THE INTERPLAY OF SUSTAINABILITY AND CAPITAL MARKETS

Dissertation

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Summary

Humanity faces significant environmental and social challenges, e.g., climate change (UN, 2019). Those challenges are, to some extent, addressed by politics. For instance, the European Union (EU) tries to address environmental topics, such as climate change, with the *EU Action Plan on Financing Sustainable Growth* to steer capital flows into more sustainable business models (EU, 2018). This regulatory development, in conjunction with a surging demand for sustainable investment solutions leads to a pressing need for research in sustainable finance. Therefore, this doctoral thesis investigates some of the most important research gaps in this field.

The first study illuminates the factors that determine the extent of sustainable investing and preferred sustainability strategies in countries across Europe. This study reveals how a country's economic wealth, pension market and cultural disposition affect the size and characteristics of SRI markets. For example, masculinity, estimated by the revenue orientation of a country, prevents the emergence of more advanced SRI strategies.

The second study focuses on one such advanced SRI strategy by investigating the importance of integrating a company's environmental sustainability into the valuation of its credit risk premium. The findings demonstrate that more environmentally sustainable companies have lower credit risk premiums and that this effect is more (less) pronounced for companies with a high (low) credit worthiness.

The third study builds on the above-outlined findings by analyzing the relation between a company's carbon and credit risk. This work extends the previous study by differentiating between the management of and exposure to carbon risk. Furthermore, the moderating role of the regulatory environment on the impact of carbon risk on credit risk is analyzed. The results reveal that both carbon risk exposure and management significantly affect credit risk. Furthermore, the regulatory environment has a moderating effect on these relations.

The fourth study extends the work of the previous two studies by investigating the impact of sustainability on credit risk not at the company level but at the portfolio level. The findings show that more sustainable portfolios have a significantly lower credit risk exposure. Therefore, performance differences between sustainable and non-sustainable portfolios can be solely attributed to their different exposures to credit risk.

Zusammenfassung

Die Menschheit steht vor großen ökologischen und sozialen Herausforderungen, wie z. B. dem Klimawandel (UN, 2019). Diese Herausforderungen werden teilweise von der Politik adressiert. Beispielsweise versucht die Europäische Union (EU) mit dem *EU-Aktionsplan zur Finanzierung nachhaltigen Wachstums* Kapitalströme in nachhaltigere Geschäftsmodelle zu lenken (EU, 2018). Diese regulatorische Entwicklung in Verbindung mit einer steigenden Nachfrage nach nachhaltigen Investitionslösungen führt zu einem dringenden Forschungsbedarf im Bereich der nachhaltigen Geldanlage. Daher werden in dieser Doktorarbeit einige der wichtigsten Forschungslücken in diesem Bereich untersucht.

In der ersten Studie werden Einflussfaktoren auf die Marktentwicklung von nachhaltigen Anlagen in Europa bestimmt. Die Studie zeigt, wie der wirtschaftliche Wohlstand, das Rentensystem und die kulturelle Veranlagung eines Landes das Volumen in nachhaltig verwalteten Anlagen beeinflusst. Beispielsweise verhindert die Einkommensorientierung eines Landes das Aufkommen fortschrittlicherer Strategien zur nachhaltigen Geldanlage.

Die zweite Studie konzentriert sich auf eine solche fortschrittliche Strategie zur nachhaltigen Geldanlage, indem sie die Wirkung der ökologischen Nachhaltigkeit eines Unternehmens auf seine Kreditrisikoprämie untersucht. Die Ergebnisse zeigen, dass ökologisch nachhaltigere Unternehmen niedrigere Kreditrisikoprämien haben und dass dieser Effekt bei Unternehmen mit hoher (niedriger) Kreditwürdigkeit stärker (weniger) ausgeprägt ist.

Die dritte Studie untersucht die Beziehung zwischen dem Klima- und Kreditrisiko eines Unternehmens. Diese Arbeit erweitert die vorangegangene Studie, indem sie zwischen dem Management von und der Belastung durch Klimarisiken differenziert. Darüber hinaus wird die moderierende Rolle des regulatorischen Umfelds auf die Auswirkungen des Klimarisikos auf das Kreditrisiko analysiert. Die Ergebnisse zeigen, dass sowohl die Belastung durch das Klimarisiko als auch dessen Management das Kreditrisiko erheblich beeinflussen. Darüber hinaus hat das regulatorische Umfeld eine moderierende Wirkung auf diese Beziehungen.

Die vierte Studie analysiert die Auswirkungen der Nachhaltigkeit auf das systematische Kreditrisiko auf Portfolioebene. Die Ergebnisse zeigen, dass nachhaltigere Portfolios ein deutlich geringeres systematisches Kreditrisiko aufweisen. Die Differenzen in der Wertentwicklung zwischen nachhaltigen und nicht-nachhaltigen Portfolios lassen sich daher ausschließlich auf Unterschiede im Kreditrisiko zurückführen.

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List of Publications Included in the Dissertation

	VHB Jourqual 3.0
Papers in Peer Reviewed Academic Journals	
Rochell, J. Cauthorn, T., Höck, A., & Zwergel, B. (2020): *Drivers of Socially Responsible Investments Across Europe*, Credit and Capital Markets - Kredit und Kapitalmarkt, 53(4), p. 493-512. https://doi.org/10.3790/ccm.53.4.493	**C**
Höck, A., Klein C., Landau, A., & Zwergel B. (2020): *The effect of environmental sustainability on credit risk*, Journal of Asset Management, 21, p. 85-93. https://doi.org/10.1057/s41260-020-00155-4	**B**
Dumrose, M., & Höck, A. (2023): *Corporate Carbon Risk and Credit Risk: The Impact of Carbon Risk Exposure and Management on Credit Spreads in Different Regulatory Environments*, Finance Research Letters, 51, Article 103414. https://doi.org/10.1016/j.frl.2022.103414	**B**
Reviewed and Submitted Papers	
The Effect of Sustainability on the Credit Risk Exposure of Corporate Bond Portfolios, submitted to Journal of Fixed Income (rejected) and Financial Research Letters (rejected after review). Conference presentation at the Annual Event of Finance Research Letters in 2021.	**B**

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I. Introduction

Humanity faces significant environmental and social challenges, ranging from changing demographics to climate change and biodiversity loss (UN, 2019). Those challenges are, to some extent, addressed by politics. For instance, the United Nations (UN) developed the *Sustainable Development Goals* (SDGs) in 2015 as a call to action to tackle the most important environmental and social challenges (UN, 2021). Similarly, the European Union (EU) and the respective regulatory bodies address with their policies environmental topics, such as climate change (EU, 2018). Furthermore, most politicians agree on the crucial role the financial sector should have in financing the transition to a more sustainable economy (ILO, 2022). Thus, policies, such as the *EU Action Plan on Financing Sustainable Growth*, aspire to steer capital flows into sustainable investments and, therefore, into more sustainable business models (EU, 2018).

This regulatory development, in conjunction with a surging demand for sustainable investment solutions leads to a pressing need for research in sustainable finance. Even though an extensive body of research has emerged in the field of sustainable finance (e.g., Grewatsch and Kleindienst, 2017; Busch and Friede, 2018; Brooks and Oikonomou, 2018), some research gaps must be addressed. Therefore, this doctoral thesis focuses on *The Interplay of Sustainability and Capital Markets*, investigating some of the most important research gaps: first, the influence of cultural and economic factors on the market for sustainable investing, and second, the impact of sustainability on the valuation and risk exposure of fixed-income instruments.

Those topics are discussed in four separate studies, which are briefly summarized in the following dissertation overview.

The first study illuminates the factors that determine the extent of sustainable investing and preferred sustainability strategies in countries across Europe. Policymakers must know which factors account for differences in socially responsible investments (SRI) between countries to create an efficient framework that supports SRI across Europe. By providing quantitative evidence for the framework established by Scholtens and Sievänen (2013), this study reveals how a country’s economic wealth, pension market and cultural disposition affect the size and characteristics of SRI markets. For example, masculinity, estimated by the revenue orientation of a country, prevents the emergence of more advanced SRI strategies. Based on these findings, policymakers should promote more advanced SRI strategies, such as engagement or integration, to ensure consistent development across European countries.

The second study focuses on one such advanced SRI strategy by investigating the importance of integrating a company’s environmental sustainability into the valuation of its credit risk premium. The findings demonstrate that more environmentally sustainable companies have lower credit risk premiums and that this effect is more (less) pronounced for companies with a high (low) credit worthiness. These results are especially important for investment professionals, who must estimate a company's fair credit risk premium as accurately as possible, and corporate leaders, who should consider the impact of their company’s environmental sustainability on its refinancing costs.

