earlier periods. This analysis is based on the possibility that major events related to climate change remind investors of the importance of these concerns and further magnify the relationship between stock returns and concerns. For this reason, the examination subsamples were located before and after the Paris Agreement, which is one of the most important events related to climate change. Also, to support this assumption, researchers have recently reported a noticeable growth in how much climate change is noticed among investors (Krueger et al., 2020). Therefore, the expected result from the examination is that in each region the

effect of climate change concerns has strengthened and is more negative after the Paris Agreement than before. Also, that this development is expected to be strongest in the USA. This is presented in hypotheses 3 and 3a.

The analysis is based on regression results estimated with OLS for Model 1 and Model 2 for both subsamples. The estimation results are reported in Tables 4, 5, 6, and 7. In these Tables, the coefficient probabilities are reported inside the parentheses below the results. Coefficients marked with asterisks \*, \*\*, and \*\*\* display significance at the 10%, 5%, and 1% levels. Tables 4 and 6 include the estimated OLS regression results before the Paris Agreement for the period 01.01.2010-31.12.2015, which included 1532 observations for each of the regions. Tables 5 and 7 include the regression results after the Paris Agreement for the period 01.01.2016-31.12.2021, which included 1544 observations for each of the regions. Firstly, the analysis for the results is carried out by evaluating the results provided in Tables 4 and 5 with the aggregate MCCC index. After this, the results in Tables 6 and 7 with the thematic MCCC indices are evaluated. The focus of the analysis will be primarily aimed at the changes between the subsamples in each region. This should provide insight on whether the effect of climate change concerns on the stock returns has altered after the Paris Agreement. Also, the attention is aimed towards how the relationship changes differ regionally. The attempt is to recognize whether there is a common trend in the change of the relationship between stock returns and concerns or whether there are considerable differences between regions. The change in the relationship is expected to be strongest in the USA. In addition, by performing the estimation to Model 2, it is possible to retrieve information on which thematic concerns and returns relationships have changed over time most explicitly.

**Table 4.** The OLS regression results with the aggregate MCCC index before Paris Agreement

Variable	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	1.763 (0.335)	-6.190 (0.600)	3.193 (0.619)	6.105 (0.261)	18.962** (0.036)	2.135 (0.296)
<i>ln_MCCC</i>	-0.036 (0.434)	-0.071 (0.149)	-0.119** (0.040)	-0.061 (0.251)	-0.038 (0.420)	-0.068 (0.240)
<i>VIX</i>	-0.036*** (0.000)	-0.032*** (0.000)	-0.030*** (0.000)	-0.029*** (0.000)	-0.033*** (0.000)	-0.032*** (0.000)
<i>ln_M1</i>	1.553 (0.131)	0.763 (0.407)	0.067 (0.930)	-0.224 (0.473)	-1.438* (0.093)	0.230 (0.319)
<i>CPI</i>	-0.096* (0.057)	-0.073 (0.158)	-0.014 (0.783)	-0.011 (0.189)	0.057 (0.255)	-0.046** (0.045)
<i>PPI</i>	0.084 (0.167)	0.023 (0.433)	-0.021 (0.449)	0.012 (0.622)	-0.042** (0.037)	-0.005 (0.428)
<i>R-squared</i>	0.039	0.025	0.019	0.019	0.031	0.018

The estimated OLS regression results for Model 1 for the subsample before the Paris Agreement are reported in Table 4. The general discovery of the coefficient for  $\ln(MCCC_t)$  is that in all the regions the coefficient is negative. This means that in all regions the stock returns are influenced negatively when the climate change concerns increase. As for the significance, the coefficient for  $\ln(MCCC_t)$  has statistical significance only in Finland at the 5% level. The R-squared for Model 1 in this subsample is slightly larger when compared to the whole sample. In general, coefficients for other variables are mostly consistent with the results estimated for the whole sample. The coefficient for  $VIX_t$  is negative and significant at the 1% level. However, the magnitude is larger in all the regions. The coefficient for M1 is positive for most of the regions, except Sweden and Denmark. The biggest change can be spotted in the USA as the magnitude of the coefficient for M1 has increased to 1.553 (0.131). As for the inflation variables, the estimated results are similar in that stock returns are negatively influenced by increased inflation, and for all regions at least one of the coefficients are negative.

**Table 5.** The OLS regression results with the aggregate MCCC index after Paris Agreement

Variable	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	-4.054*** (0.001)	-21.704*** (0.000)	-14.541*** (0.000)	-16.769*** (0.000)	-12.250* (0.051)	-35.380*** (0.005)
<i>ln_MCCC</i>	-0.069 (0.245)	0.037 (0.502)	-0.001 (0.981)	0.033 (0.562)	0.088* (0.099)	0.079 (0.194)
<i>VIX</i>	-0.035*** (0.000)	-0.026*** (0.000)	-0.029*** (0.000)	-0.024*** (0.000)	-0.015*** (0.000)	-0.020*** (0.000)
<i>ln_M1</i>	0.077 (0.278)	1.799*** (0.002)	1.311* (0.069)	1.518*** (0.006)	0.835 (0.329)	2.955*** (0.009)
<i>CPI</i>	0.095*** (0.000)	-0.048 (0.235)	0.030 (0.719)	-0.012 (0.465)	0.021 (0.771)	-0.061* (0.098)
<i>PPI</i>	-0.171*** (0.000)	-0.016 (0.129)	-0.034*** (0.007)	-0.015 (0.196)	-0.013 (0.187)	-0.008** (0.039)
<i>R-squared</i>	0.043	0.034	0.037	0.030	0.017	0.022

The estimated OLS regression results for Model 1 for the subsample after the Paris Agreement are reported in Table 5. As an initial discovery, the coefficient for  $\ln(MCCC_t)$  varies notably between different regions. Only in two regions, the USA and Finland, the coefficient for  $\ln(MCCC_t)$  remains negative. As for the significance, the coefficient for  $\ln(MCCC_t)$  has statistical significance only in Denmark at the 10% level. The R-squared for Model 1 in this subsample is the largest compared to the other samples, except in Denmark. In general, coefficients for other variables are mostly consistent with the results estimated for the whole sample. The coefficient for  $VIX_t$  remains negative and significant at the 1% level. However, the magnitude is smaller in all the regions when compared to the subsample results before the Paris Agreement. The coefficient for M1 is positive for all the regions but the magnitude is notably larger in all other regions except in the USA. As for the inflation variables, the estimated results are similar in that stock returns are negatively influenced by increased inflation, and for all regions at least one of the coefficients are negative. When comparing the coefficients for the inflation variables, there are notable shifts in coefficients between the samples used in this thesis. It may change between different periods whether the consumer or producer inflation has more effect.

In the USA the negative effect of climate change concerns has nearly doubled. In this region, the coefficient for  $\ln(MCCC_t)$  has changed after the Paris Agreement from -0.036 (0.434) to -0.069 (0.245), which provides support to hypotheses 3 and 3a. The change in the relationship to a more negative direction is clearly strongest in the USA. When climate change concerns increase, it has a stronger negative effect on the stock returns when compared to the period before the Paris Agreement. This is consistent with Bolton and Kacperczyk (2021), who reported an increase in carbon risk premium in the period after the Paris Agreement. This indicates that investors paid more attention to climate change related risks after the Paris Agreement. Also, our analysis is consistent with Fahmy (2022), who found evidence about the intensifying climate risks and rewards after the Paris Agreement. Therefore, it is accurate that stock returns would decrease when climate change concerns increase.