The third study builds on the above-outlined findings and analyzes the importance of environmental sustainability for pricing credit risk in more detail. In contrast to the previous study, the relation between a company’s carbon and credit risk is investigated. In addition to concentrating on a specific aspect of environmental sustainability, this work extends the previous study by differentiating between the management of and exposure to carbon risk. Furthermore, the moderating role of the regulatory environment on the impact of carbon risk on credit risk is analyzed. The results reveal that both carbon risk exposure and carbon risk management significantly affect credit risk. Furthermore, the regulatory environment has a moderating effect on these relations. These results are relevant for investors to improve the valuation of the fair credit risk premium, companies to make better strategic management and investment decisions, and policymakers to implement a framework for a transition to a carbon-free economy more efficiently.

The fourth study examines the impact of sustainability on credit risk at the portfolio level by analyzing the return time series of a sustainable and a non-sustainable corporate bond portfolio. Thus, this study extends the work of the previous two studies by investigating the impact of sustainability on credit risk not at the company level but at the portfolio level. The findings show that more sustainable portfolios have a significantly lower credit risk exposure. Therefore, performance differences between sustainable and non-sustainable portfolios can be solely attributed to their different exposures to credit risk. These findings are especially relevant for investment professionals to better understand the effect of integrating sustainability strategies into their fixed-income investment processes.

In sum, this doctoral thesis contributes to the current academic discussion by giving detailed insights into the key drivers of sustainable investments across European countries and the effects of sustainability on the valuation and risk exposure of fixed-income instruments. The insights of both topics are significant for praxis and aiding policymakers, investors and companies in making sound decisions in their field of expertise.

II. Drivers of Socially Responsible Investments Across Europe

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Abstract: The European Union wants to foster the sustainable growth of the economy by using the financial markets as an intermediary. Thus, politicians need to know which factors account for differences in socially responsible investments (SRI) between countries to create an efficient framework, which supports SRI across Europe. This study aims to provide important insights about the drivers of SRI markets for politicians as well as academics. To the best of our knowledge, this is the first study that provides quantitative evidence on the framework established by Scholtens and Sievänen (2013) using a comparatively large data sample comprising 13 European countries during a period from 2005 to 2015. Our results can be summarized as follows: Firstly, we show that economic wealth and the size of the pension market of a country influence the size of the SRI market per capita. In particular, it seems that countries need a certain level of wealth and pension market size to start adopting basic sustainability strategies like negative screening. Secondly, we provide evidence that the differences in national SRI evolvement stem from the individual cultural characteristics of a nation. For example, masculinity, as seen by the revenue orientation of a country, prevents the emergence of more advanced SRI strategies, like engagement or integration. However, femininity, which relates to a more societal and environmental orientation, drives the emergence of more advanced SRI strategies. In this context, the recommendation to European policymakers is to opt for a minimum standard for the integration of more advanced SRI strategies, so that non-feminine countries also implement a deep-rooted sustainable investment behavior.

Keywords: Socially Responsible Investment, Economic Growth, Financial Markets, Institutional Systems, Culture

1. Introduction

The European Union recently declared the goal to foster the sustainable development of the European economy using the financial markets as an intermediary. Accordingly, knowledge about which factors influence SRI have become increasingly important for politicians. Therefore, we investigate the driving forces behind SRI and analyze why countries across Europe have different levels of SRI adoption.

Despite the surge in academic literature regarding SRI, there is a lack of empirical evidence on the general drivers for the SRI market. The only other study, which we know of in this field of research, was conducted by Scholtens and Sievänen (2013). They developed the foundation for an international theory of SRI that is based on the impact of economic, financial, cultural and institutional influence. However, their study faced limitations due to a lack of available data, which is why there is a need for further research. This study tries to overcome these shortcomings by analyzing the effect of economic, financial and cultural factors on the SRI market using a relatively large dataset covering 13 European countries from 2005 to 2015. Hence, this is the first empirical study which provides evidence on the theory from Scholtens and Sievänen (2013) regarding the driving forces of SRI markets in different countries.

Our results show that economic, financial and cultural factors account for differences in the SRI market between countries. In more detail, the results suggest that wealthier countries with bigger financial systems are more likely to adopt basic SRI strategies, namely negative screens. Hence, it seems that countries have to exceed a certain threshold in terms of wealth and financial market size to start adopting basic SRI strategies. Additionally, a strong focus on profitability measured by masculinity is found to be detrimental to the evolution of more advanced SRI strategies, meaning that revenue-oriented nations do not perceive those strategies to be value adding. We conclude that institutional policies regarding the incorporation of more advanced SRI strategies are a powerful tool to overcome those cultural imprints. Furthermore, these policies foster a culture of sustainable development (Busch et al. 2015) by anchoring sustainable investment practices in European countries.

The remainder of this paper has the following structure. The next section provides a detailed overview of the current academic literature, which provides the basis for the formulation of our research questions. Section 3 explains the data and methodology used in the empirical analysis followed by a section that outlines the limitations of this study. Section 5 describes the main findings of our analysis. Finally, the paper concludes with a short summary of the results and a discussion on the implications for European policymakers as well as an outlook on further research needs.

2. Literature Review and Hypothesis Development

A large stream of academic literature focuses on the impact of the adoption of environmental, social and governance (ESG) criteria on risk and return characteristics of investments (e.g., Renneboog et al. 2008; Duuren et al. 2015; Lean et al. 2015; Friede et al. 2015; Wallis and Klein 2015; Leite and Cortez 2016; Höck et al. 2020). Nevertheless, there is a lack of research on the drivers of the SRI market on a country level. Even though a few studies were conducted on the personal or institutional motives of sustainable investors (e.g. Nilsson 2008; Scholtens 2006; Jansson and Biel 2011; Wins and Zwergel 2015), there is only one study which aims to develop a framework to describe the factors that influence the development of SRI markets in countries. This study, by Scholtens and Sievänen (2013), identified the economic and financial development as well as the culture of a country to be crucial for SRI. Their model is displayed in Figure II.1.

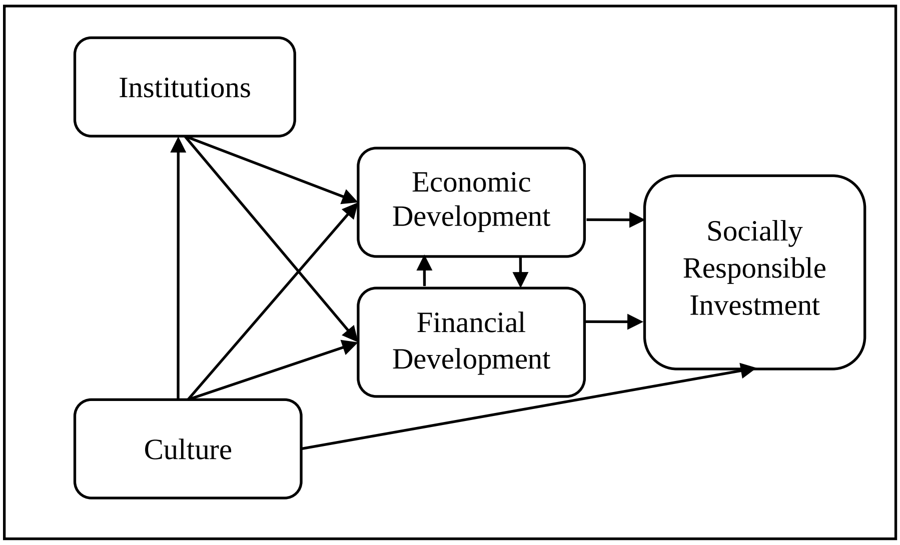

Figure II.1: Model of the Relationship between Economic, Finance, Culture, Institutions and SRI (Scholtens and Sievänen, 2013)

These researchers base their model on a case study from Denmark, Finland, Norway and Sweden and analyze the differences in size and composition of the SRI market in each of those countries using EUROSIF[1] data. The size and composition of the respective SRI markets is measured as the sustainable investments of a country in absolute terms, per capita and as a percentage of GDP. In addition, they investigate differences between broad and core SRI strategies and compare the growth of the SRI market.[2] Their findings suggest that the economic openness, size of the financial industry and cultural factors can explain differences in both the size and composition of SRI between those countries. In contrast, they could not find evidence of a relationship between institutions and SRI. Even though their study provides important insights and the basis for this field of research, it is limited due to the data quality[3] and the small sample size in terms of countries and duration. Additionally, the four Nordic countries are very homogenous regarding their economic and financial development as well as their institutional framework and cultural background, which makes it difficult to transfer Scholtens and Sievänen’s findings to other countries. This study tries to overcome these limitations and provides empirical evidence for their theory using a panel dataset. Hence, we focus on the factors suggested to have a direct impact on SRI. Based upon the findings of Scholtens and Sievänen (2013) our hypotheses are as follows:

H1: Economic and financial development accounts for differences in the size of the SRI market across countries

When determining the factors that account for differences in the size of the SRI market across countries, we first aim to demonstrate the influence of economic wealth and the size

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[1] EUROSIF (European Sustainable Investment Forum) is the European umbrella association for sustainability on financial markets.

[2] According to EUROSIF, core SRI strategies comprise at least three exclusion criteria and positive screening, whereas broad SRI strategies are composed of at most two exclusion criteria, engagement, and integration. EUROSIF stopped distinguishing between broad and core strategies in 2012. Therefore, this study focusses on single strategies, which are classified as negative screening, positive screening, engagement and voting as well as integration.

[3] The EUROSIF data is self-reported and compiled using different sources which do not necessarily use the same definition as the SRI strategies. However, EUROSIF is the best available source for SRI data on a country level. For further remarks see Scholtens (2014).

of the pension market which are both assumed to positively impact the size of the SRI market across countries.

H1a: Economic development proxied by gross domestic product (GDP) per capita has a positive impact on the size of the SRI market.

Scholtens and Sievänen (2013) claim that economic openness and wealth represent crucial factors when it comes to explaining differences in the size of SRI markets across countries. This is supported by the study conducted by Gjølberg (2009), which provides evidence of a strong influence of macroeconomic variables on CSR. We claim that economic wealth measured by GDP per capita is a relevant driver for the size of the SRI market. For instance, since low economic output places pressure on a society's level of wealth, it leaves little incentive for additional investment, especially for SRI. Consequently, economic wealth is hypothesized to be a prerequisite for SRI. Hence, we claim that GDP per capita is relevant when it comes to the emergence of SRI.

H1b: The size of the pension market per capita (Pens), an indicator of financial development, has a positive impact on the size of the SRI market.

The literature provides various arguments about the impact of the financial system on sustainability. For example, Scholtens (2006) argues that financial markets can force companies to adopt CSR policies and act as a vehicle to accelerate sustainable economic development. Sievänen et al. (2013) find, that the legal origin, the ownership of the pension fund and size related variables drive SRI. This supports the view that the size and structure of the pension industry as a part of financial market composition matters for the adoption of SRI. Giamporcaro and Gond (2016) also identify the market structure as influential on SRI via the selected pension system and the pension reform policy. Earlier, Sandberg (2010) states that some social and environmental considerations are not in opposition to the fiduciary duty of the management of pension funds. This view is also shared by Friede et al. (2015) who conclude that the orientation towards long-term responsible investing should be important for all kinds of rational investors in order to fulfill their fiduciary duties. We follow this argumentation and hypothesize that the size of the pension market is positively correlated with the size of the SRI market, because SRI supports the fulfillment of the fiduciary duty due to the long-term orientation of the investments of pension funds.[4]

H2: Cultural factors account for national differences in the emergence of SRI

On the national level, culture can be defined as "the collective programming of the mind which distinguishes the members of one human group from another" (Hofstede 1984). Dutta and Mukherjee (2012) view culture as an informal institution identified by norms, conventions, grassroots, institutions, and trust. With regards to SRI, Dumas and Louche (2016) argue that responsible investment emerges once the group members form joint preferences, referred to as collective beliefs. Sandberg (2008) and Sandberg et al. (2009) investigate the cultural and ideological differences in the SRI market while the common denominator of intrinsic social preferences in a country is assumed to influence the SRI level (Riedl and Smeets 2015). Following Scholtens and Sievänen (2013), Uncertainty Avoidance (UAI) and masculinity (MAS) are hypothesized to specifically relate to SRI. The following two hypotheses are based on those two cultural factors:

H2a: The level of Uncertainty Avoidance (UAI) positively impacts the size of the SRI market.

UAI measures the extent to which a society feels threatened by uncertain and ambiguous situations, by consequently trying to avoid these situations through the establishment of additional formal rules (Hofstede 1980). A vast stream of literature, including Kwok and Tadesse (2006) and Lavezzolo et al. (2018) propose that the level of UAI plays an influential role in the financial market architecture, linking a high level of UAI to the preference for a bank-based system as opposed to a market-based system and explain their findings with national risk preferences. For pension funds, Jansson et al. (2014) conclude that investors' beliefs about the financial risk and returns drive SRI. However, the authors emphasize that both financial and value-based motives are important and there is no indication that the financial motives dominate. Scholtens and Sievänen (2013) find that for the Nordic countries a high UAI leads to a preference for SRI strategies based on positive and negative

[4] The size of the pension market highly depends on the pension system of a country. A pay-as-you-go (PAYG) pension system, as found in Germany, Austria, Italy and Spain, is financed intra-generationally with contributions from the working population going to the retired population. The PAYG system bypasses the financial market, whereas in prefunded pension systems, e.g., the system in the Netherlands, Norway, Denmark or Sweden, pensions are managed through long-term oriented asset vehicles.

screenings and Duuren et al. (2015) find that ESG information is used to red flag and manage risk. We follow Scholtens and Sievänen (2013) and Duuren et al. (2015) and hypothesize that a high level of UAI positively affects the national size of the SRI market, because the impact of SRI strategies on the risk characteristics of investments is perceived to be positive.

H2b: The masculinity of a country negatively impacts the size of the SRI market.

The dimension "masculinity versus femininity" (MAS) measures to which extent the dominant values of a society are "masculine" meaning that a culture values achievement, assertiveness, money and material success over social relationships, interpersonal harmony and environmental concerns which are considered to be "feminine" characteristics (Hofstede 1980). Scholtens and Sievänen (2013) as well as Bauer and Smeets (2015) find a strong positive relation between the femininity of the society and the SRI level, indicating that SRI goes along with a feminine cultural focus. In line with previous literature, Riedl and Smeets (2015) find that masculine societies are rather revenue oriented and therefore focus on the financial performance of their investments. Thus, we hypothesize that a high level of MAS has a negative impact on the size of the national SRI market since a masculine society shares the collective belief that SRI lowers the expected return.

Summarizing the predicted cultural influence on SRI, we expect a negative impact on SRI when country levels for MAS are high and a positive impact on SRI, when country levels for UAI are high. The remaining cultural factors, power distance (PDI) and individualism (IDV) defined by Hofstede (1980), are employed as control variables.

3. Data and Methodology

The original study by Scholtens and Sievänen (2013) relies on a case study of four Nordic countries. Their study faced two sorts of data limitations. First, the depth of data was limited to a short period and it only covered four countries. Second, the quality of the data suffered due to both a lack of transparency and clearly defined categories of sustainable investing (Scholtens and Sievänen 2013; Scholtens 2014). We extend the data set from Scholtens and Sievänen (2013) in terms of duration and number of countries. This study covers 13

European countries[5] from 2005 to 2015 using biennial data in order to establish an empirical research design which extends the case study of Scholtens and Sievänen (2013). Additionally, we use four SRI strategies[6] as dependent variables: Negative Screens (Excl), Positive Screens (Pos), Engagement and Voting (EV) and Integration (Int). The SRI strategies are denoted in euros per capita and are derived from the EUROSIF reports[7]. The usage of the same data source as Scholtens and Sievänen (2013) is seen as the main limitation of this study. Section 4 elaborates on the limitations of this study in more detail.

The explanatory variables, comprising economic, financial and cultural factors, are defined below. First, the economic development factor is measured by annual Gross Domestic Product (GDP) taken from Eurostat. Second, the financial development factor is assessed by the book value of pension funds at year's end (Pens), based on "Private Pension Assets" and "Assets Life Insurance" data from the OECD database. The economic and financial development factors are scaled by the country population at the end of the year provided by Eurostat. Additionally, data are winsorized per country and year at the 10% level in order to control for the influence of outliers. Third, the cultural factors are derived from the homepage of Hofstede[8]. They range from 0 to 100 with a high score indicating a strong presence of the respective cultural factor in a society. It must be noted that the cultural factors are time-invariant and thus can only explain differences in the cross-section. The SRI evolvement over time is considered to be partly captured by the development factors GDP and Pens. With this in mind, we do not address additional considerations on the time dimension as the obtained SRI strategy sample sizes are comparatively small, which is why the incorporation of time effects is not appropriate.

The following table summarizes the correlation between the different dependent and independent variables that are proposed to have direct relationships:

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[5] An overview of the descriptive data for the whole sample can be found in Table A.1 and on a country-level in Table A.2 in the Appendix.

[6] Definitions of the SRI strategies are outlined in the Appendix.

[7] The EUROSIF reports do not account for any double counting. Thus, the assets of one fund that applies more than one SRI strategy is counted in every relevant category. Accordingly, it would be an overestimation to add the sum of the strategies and to use this sum as a variable to proxy the total level of the SRI market.

[8] www.geerthofstede.com.