In other regions, the results seem to be the exact opposite, which provides support to hypothesis 3a. In Europe and mainly in the Nordics, the coefficient for  $\ln(MCCC_t)$  is negative before the Paris Agreement but the coefficient shifted to a positive sign after the event. The only exception is Finland, where the coefficient for  $\ln(MCCC_t)$  remains negative but is clearly reduced in size. After the Paris Agreement, it has changed from -0.119 (0.040) to -0.001 (0.981), which means that stock returns are less affected by the concerns. These estimated results contradict hypothesis 3, which expected the negative influence to be strengthened in all the regions. In Europe, Sweden, Denmark, and Norway the results indicate that if climate change concerns increase, it would have a positive impact on stock returns. The effect is largest in Denmark and Norway. The estimated coefficients illustrate that if climate change concerns increase by 1%, in Denmark the stock returns would increase by 8.8 basis points and in Norway by 7.9 basis points. In Europe and Sweden, the positive impact is slightly more moderate.

This change in the relationship between climate change concerns and stock returns is further analyzed with the estimation results for Model 2 for both subsamples. By using

the thematic MCCC indices, it is possible to detect how the relationship has developed with concerns related to each theme. These results are reported in Tables 6 and 7. On a general level, the coefficients for other variables and the constants are at a similar level for Model 2 as they were for Model 1. This confirms that the thematic MCCC indices are successfully capturing all concerns of the aggregate MCCC and that the separate effect can be analyzed. The attention is mainly focused on analyzing the change in the impact of concerns related to Business Impact and Environmental Impact, as those concerns showed importance in the main analysis.

**Table 6.** The OLS regression results with the thematic MCCC indices before Paris Agreement

<i>Variable</i>	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	1.910 (0.299)	-5.684 (0.632)	3.296 (0.609)	6.953 (0.204)	20.074** (0.027)	2.334 (0.255)
<i>ln_B</i>	-0.047 (0.410)	-0.114* (0.062)	-0.117 (0.103)	-0.090 (0.172)	-0.046 (0.431)	-0.106 (0.139)
<i>ln_E</i>	0.003 (0.945)	-0.051 (0.312)	-0.035 (0.551)	-0.004 (0.946)	-0.042 (0.391)	-0.042 (0.480)
<i>ln_S</i>	0.030 (0.541)	0.096* (0.071)	0.056 (0.373)	0.074 (0.199)	0.062 (0.220)	0.144** (0.021)
<i>ln_R</i>	-0.020 (0.729)	-0.014 (0.822)	-0.029 (0.692)	-0.051 (0.440)	-0.010 (0.865)	-0.071 (0.326)
<i>VIX</i>	-0.037*** (0.000)	-0.032*** (0.000)	-0.030*** (0.000)	-0.029*** (0.000)	-0.034*** (0.000)	-0.033*** (0.000)
<i>ln_M1</i>	1.503 (0.145)	0.718 (0.437)	0.039 (0.959)	-0.314 (0.327)	-1.533* (0.074)	0.242 (0.296)
<i>CPI</i>	-0.098* (0.053)	0.075 (0.149)	-0.014 (0.779)	-0.009 (0.280)	0.058 (0.247)	-0.052** (0.024)
<i>PPI</i>	0.089 (0.144)	0.028 (0.360)	-0.019 (0.500)	0.011 (0.659)	-0.041** (0.041)	-0.002 (0.753)
<i>R-squared</i>	0.039	0.028	0.021	0.020	0.032	0.023