Table II.1: Pearson Correlation Coefficient for the Employed Variables

	Negative Screens	Positive Screens	Engagement and Voting	Integration
Negative Screens (Excl)	1			
Positive Screens (Pos)	0.57 ***	1		
Engagement and Voting (EV)	0.55 ***	0.81 ***	1	
Integration (Int)	0.29 **	0.54 ***	0.74 ***	1
Gross Domestic Product (GDP)	0.77 ***	0.47 ***	0.42 ***	0.12
Pensions (Pens)	0.60 ***	0.57 ***	0.64 ***	0.36 **
Uncertainty Avoidance (UAI)	-0.32 **	-0.57 ***	-0.66 ***	-0.29 **
Masculinity (MAS)	-0.31 **	-0.72 ***	-0.63 ***	-0.38 ***
Individualism (IDV)	0.10	0.22 *	0.43 ***	0.44 ***
Power Distance (PDI)	-0.25 *	-0.27 **	-0.34 ***	0.04

Notes: This table presents the Pearson correlation between the dependent (SRI strategies) and independent variables (economic, financial and culture factors) used in the regression. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

All SRI strategies are significantly positively correlated with one another. The highest correlation among the SRI strategies can be found between the strategies Pos and EV (0.81***), Int and EV (0.74***) and Pos and Excl (0.57***) indicating that investors with a preference for positive screens are likely to add engagement and voting to their strategy and that investors using an engagement and voting strategy are likely to incorporate an integration strategy as well. Additionally, negative screens are positively correlated to the second screening strategy, positive screens, meaning that these strategies are often applied together.[9]

[9] Additionally, Table A.2 in the Appendix shows that the level of negative screens is high in almost every country, whereas only countries with well-developed SRI markets have high values for the other, more complex SRI strategies. A reason could be that negative screens are included as a basic strategy to classify investments as socially responsible due to their low integration costs.

The economic and financial factors show significant positive correlations with almost all SRI strategies. Hence, these results support the respective hypotheses that the wealthier countries with bigger pension markets have a higher level of SRI. The only SRI strategy which is not affected by GDP is Integration. Thus, the integration of ESG data in the investment process would, in our model, only depend on the pension system of a nation. A reason for the lack of importance of wealth (GDP) could be that this strategy is not perceived to lower the expected return, because it can be used to enhance the risk valuation. Furthermore, MAS shows the expected direction and thus supports H2b while the direction of UAI stands in opposition to our hypothesis and the results of Scholtens and Sievänen (2013).

In the remainder of this study, the estimated direct effects are derived from a random effects (RE) regression due to the time-invariance of the cultural factors. Additionally, we report Arellano-clustered robust standard errors (in parentheses) due to autocorrelation and heteroscedasticity. An observation enters the regression if full model data in terms of the explanatory variables is given, following the "complete observations" approach. Two kinds of robustness checks are conducted. First, we regress the development and culture variables separately on the SRI strategies. Second, we add the Gini coefficient as an additional control variable. The results of these regressions are in line with the outcomes in section 5 and can be found in Tables A.4 to A.6 in the Appendix.

4. Limitations of the Study

First, we note that the usage of the EUROSIF dataset does not overcome the limitations in terms of data quality as outlined by Scholtens and Sievänen (2013). However, retrospectively no better data can be obtained. For lack of a better alternative, EUROSIF is still the best available data source and with regards to future research, we hope that historical data limitations will be overcome with the broadening and harmonization of the EUROSIF database.

Second, the conceptual model depicted in Figure II.1 suggests that culture also has an indirect impact on SRI through a country's economic and financial development. However, we analyze the direct effects of economic and financial development and cultural factors on SRI in order to obtain initial confirmation of the theoretical connections. Our regression is, due to the size of the data set, limited in the number of regressors and sharply restricts the simultaneous inclusion of direct and indirect effects. Nevertheless, the correlations between the development factors and cultural factors indicate the existence of indirect connections. UAI, MAS and PDI have significant negative correlations with GDP and Pens, while IDV has a positive significant correlation with Pens. Therefore, we encourage further research that addresses the indirect connections that contribute to an international theory of SRI. An overview of the correlations can be found in Table A.3 in the Appendix. In addition to the indirect effects, the time component is also neglected in the present study design and should likewise be addressed in further research.

Third, we omit the analysis and identification of institutions that drive the emergence of SRI. Literature including Sandberg et al. (2008), Tabellini (2008) as well as Jackson and Apostolakou (2009) provide insights on possible relationships between institutions and SRI or CSR. Renneboog et al. (2008) state that governments in Western countries have taken many regulatory initiatives to stimulate SRI. Steurer et al. (2008) even conduct a survey on governmental SRI initiatives in Europe. However, there is no source available that measures the initiatives numerically and the country initiatives are highly diverse, including but not limited to legal, economic or fiscal instruments. We encourage the algebraic assessment of institutional impact on the emergence of SRI to overcome this shortage.

Due to the many effects and influencing factors that we cannot consider in this study, our research should only be understood as an initial contribution to an international theory of SRI and not as a final result.

5. Empirical Results

In general terms, the results presented below empirically support the hypotheses that economic and financial development as well as cultural factors influence the size and the composition of the SRI market across the 13 European countries in our dataset.

Table II.2: Regression Results

$$\text{Strategy}_i = \beta_0 + \beta_1\text{Economic Development}_i + \beta_2\text{Financial Development}_i + \beta_3\text{Uncertainty Avoidance}_i + \beta_4\text{Masculinity}_i + \beta_5\text{Individualism}_i + \beta_6\text{Power Distance}_i + \varepsilon_i$$

	Negative Screens	**Positive Screens**	**Engagement and Voting**	**Integration**
GDP	1.933***	0.200	0.131	0.017
	(0.254)	(0.170)	(0.207)	(0.099)
Pens	0.247**	0.100	0.166**	0.093
	(0.108)	(0.063)	(0.072)	(0.068)
UAI	55.759	231.042**	242.212	172.804
	(383.529)	(114.606)	(227.174)	(200.184)
MAS	-44.408	-433.271***	-281.509**	-162.104*
	(152.259)	(96.518)	(143.075)	(83.405)
IDV	-137.183	349.574*	577.313**	489.443**
	(398.510)	(205.696)	(288.083)	(191.812)
PDI	391.766	-244.828	-264.996	12.403
	(363.922)	(178.558)	(258.197)	(220.764)
Constant	-65,978.320**	-9,058.886	-33,198.010*	-33,451.310**
	(31,182.170)	(10,632.150)	(18,923.660)	(14,896.570)
FE Country	Yes	Yes	Yes	Yes
FE Year	No	No	No	No
Observations	52	56	53	49
Adj. R^2	0.646	0.527	0.46	0.118
SE of regression	16,440.502	7,145.94	6,493.496	6,921.864
F Statistic	16.479***	11.218***	8.374***	2.064*

Notes: This table presents the estimation results from the random effects model on the SRI strategies (Negative Screens, Positive Screens, Engagement and Voting and Integration) on the economic and financial development and culture variables. Arellano-clustered standard errors (in parentheses) are applied to account for heteroscedasticity and autocorrelation. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

The results of our regression analysis are discussed in more detail in the context of the respective hypothesis.

H1: Macroeconomic drivers account for the evolvement of SRI

The first hypothesis, “Economic development proxied by gross domestic product (GDP) per capita has a positive impact on the size of the SRI market”, is confirmed for the negative screening strategy, which could be used as an estimate for the overall SRI market. Hence, a certain level of wealth could be seen as a prerequisite for the evolution of SRI. Furthermore, the positive impact of GDP is present for the other SRI strategies as well, though it is not significant. A similar pattern can be detected for the second hypothesis: “The size of the pension market per capita (Pens), an indicator of financial development, has a positive impact on the size of the SRI market”. The size of the pension market seems to be an important factor in explaining the level of SRI for the negative screening strategy as well as for the engagement and voting strategy, whereas it is not significant for the two other SRI strategies. Our results support earlier findings from Scholtens and Sievänen (2013) who point out that the size of the pension industry matters. The fact that the pension market is significant in engagement and voting strategies could be explained by the fiduciary duty of the pension funds, which use this SRI strategy to ensure the sustainable growth of the companies in which they are invested.

In summary, GDP and Pens have a significant positive impact on the adoption of negative screens. This finding could also be relevant for the dissemination of more enhanced SRI strategies if negative screens are assumed to be the basic strategy to enter the SRI market. However, we can only partially confirm the first two hypotheses due to the fact that just 3 of 8 coefficients are significant.

H2: Cultural factors account for national differences in the emergence of SRI

The UAI of a society has a partly significant impact and the direction is as expected. The risk mitigating impact of implementing an SRI strategy is perceived to be positive which would drive the level of SRI in societies with high UAI. Hypothesis H2a, “The level of Uncertainty Avoidance (UAI) positively impacts the size of the SRI market”, is therefore confirmed with respect to positive screens as the dependent variable. We assume that SRI strategies are perceived as an instrument to measure risk more precisely, which could be why societies with high UAI favor SRI. Hypothesis H2b, “The masculinity of a country negatively impacts the size of the SRI market", is widely supported by our results: For all strategies, MAS shows the expected direction and is significant for the strategies Positive Screens, Engagement and Voting and Integration. We therefore confirm the negative impact of the masculinity of a nation on the size of its SRI market. For example, very masculine countries like Austria, Switzerland and Italy tend to have a smaller SRI market than more female countries like Denmark, Sweden and Norway. We therefore conclude that the natural evolvement of SRI in the Nordic countries is based on a deep-rooted set of feminine values such as social relationships, interpersonal harmony and environmental concerns. Our results for the cultural factors confirm the findings from Scholtens and Sievänen (2013). The masculinity of a country especially seems to prevent the adoption of SRI in a country.

Additionally, the results for IDV support the thesis that culture has an impact on SRI as well. The degree of individuality seems to affect the preference for the more advanced SRI strategies like positive screens, engagement and voting as well as integration as the results are significant and all show a positive impact. Culture, in the sense of a collective programming of the mind (Hofstede 1984) in addition to joint preferences and collective beliefs (Dumas and Louche 2016), seems to have an impact on the application of complex SRI strategies on a national level at least with respect to MAS and IDV.

Moreover, the results suggest that economic and financial factors are more important for the adoption of negative screens, which penalize unsustainable businesses. In contrast, some cultural factors are crucial for the integration of positive screens, engagement and voting as well as integration, which tend to benefit sustainable business practices.

Politicians must keep these findings in mind when they discuss further regulations that aim to foster sustainable growth. If regulators want sustainable companies to benefit in order to foster a sustainable development culture, they must tackle cultural imprints with laws. Based on our results, regulations seem to be the only way to promote more advanced SRI strategies like positive screens, engagement and voting as well as integration.

6. Interpretation and Conclusion

This paper provides general empirical support for the theoretical model from Scholtens and Sievänen (2013) with data for SRI markets from 13 European countries. We contribute to their international theory of SRI and show that the SRI market size of a country is to some extent driven by economic and financial development factors as well as various cultural dimensions.

The development factors, GDP and the size of the pension market, measured by private pensions, affect the adoption of negative screening strategies, which constitute the largest SRI strategy in terms of assets under management per capita, and thus have an impact on the overall size and composition of the SRI market across countries. In contrast, GDP has no effect on more advanced SRI strategies like positive screens, engagement and voting and integration. The size of the pension market positively affects the adoption of engagement and voting strategies which can be explained by the long-term orientation and the fiduciary duty of pension funds.

In addition to the mentioned development factors, some cultural factors are important for the evolvement of more advanced SRI strategies according to our results. Social preferences regarding uncertainty avoidance help explain the different levels of positive screening strategies across countries. Moreover, our results show that revenue orientation (proxied by MAS) prevent countries from the implementation of positive screens, engagement and voting as well as integration strategies. Thus, countries with a masculine set of values such as revenue orientation instead of societal and environmental orientation are less likely to adopt these more advanced strategies, which would benefit sustainable business conduct instead of just penalizing unsustainable business models.

Hence, supranational regulatory authorities like the European Commission must set binding guidelines if European capital markets are to overcome the simple exclusion of non-sustainable companies and make a contribution to a culture of sustainable development. This cultural change would contribute to the long-term stability of the European Union by rewarding sustainable corporate behavior. Furthermore, it would help anchor the presence of sustainable investment practices in European countries.

To better examine the impact of advanced SRI strategies, there should be more in-depth analyses to give politicians and regulators more detailed information on how to foster sustainable growth in Europe by regulating the financial market and embedding deep-rooted sustainable investment behavior in European countries.

III. The Effect of Environmental Sustainability on Credit Risk

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Abstract: The European Commission has proposed establishing a framework that redirects capital to sustainable investments in order to foster sustainable economic growth. A key proposal from this framework is the mandatory consideration of environmental criteria for investment decisions. However, in particular for bond investors, there is not much academic guidance on how to integrate sustainability criteria in the investment process. Hence, this study investigates the impact of environmental sustainability on the pricing of credit risk for European corporations. Furthermore, whether or not the credit worthiness of a corporation has a moderating effect on the relationship between the environmental sustainability and the credit risk premium is analyzed. The findings prove that more sustainable companies have lower credit risk premiums if they also have a high credit worthiness.

Keywords: Sustainability, Environment, Default Risk Measurement, CDS Spreads

1. Introduction

The European Union (EU) wants to support the transition to a more sustainable economy in accordance with international agreements, e.g., the Paris Climate Agreement, the UN 2030 Agenda and the Sustainable Development Goals. Therefore, the EU is in the process of establishing a framework, which redirects capital to sustainable investments. The first key step is the creation of a unified classification system ("taxonomy"), new sustainable benchmarks and sustainability-related disclosure obligations for asset-managers. Furthermore, the EU plans to make it mandatory for asset managers to disclose whether and how they implement sustainability criteria in their investment processes. Even though the EU has a very comprehensive definition of sustainable investing, the main focus is on environmental issues, which includes minimizing green-house gas emissions, pollution and toxic waste as well as increasing the efficient use of natural resources (European Union, 2019). So, investment professionals are faced with the challenge to find the best way to consider ecological criteria in their investment decisions.

The surge in academic studies covering the relationship between a company's sustainable and financial performance should provide enough insights to find a good solution for this challenge. Unfortunately, over 85 percent of the studies investigating this relationship are equity-linked (Friede et al., 2015), although bonds have a market share of almost 40 percent of sustainable investments in Europe (Eurosif, 2018). Furthermore, the studies covering the impact of sustainability on bonds partly contradict each other. Most studies suggest that sustainability has a positive impact on credit risk (Friede et al., 2015). For example, the study from Oikonomou et al. (2014) shows that good corporate social performance leads to lower bond yields and better credit ratings. These findings are confirmed by other studies, which focus on the impact of environmental sustainability on credit risk (e.g. Bauer and Hann, 2010; Graham and Maher, 2006; Schneider, 2011) or environmental and social sustainability on credit risk (Dorfleitner et al., 2019). However, some studies indicate a neutral or negative impact from sustainability on credit risk. For instance, the findings from Menz (2010) indicate that socially responsible companies have higher risk premiums than non-socially responsible firms.

In order to give investment professionals more clarity on how to incorporate environmental sustainability criteria into their fixed income investment process as well as to contribute to the current academic discussion, we investigate if the environmental sustainability of a company effects its default risk premium. We further investigate whether a firm's creditworthiness has a moderating effect on this relationship which could explain some of the different findings in the academic literature.

This study expands the existing body of research in three aspects. It is the first study in this field of research analyzing European corporations. This is of special interest due to the changing European regulatory framework which will force European investment firms to mandatorily disclose how they incorporate sustainability criteria in their investment process. Additionally, it is the first study to use credit default swap (CDS) spreads to measure credit risk in addressing the link between environmental sustainability and credit risk. The main advantage of using CDS spreads is that there is no need to correct for different maturities, coupon effects and other features, like optionality (Benkert, 2004; Ericsson, Jacobs and Oviedo, 2009). Furthermore, this paper is the first that investigates the moderating effect of a company's credit quality on the relationship between their environmental sustainability score and credit risk while covering firms from all industry sectors, except financials.

To provide a comprehensive analysis, a sample with yearly data from 149 companies for the period from 2006 to 2017 is considered. The findings of the whole sample show that companies with higher environmental sustainability have lower credit spreads. However, the results of the sub-samples are more heterogenous and highlight that only companies with a high creditworthiness profit from being environmentally sustainable. Market participants only reward companies with a high creditworthiness for being more sustainable, whereas companies with a lower creditworthiness have almost no advantage from their sustainability efforts. This highlights the importance of a sophisticated assessment, when implementing sustainability criteria in the investment process. Investment professionals should always consider the moderating role of a firm's creditworthiness in order to correctly assess the effect of sustainability on credit risk.

The remainder of this paper has the following structure: The next section presents the hypotheses development and gives a short review of the related literature. Chapter 3 explains the methodology and the data sample for the empirical analysis. This section is followed by the description of the main findings. Finally, this paper concludes with a short summary of the empirical results and an outlook on further research needs.

2. Hypothesis Development and Related Literature

2.1 Hypothesis Development

The default risk of a company could be negatively affected by a lack of environmental sustainability via four interconnected transmission channels. First, companies with a higher environmental sustainability have less regulatory risks because they have a lower probability of being fined for environmental misconduct and they are better prepared to adopt any regulatory changes regarding environmental issues. For example, the U.S. Environmental Protection Agency (EPA) enforced private parties to spend over USD 450 million to cleanup Superfund sites in fiscal year 2018 (EPA, 2019). Similar to the U.S. Superfund, the EU put the Environmental Liability Directive (ELD) into force to prevent and remedy environmental damage based on the “polluter-pays” principle. This directive, which is enforced by the particular member states, is one European regulation that makes companies liable for the environmental damage they have caused (European Union, 2006). Additionally, stricter regulations can be expected based on the Sustainable Development Strategy (SDS) of the European Union (European Union, 2019). The implementation of these new regulations could pose a major challenge to environmental sinners and increase their compliance costs. In summary, the companies with lower environmental sustainability have a higher regulatory risk due to potentially higher fines as well as a slower and more costly adaption of upcoming regulatory changes which are expected to increase their default risk.