**Table 7.** The OLS regression results with the thematic MCCC indices after Paris Agreement

<i>Variable</i>	USA	EUROPE	FINLAND	SWEDEN	DENMARK	NORWAY
<i>Constant</i>	-4.034*** (0.001)	-21.702*** (0.000)	-14.37*** (0.000)	-16.807*** (0.000)	-12.017* (0.057)	-38.002*** (0.003)
<i>ln_B</i>	-0.102 (0.196)	-0.049 (0.494)	-0.030 (0.681)	-0.019 (0.803)	0.046 (0.514)	0.049 (0.536)
<i>ln_E</i>	-0.037 (0.596)	-0.005 (0.932)	0.041 (0.531)	0.066 (0.320)	0.010 (0.870)	-0.013 (0.846)
<i>ln_S</i>	0.009 (0.905)	0.114* (0.087)	0.050 (0.468)	0.046 (0.508)	0.001 (0.990)	0.093 (0.207)
<i>ln_R</i>	0.062 (0.430)	-0.012 (0.864)	-0.060 (0.411)	-0.064 (0.387)	0.033 (0.642)	-0.054 (0.487)
<i>VIX</i>	-0.035*** (0.000)	-0.026*** (0.000)	-0.029*** (0.000)	-0.024*** (0.000)	-0.015*** (0.000)	-0.021*** (0.000)
<i>ln_M1</i>	0.083 (0.246)	1.832*** (0.001)	1.384* (0.057)	1.557*** (0.005)	0.812 (0.345)	3.192*** (0.005)
<i>CPI</i>	0.094*** (0.000)	-0.055 (0.179)	0.018 (0.832)	-0.014 (0.399)	0.023 (0.758)	-0.069* (0.067)
<i>PPI</i>	-0.170*** (0.000)	-0.015 (0.174)	-0.032*** (0.010)	-0.014 (0.230)	-0.013 (0.181)	-0.008* (0.053)
<i>R-squared</i>	0.044	0.036	0.037	0.031	0.017	0.023

In general, the effect of different themes of climate change concerns is different as presented in the main analysis. Firstly, from the estimation results presented in Tables 6 and 7, it can be seen that the effect has changed over time differently depending on the theme of the concern and the region. In the USA, the effect of the Business Impact concerns has more than doubled. The coefficient for  $\ln(B_t)$  has changed after the Paris Agreement from -0.047 (0.410) to -0.102 (0.196). This magnification of the impact of transition risk linked concern is consistent with the existing literature (Ardia et al., 2023; Stroebel & Wurgler, 2021). Also, a notable change has been in the coefficient for Environmental impact which has changed from 0.003 (0.945) to -0.037 (0.596). This would suggest that the strengthening of the relationship in the USA is driven by the effect of concerns linked to Business Impact and Environmental Impact. After the Paris Agreement, if climate change concerns related to Business impact increase by 1% the stock returns decrease by 10.2 basis points. This change in the effect in the USA is

consistent with the existing literature (Bolton & Kacperczyk, 2021). This clear negative development of the relationship in the USA provides support to the hypotheses 3 and 3a. Whereas, in the other regions the relationship has developed in the opposite direction.

In all the other regions, the effect of Business Impact and Environmental Impact concerns has either changed from negative to positive or at least decreased in size if it remains negative. In Europe, both coefficients have remained negative but have reduced in size. The change has been largest in the effect of Environmental Impact in percentage terms. However, the change in the impact of Business Impact is also substantial. In the Nordics, similar discoveries can be made. In Finland, the coefficient for Business Impact has decreased from -0.117 (0.103) to -0.030 (0.681), even though it remains negative. As for the coefficient for Environmental Impact, it has even changed to positive, 0.041 (0.531). This would mean that the stock returns in Finland are not as susceptible to these types of risks as the attention toward sustainability has increased. A similar development of the relationship can be detected in Sweden, where the coefficient for Business Impact has been reduced in size, and the coefficient for Environmental Impact has changed to positive.

In Denmark, both coefficients for Business Impact and Environmental Impact have turned positive. Therefore, indicating that if concerns related to those themes increase, it would have a positive impact on the stock returns. In Norway, the change in coefficients is similar. However, the change in the coefficient for Business Impact is greater, whereas the coefficient for Environmental Impact has remained negative. The coefficient for Business Impact has changed from -0.106 (0.139) to 0.049 (0.536). Therefore, indicating that the change in the relationship between concerns and returns could be mainly driven by Business Impact in Norway. Still, in other regions, it can be generalized that the change over time seems to be caused by the impact of all the aspects of the climate change concerns. Therefore, indicating that the shift is gradual in the effect of all the themes. All in all, the results confirm that the change in the

relationship has the same direction with Business Impact and Environmental impact in Europe and Nordics. It is possible that the stage of sustainability in these regions is the reason for this change.

The results reported in other regions than the USA contradict the existing literature as the impact of climate change concerns has strengthened (Bolton & Kacperczyk, 2021). However, this existing literature is mostly based on the US stock market and might not be universally generalizable. At least not with the regions selected for this sample, as there are many differences in the sustainability levels of countries. According to Strand (2024), the Nordic countries can be appointed as the world sustainability leaders and the countries are constantly improving on this subject. This could mean that in general, the stocks selected to the market representing indices in the Nordics might be more sustainable than the stocks selected in the US stock index. Therefore, making the Nordic indices categorized as more sustainable. The estimated results would be acceptable as research has shown that returns of sustainable stocks are influenced positively when attention toward climate change related risks is increased (Ardia et al., 2023; El Ouadghiri et al., 2021). Based on this argumentation, the regional sustainability of the Nordics and Europe would cause stock returns to react positively, when climate change concerns increase. This would mean that investors could partially reduce the climate risk by investing in more sustainable regions. At least this seems to be the direction where the relationship is developing. However, further research would be required to properly confirm this conclusion. Also, as a separate argumentation for the results, in the period after the Paris Agreement, the regional differences may alter the results more. After the Paris Agreement, in all other regions than the USA there is estimated a largely negative constant, which indicates poor market returns. This could alter the relationship between stock returns and climate change concerns.

### 6.3 Limitations and future research

The results reported in this thesis provide new insights about the relationship between stock returns and climate change concerns. However, it is important to keep in mind the limitations of this examination. As previously mentioned, the estimator of climate change concerns is the MCCC index constructed by Ardia et al. (2023). Even though the concerns related to climate change can be detected globally, there is still a possibility that an index constructed for the USA does not simulate the concern levels accurately in other regions. It is possible that the actual concern levels may increase in each region more independently. Therefore, it is possible that the results provided in this thesis are just indicative and the relationship would need further evaluation.

Other limitations regarding the analysis are linked to the sample. The European region has some difficulties with the control variables and the variability inside the region. It is difficult to retrieve accurate results for Europe, as the control variables were estimated mostly to the Economic and Monetary Union (EMU) of the European Union. Whereas the chosen stock index illustrates the whole European stock market. This could cause inaccuracy in the results. Also, the Europe region contains countries that view sustainability very differently. One limitation is also linked to the chosen sample but regarding the chosen period. The whole sample period is located in the years 2010-2024, which includes the COVID-19 crisis period. The spread of COVID-19 caused a massive fall in the stock market in 2020. The occurrence of this unexpected crisis caused uncertainty to spread across stock markets, which could impact the estimation results.

Based on this thesis and its limitations, there are many suggestions for future research. In general, most of the existing literature regarding climate risk pricing or the effects of climate change on stock returns is based on the US financial markets. Therefore, future research could be more focused on the Nordics. As the Nordics are considered to be sustainability leaders, researching those markets could provide new information on the role of climate risk. Whether the sustainability efforts of an entire country are transferred to the stock market. There could be further evaluation of whether Nordics

are actually the sustainability frontier and therefore less sensitive to climate risk. In addition, in future research, the creation of regional climate change concern indices would be useful. It would help to conclude how stock returns are affected by the changes in regional climate change concerns. In different countries, there are national political debates that can affect the sentiment towards climate change on the stock market. Because of these political changes in regions, it is possible that the climate change concern levels are not identical across regions. When there is more information about the regional differences, it provides investors the knowledge of whether climate risk can be partially reduced with geographical diversification.

The effect of climate change on the stock market has been often connected to the attention of investors. However, the attention of investors is limited. Therefore, not all information available about climate change concerns is registered accurately. Also, it is possible that if more immediate information is reported, those might sideline the climate change concerns. For example, the occurrence of COVID-19 caused uncertainty across the financial market. During that time the attention capacity was mainly filled with concerns and news related to COVID-19. Therefore, in future research, it would be interesting to pay more attention to how the relationship between climate change concerns and stock returns changes during crisis periods.