Second, companies with a lower environmental sustainability face higher stakeholder and reputational risks. The perception of environmental issues has changed leading to an increased public awareness and media coverage (Leiserowitz et al., 2018). Hence, many customers have become more sensitive to ecological issues and punish environmental misconduct by avoiding products from environmentally unfriendly companies, which can lead to a severe reduction in sales and harm profits. Additionally, other companies do not want to be associated with environmental sinners and thus are likely to cut off business dealings with polluters, which could have a negative impact on the whole supply chain. Bauer and Hann (2010) demonstrate that a deterioration of stakeholder relationships directly affects the cash flow, which influences both the firm value and the default risk.

Third, companies, which are involved in environmental issues, have a higher financial risk, because many investors start to integrate sustainability criteria in the investment process and thus either refuse to invest in those companies or demand a higher risk compensation. The EU plans to reinforce this development by introducing the EU taxonomy[10], sustainability-related disclosure for investment products and alternative sustainable benchmarks (European Union, 2019). This is likely to redirect capital to more sustainable firms and thus lead to a further increase in refinancing costs for less sustainable companies. Additionally, banks and credit rating agencies start to incorporate sustainability criteria in their credit risk assessment process (Fitch Ratings, 2019; Goss and Roberts, 2011; Weber et al., 2010, 2008). Hence, less sustainable companies are likely to face higher refinancing costs for both loans and bonds if they receive lower credit ratings from banks and rating agencies, respectively. This will not only increase funding costs but also constrain access to sufficient funding sources in times of financial distress.

Fourth, companies, which are less sustainable, in particular in regard to environmental factors, have higher event risks. The Exxon Valdez (1985), BP (2010), Tepco (2011) and Vale (2019) catastrophes are a few examples that highlight the effect of environmental disasters on the creditworthiness of a company. For instance, the most recent disaster was the burst of Vale's dam in Brazil which led to the death of at least 248 people. Besides destroying the surrounding area, the whole ecosystem is now contaminated by metals which were released after the dam burst. As a result, Vale's stock price fell 24 percent after the catastrophe and their credit rating was reduced by Fitch to BBB-. Furthermore, it significantly deteriorated their relationship with many stakeholders and will probably lead to stricter regulations. Vale could have prevented a decline in their creditworthiness, the deterioration of its stakeholder relationships and stricter regulations by better managing their environmental risks. The event risks that emerge from questionable business practices can lead to immense liabilities, which often question the continuation of the business and thus increase the default risk.

In summary, the higher regulatory, reputational, financial and event risk of companies with a lower environmental sustainability score is expected to negatively affect the creditworthiness of the respective company. Hence, our first hypothesis is as follows:

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[10] The EU taxonomy is a classification system for sustainable activities which aims to provide guidance for policy makers, industry, and investors on how to best support and invest in economic activities that contribute to achieving a climate neutral economy.

Hypothesis 1: Companies with higher environmental sustainability have lower credit risk premiums.

The previously outlined risk-mitigation view, which states that higher sustainability leads to lower default risk, is widely held by researchers and investment professionals (e.g. Bauer and Hann, 2010; Dorfleitner et al., 2019; Schneider, 2011). However, some argue that investments in sustainability are a waste of scarce resources, which could be better spent by investing in the expansion of the firm or paying dividends. In accordance with this overinvestment view, the credit risk premia for more sustainable companies should be higher (e.g. Menz, 2010). We hypothesize that companies with a high creditworthiness have more financial scope and are thus able to afford being “green”. For them, the risk reduction effect from being sustainable overcompensates the additional costs. Furthermore, companies with a low creditworthiness have less financial scope, which makes it more difficult for them to direct their few resources towards sustainable development. Moderating effects could provide a link between the risk-mitigation view and the overinvestment view, as shown by Stellner et al. (2015) for the moderating effect of country sustainability on the relationship between credit risk and sustainability on company level. Based on these considerations our second hypothesis is as follows:

Hypothesis 2: Only companies with a high creditworthiness profit from a high environmental sustainability.

2.2 Related Literature

The first study regarding the effect of environmental sustainability on credit risk was conducted by Graham et al. (2001), who show that off-balance-sheet environmental obligations have a negative impact on bond ratings. Graham and Maher (2006) confirm these results and extend the previous work by investigating the impact of environmental liability information on bond yields. Their findings indicate that environmental obligations are accounted for in bond yields. However, the environmental liability information has no additional explanatory power if bond ratings are also considered in the model. The study from Schneider (2011) focusses on firms in the pulp and paper as well as chemical industry and highlights that poor environmental performance has a negative impact on bond pricing. Additionally, Bauer and Hann (2010) confirm the positive impact of good environmental management on bond ratings and yield spreads. However, their results indicate that there is no general industry or sector level effect moderating the effect of sustainability on credit risk due to the high heterogeneity of firms within these sectors. The most recent study in this field of research was conducted by Dorfleitner et al. (2019) which concludes that considering social and environmental criteria improves the prediction of credit ratings and that firms with a higher social or environmental sustainability receive better credit ratings. Additionally, we review the literature on green bonds, which are attracting growing investor interest. Hachenberg and Schiereck (2018) show that green bonds have a lower credit risk premium, which could be economically important, even though their results are often not statistically significant. In summary, the current literature regarding the impact of environmental sustainability on credit risk supports our first hypothesis.

In contrast, the moderating effect of creditworthiness on the impact of sustainability on credit risk is hardly analyzed by academics. Moreover, the few existing studies contradict each other. For instance, the findings of Schneider (2011) highlight that the effect of environmental sustainability on credit risk is more positive for U.S. companies from the pulp and paper as well as chemical industry if they have lower credit ratings. Goss and Roberts (2011) analyze loans from U.S. banks and investigate the impact a firm’s investment in corporate social responsibility (CSR) has on its loan spreads. Their results contradict the findings from Schneider (2011), when they conclude that low-quality borrowers face higher refinancing costs if they invest in discretionary CSR.

To the best of our knowledge, this is the first study that analyzes the impact of environmental sustainability on credit risk for European companies using CDS spreads and investigates the moderating effect of creditworthiness while incorporating all industry sectors, except the financial sector, with an extensive sample ranging from 2006 to 2017.

3. Data and Methodology

The starting point for the sample is the MSCI Europe Index, which includes more than 400 European firms. For this study financial firms are excluded from the sample for two reasons. First, companies from the financial sector have no essential impact on the environment and thus exhibit low direct environmental risks. They mainly face indirect environmental risks due to their loan portfolios, which have to be assessed differently.[11] Second, credit risk models differ for financial and nonfinancial firms. For that reason, most studies regarding credit risk focus on companies from industrial sectors (e.g. Bai and Wu, 2016; Ericsson et al., 2009). Additionally, all firms without a quoted CDS spread and sustainability data were excluded from the sample. So, the final sample comprises 149 European companies in the period from 2006 to 2017 based on yearly data.

In this study, CDS spreads are used instead of bond spreads to measure the default risk premium. There are three main advantages of using CDS spreads. First, CDS prices reflect changes in the firm-specific fundamental data faster and more accurately than bond prices, which tend to follow the CDS market (Blanco et al., 2005). Second, CDS is a pure measurement of credit risk. Hence, the CDS premium does not have to be separated into a term structure, credit risk and liquidity risk premium. Third, when CDS is used instead of bonds, it is not necessary to account for different and varying maturities due to their fixed tenor (Bai and Wu, 2016; Ericsson et al., 2009). In accordance with Bai and Wu (2016), we use the natural logarithm of the CDS premium to accounted for variable skewness and to receive a better distributional behavior.

Based on prior studies, both fundamental and stock market data is used with the sustainability factor to explain the default risk premium of companies. In more detail, the fundamental data used in this study are leverage, profitability and market capitalization. Leverage, an indicator for the indebtedness of a company, is derived by dividing the total debt of a firm by its total assets. In accordance with the structural framework developed by Merton (1974), the distance-to-default shrinks if the leverage rises which ultimately leads to an increased default probability. In this framework, the default of a company is triggered if it has more debt than assets, which would be equal to a leverage ratio greater than 1. Hence, companies with higher leverage have to pay higher risk premiums due a higher default risk (Bai and Wu, 2016; Collin-Dufresne et al., 2001). Profitability is measured by earnings before interest and taxes (EBIT) divided by the total assets. This figure should have a negative effect on the default risk because companies with higher earnings are more likely to repay their debt and thus less likely to default (Bai and Wu, 2016; Benkert, 2004). The last fundamental firm-specific variable is market

[11] The impact of environmental sustainability on the credit risk of loans has been investigated by, for example, Weber et al. (2010).

capitalization[12], which is derived by multiplying a company's outstanding shares with its share price. Larger firms should have more financial flexibility than smaller firms which is why market capitalization is expected to also have a negative relationship with the default risk (Bai and Wu, 2016; Du and Suo, 2007; Shumway, 2001).

In addition, two variables derived from the stock market are taken into account to explain the CDS prices. The first variable is the return of a company's stock measured as the annualized return of the stock during the last 180 trading days. Duffie et al. (2007) suggest in their study that a higher stock return leads to a lower credit risk premium. The other variable is the annualized volatility of a firm's stock, which is based on the daily stock returns of the last 180 trading days. In light of the structural framework, a firm's bond can be regarded as a short put option on the stock of the company whose value increases if the volatility of the respective stock increases (Campbell and Taksler, 2003; Collin-Dufresne et al., 2001; Merton, 1974). Thus, a higher stock volatility should be accompanied by a higher credit risk premium.

The environmental rating from MSCI is used in this study.[13] This score measures the environmental sustainability of a company with a score ranging from 0 to 10, whereby a higher score indicates a higher level of sustainability. The assessment of a company's environmental sustainability covers several key ecological issues with regard to climate change, natural resources, pollution and waste and environmental opportunities. Moreover, this sustainability rating takes the management of sustainability related risks as well as the exposure of the firm to those risks into account and weights the respective scores based on a firms' risk exposure (MSCI ESG Research, 2018). Hence, the environmental score from MSCI is a very comprehensive assessment of the sustainability risks and opportunities a company faces. In accordance with our first hypothesis, we expect higher environmental sustainability to lead to lower CDS premiums due to less regulatory, reputational, financial and event risk.

All variables used in the regression are summarized in Table III.1, which contains their abbreviations, short descriptions, and the data source.

[12] Similar to the CDS, the natural logarithm of the market capitalization is used in the regression to account for skewness.

[13] The correlation between environmental scores from different sustainability rating agencies is low (Berg et al., 2019; Dorfleitner et al., 2015). Thus, the results derived in this paper could change if sustainability scores from other agencies were used.

Table III.1: Overview of Variables

Variable	Description	Source
CDS	Natural logarithm of the CDS spread for the euro debt of a company	Bloomberg
RET	Annualized stock return from the last 180 trading days	Bloomberg
VOL	Annualized volatility of the stock from the last 180 trading days	Bloomberg
LEV	The leverage of a firm measured by total debt (Euro) divided by total assets (Euro)	Bloomberg
PROF	Profitability of a firm measured by EBIT (Euro) divided by total assets (Euro)	Bloomberg
Market Cap.	Natural logarithm of the market capitalization (Euro), derived from shares outstanding times their market price	Bloomberg
ENV	Environmental score	MSCI ESG Research

The following model uses a random-effects estimator[14] with both time and individual dummies to account for unobserved time-variant and time-invariant effects. Additionally, time-clustered White standard-errors[15] are reported to correct for heteroscedasticity and serial-correlation. The model is summarized in the following equitation:

$$\mathrm{CDS}_{i,t} = \alpha + \beta_1 RET_{i,t} + \beta_2 VOL_{i,t} + \beta_3 LEV_{i,t} + \beta_4 PROF_{i,t} + \beta_5 \text{Market Cap}_{i,t} + \beta_6 ENV_{i,t} + \varepsilon_{i,t}$$

Similar to the methodology from Akdoğu and Alp (2016), sub-samples are created to test for possible moderating effects by the creditworthiness of a firm. In order to analyze the effect of a firm’s solvency, the sub-samples are created based on the worst credit rating of each company assigned by Moody’s, S&P or Fitch. All of the corporations with a rating above the median rating are part of the good credit quality sample and vice versa. Additionally, three sub-samples are built with the same sampling routine based on leverage, profitability and market

[14] According to Wooldrige (2010) the Hausman test is not applicable, if the regression includes time fixed effects. We used the Mundlak (1978) approach instead to choose between the fixed and random effects model.

[15] The Breusch-Pagan test and the Breusch-Godfrey/Wooldridge test indicated heteroscedasticity and serial-correlation, respectively. Hence, time clustered White standard errors are used to account for both heteroscedasticity and serial-correlation.

capitalization. This process is repeated yearly to account for changes in the creditworthiness of the companies over time.

4. Results

In this section, we provide a detailed overview of our results for each hypothesis. First, the impact of the control variables on the CDS spread is discussed for every sample. After that, the general impact of environmental sustainability and the moderating effect of creditworthiness is analyzed. The results for the whole sample as well as for the respective sub-samples are summarized in Table III.2.

With two exceptions, all the control variables based on the stock market have the expected impact on the CDS spread, though only the effect of the stock volatility is significant. These results are logical in view of the structural framework because a bond has limited upside and unlimited downside potential. Hence, bond investors focus more on the possible losses, for which the stock volatility is a better estimator. Moreover, volatility is especially important for firms with a high leverage. This is plausible with regard to Merton’s structural framework, as well, because a high leverage is associated with a low distance-to-default which reinforces the effect of the stock volatility.

The fundamental variables have the expected effect on the CDS spread as well. Both profitability and market capitalization have a negative effect on the CDS premium. That means, companies that are more profitable and have a higher market capitalization have a lower credit risk. Furthermore, profitability seems to be particularly crucial for companies with a high creditworthiness. Thus, investors view profitability as the more important factor when distinguishing between firms with an already good solvency. The last control variable is leverage which also has the expected impact on the CDS premiums. In all samples, a higher leverage leads to an increase in the default risk premium.

The findings based on the whole sample show that the environmental factor has a negative impact on the CDS spread. Hence, firms with a higher environmental sustainability have, in general, lower CDS spreads.

Table III.2: Regression Results of the Whole Sample and the Sub-Samples

	Whole Sample	Rating		Leverage	
		Good	Bad	Low	High
Constant	6.373***	5.231***	5.595***	6.909***	5.212***
	(0.229)	(0.399)	(0.433)	(0.338)	(0.348)
RET	-0.019	-0.061	-0.071	-0.001	-0.030
	(0.046)	(0.099)	(0.056)	(0.061)	(0.073)
VOL	2.091***	2.049***	2.124***	1.646***	2.609***
	(0.176)	(0.348)	(0.258)	(0.252)	(0.257)
LEV	0.758***	0.819***	1.059***	1.098**	0.976***
	(0.140)	(0.294)	(0.205)	(0.461)	(0.267)
PROF	-2.112***	-2.213***	-1.943***	-1.891***	-2.276***
	(0.310)	(0.642)	(0.459)	(0.509)	(0.394)
Market Cap.	-0.263***	-0.146***	-0.182***	-0.302***	-0.176***
	(0.019)	(0.033)	(0.041)	(0.027)	(0.029)
ENV	-0.018*	-0.043***	-0.007	-0.032**	-0.001
	(0.010)	(0.016)	(0.015)	(0.015)	(0.013)
R^2	0.499	0.420	0.470	0.495	0.508
adj. R^2	0.496	0.410	0.460	0.489	0.502
Obs.	1.003	365	350	526	475
F Stats	158.271***	37.718***	45.840***	81.269***	75.868***
	(df = 6; 996)	(df = 6; 358)	(df = 6; 343)	(df = 6; 519)	(df = 6; 468)

Note: This table presents the estimated coefficients and standard-errors (in parentheses) from the random effects model of the natural logarithm of the CDS spreads on the environmental-score as well as fundamental and market control variables for the whole sample and two sub-samples. The sub-samples differ in terms of particular fundamental characteristics (rating, leverage, profitability and market capitalization). To account for heteroscedasticity as well as serial auto-correlation time clustered White standard errors are reported. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

Table III.2 (continued): Regression Results of the Whole Sample and the Sub-Samples

	Profitability		Market Cap.	
	High	**Low**	**High**	**Low**
Constant	5.620***	6.280***	6.234***	7.018***
	(0.314)	(0.327)	(0.453)	(0.516)
RET	0.039	-0.048	0,008	-0.055
	(0.080)	(0.059)	(0.066)	(0.063)
VOL	2.338***	2.244***	2.356***	2.119***
	(0.286)	(0.229)	(0.268)	(0.238)
LEV	0.753***	0.650***	1.065***	0.624***
	(0.203)	(0.193)	(0.222)	(0.178)
PROF	-2.114***	-1.803***	-2.530***	-1.638***
	(0.467)	(0.717)	(0.546)	(0.373)
Market Cap.	-0.202***	-0.259***	-0.242***	-0.344***
	(0.026)	(0.028)	(0.038)	(0.053)
ENV	-0.009	-0.011	-0.042***	-0.007
	(0.013)	(0.014)	(0.013)	(0.014)
R^2	0.455	0.494	0.542	0.471
adj. R^2	0.448	0.488	0.537	0.464
Obs.	476	525	500	499
F Stats	59.926***	79.489***	84.450***	68.392***
	(df = 6; 469)	(df = 6; 518)	(df = 6; 493)	(df = 6; 492)