## 7 Conclusion

The importance of climate change has caused a flood of research in the field of climate finance. There is a constant effort in trying to understand how climate risks are incorporated into stock prices and how those affect the realized stock returns. The pricing of climate risks seems to depend on the nature of the risks, as transition risks are more effectively priced on the stock market (Faccini et al., 2023). Also, the investor attention level impacts how immediate the climate risk is perceived and whether the investment decisions are adjusted to it. In general, there has been a lot of evidence that climate change has an impact on stock returns and creates performance differences among different types of stocks (Ardia et al., 2023; Pástor et al., 2021). In this thesis, the aim was to further expand the knowledge of climate risk by performing an analysis of the relationship between climate change concerns and stock returns in different regions.

Most of the existing literature is based on the research conducted on the US stock market, and therefore the analysis of different regions was the main goal. The results regarding the effect of the aggregate climate change concerns on the stock markets were mostly consistent with the existing literature (Ardia et al., 2023; El Ouadghiri et al., 2021). In all the regions, except Denmark, the increase in climate change concerns has a negative impact on stock returns. The negative impact of climate change concerns is strongest in the US and Finland with both having the same negative magnitude. When investors are reminded of the risks related to climate change, they adjust their investment decisions accordingly and this affects negatively the performance of conventional stocks (Ardia et al., 2023; Pástor et al., 2021). In Denmark and Norway, the impact of climate change concerns was the least significant.

In the examination of how different types of climate change concerns affect the stock returns, the results altered more based on the region. In the US, Finland, and Sweden the effects of transition risk related climate change concerns were the most significant. This is consistent with the investors perceiving transition risks to be the most important climate risk (Stroebel & Wurgler, 2021). The greatest magnitude in these regions was

with concerns related to the Business Impact theme which is consistent with the results reported by Ardia et al. (2023). However, contradicting the existing literature, the importance of physical risks can be detected in all other regions except the US. In Europe, Denmark, and Norway the climate change concern related to Environmental Impact has the most significant negative impact on the stock returns. Lastly, the climate change concerns related to Social Debate and Research resulted in alternating effects depending on the region. This is most likely caused by the fact, that Social Debate and Research concerns are more localized to the US and might not be as imminent in other regions.

The examination of the relationship between climate change concerns and stock returns before and after the Paris Agreement generated interesting results. For the US region, the results were consistent with the existing literature. The negative effect of climate change concerns had nearly doubled when comparing the period before and after the Paris Agreement. Therefore, supporting the theory that attention toward climate change has increased during the recent years which further strengthens the relationship between climate risk and stock returns (Bolton & Kacperczyk, 2021; El Ouadghiri et al., 2021). However, in almost all other regions the effect has been the exact opposite. In Europe, Sweden, Denmark, and Norway the effect of climate change concerns has shifted from negative to positive. Indicating that if climate change concern level increases, the stock returns in these regions are positively impacted. This is contrary to what was expected. However, this raises the question of whether it is possible that the level of sustainability in these regions causes the stock return to be impacted positively by the climate change concerns. This would be consistent with the literature suggesting that more sustainable stock indices react positively as climate change related concerns are brought to attention (El Ouadghiri et al., 2021). However, further research would be required to make this conclusion.

The results of this thesis provided new insight into how climate change concerns affect stock returns in different regions. As previously stated, climate change is an important aspect for investors to include in the asset selection process because of the risk it creates

on the stock market. Evidence of this is found in different regions, indicating that the concerns related to climate change distinctively affect the stock returns. These results of regional differences could provide useful information for investors on the risk management of investments. Based on the fact, that climate change concerns have smaller effects in some regions, it can be possible to partially alleviate the risk with geographic diversification. This assumption would be an interesting base on future research. A more extensive examination of regional differences in how climate change concerns are perceived should be carried out.

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