Note: This table presents the estimated coefficients and standard-errors (in parentheses) from the random effects model of the natural logarithm of the CDS spreads on the environmental-score as well as fundamental and market control variables for two sub-samples. The sub-samples differ in terms of particular fundamental characteristics (rating, leverage, profitability and market capitalization). To account for heteroscedasticity as well as serial auto-correlation time clustered White standard errors are reported. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

This finding supports our first hypothesis, which stated, with regard to the risk-mitigation view, that more sustainable firms have a lower default probability and have to pay less for their debt due to lower regulatory, reputational, financial and event risks. For instance, companies that increase their environmental score by 1 point can decrease their CDS spread by 1.8 percent. Thus, a company that has a CDS spread of 122.9 bp, which is the average CDS premium of the whole sample, can decrease their CDS spread by 2.1 bp by increasing their environmental score by 1 point.

After analyzing the general impact of environmental sustainability on CDS spreads, we elaborate on the potential moderating effect of a company's credit quality. Even though the effect of environmental sustainability remains negative, irrespective of the sub-sample, the magnitude of the effect varies notably between the different samples. For example, environmental sustainability has almost no effect on companies with a low credit rating. In contrast, environmental sustainability has a big influence on the credit risk premium of companies that have high credit ratings and good creditworthiness. Moreover, the effect is strong for companies with a low leverage and high market capitalization, whereas it does not pay of to be green for small and indebted companies, though they do not incur a penalty for being sustainable. Profitability is the only variable that does not affect the impact of sustainability on CDS premiums. The impact on firms with either a high or low profitability is almost the same and, in both cases, not statistically significant. A reason for this result could be that leverage and market capitalization are more important indicators for a firm's ability to fund its sustainable development. So, if a firm has a high leverage or a low market capitalization, the investors prefer paying debt off or retaining the earnings to investing in the environmental sustainability, irrespective of the profitability. In particular, the results for the sub-samples based on the credit ratings confirm our second hypothesis and show that only companies with a high creditworthiness profit from a high environmental sustainability.

5. Conclusion

In this paper we analyzed whether environmental sustainability has an effect on the credit risk of European nonfinancial companies to help investors making sound decisions, when incorporating sustainability into their investment process. This topic is expected to gain even more importance in view of the upcoming EU directives based on their sustainable development strategy, which will directly affect both asset owners and investment managers.

In general, the findings show that more sustainable companies have a lower credit risk due to lower reputational, financial, regulatory and event risks, which provides proof for our first hypothesis and the risk-mitigation view. Furthermore, our findings indicate that a company's creditworthiness moderates the impact of environmental sustainability on credit risk. It appears that only companies with high creditworthiness benefit from having a high environmental sustainability score, though companies with a low creditworthiness do not incur a penalty for being sustainable.

Therefore, investment professionals should integrate environmental criteria into the assessment of a company's default risk and consider the moderating effect of a firm's creditworthiness. This integration should improve existing credit models and lead to a slightly more precise valuation of credit risk.

Further research should expand this study by analyzing the impact of sustainability on the credit risk of companies which have a sub-investment grade credit rating or are from emerging market countries because investors tend to shift their assets into these asset classes in a search for yield and need precise valuation models, which incorporate sustainability data. Additionally, the impact of the new EU regulations on the pricing and allocation of loans could be further investigated to better understand whether the perception of environmental risks within the credit portfolios of banks and other financial firms is changing.

IV. Corporate Carbon-Risk and Credit-Risk: The Impact of Carbon-Risk Exposure and Management on Credit Spreads in Different Regulatory Environments

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Abstract: Global efforts to mitigate climate change can affect a company's business outlook thereby creating risks and opportunities for companies and investors. We investigate the relation between a company's carbon-risk and its credit-risk. Moreover, we highlight the importance of carbon-risk management and the role of the regulatory environment in this context. Using a global sample of corporate bonds, we show that both carbon-risk exposure and carbon-risk management significantly affect credit-risk while the regulatory environment moderates these relations. Our results are relevant for policy makers, investors and companies, especially those with a high carbon-risk exposure.

Keywords: Carbon Risk, Credit Risk, Climate Change, Climate Policy

1. Introduction

Climate change is one of the major challenges of our time with potentially severe negative societal and economic impact. Institutional investors perceived climate action failure as the most significant risk in 2020 (World Economic Forum [WEF], 2020). With the Paris Agreement negotiated in 2015, the global society decided to keep global warming to well below two degrees Celsius (United Nations [UN], 2015) to reduce physical risks resulting from climate change. To accomplish this goal, global carbon emissions must be significantly cut, raising the necessity for a transition towards a low-carbon economy. This transition can affect a company's business outlook through various channels (Network for Greening the Financial System [NGFS], 2019). Hence, climate change affects a company's risk profile through both physical and transitional climate risk.

Studies investigating the effect of climate risks and opportunities on credit fundamentals show that leverage (Nguyen & Phan, 2020), profitability (Caby et al., 2022; Hugon & Law, 2018), liquidity and investments (Huang et al., 2018; Phan et al., 2022) are affected by a company's climate-risk. Those credit fundamentals help predict a company's default probability (Altman, 1968, 1989). Thus, we expect companies with lower carbon-risk should be less likely to default. This positive link between carbon-risk and credit-risk is substantiated by recent research (e.g., Capasso et al., 2020; Caragnano et al., 2020). Given the importance of a company's regulatory environment for its transitional climate risk (NGFS, 2019), it should be considered when investigating the relationship between carbon-risk and credit-risk.

In this paper, we comprehensively investigate the relation between a company's carbon-risk performance and its credit-risk while considering national climate regulatory ambitions. Our results demonstrate that investors should not only carefully examine a company's exposure but also incorporate its ability to manage carbon-risk. Furthermore, carbon-risk management gains importance in the presence of an ambitious climate regulatory environment while negative effects associated with higher carbon-risk exposure are less pronounced.

We add to the literature in the following areas. First, previous studies use carbon emissions or carbon intensity (e.g., Capasso et al., 2020) and the disclosure of carbon emissions (e.g., Jung et al., 2016; Kleimeier & Viehs, 2016) to proxy carbon-risk exposure and management separately. We use a comprehensive set of indicators to measure carbon-risk performance, carbon-risk management, and carbon-risk exposure[16] which enable an in-depth analysis of companies' overall carbon-risk. Second, to the best of our knowledge, we are the first to investigate the effect of regulatory environments on the relation between carbon-risk and credit-risk using a global sample of corporate bonds. This global perspective enables a better understanding of the dynamics between constantly evolving national climate policy frameworks and the credit-risk of companies exposed to those frameworks. Furthermore, we extend the literature by using a thorough proxy for the national climate regulatory environment which allows us to compare different jurisdictions.

In line with current research (Capasso et al., 2020; Seltzer et al., 2021), we expect higher exposure to be linked to higher credit spreads. Moreover, companies with a better management are associated with a better financial performance (Melnyk et al., 2003) and thus should have a lower credit-risk (Sharfman & Fernando, 2008). We, therefore, expect that the importance of management increases with a company's exposure. In summary, we hypothesize the following:

H1a: A better carbon-risk performance is associated with lower credit spreads.

H1b: Companies with a higher carbon emission exposure have higher credit spreads.

H1c: Companies with a better carbon emission management have lower credit spreads.

H2: Management is more important for companies with higher exposure to carbon-risk.

Companies perceive regulatory risk as the most important risk related to climate change (Sakhel, 2017) and many institutional investors realize that they already need to account for this risk (Krueger et al., 2020). Hence, a company's overall carbon-risk performance should be more important in a more ambitious climate regulatory environment. Recent research shows that both the announcement of a more ambitious climate policy (Liu & Qiao, 2021) and its stricter enforcement (Seltzer et al., 2021) negatively affect credit-risk of highly exposed companies. Thus, both a) exposure to and b) management of carbon-risk should gain importance when climate policy ambitions are high. Consequently, we hypothesize:

H3a: A company's carbon-risk performance is more important for its credit spreads if it operates in a more ambitious climate regulatory environment.

[16] To increase the readability, we henceforth replace carbon risk exposure and carbon risk management with exposure and management in the following.

H3b: A company's carbon-risk exposure is more important for its credit spreads if it operates in a more ambitious climate regulatory environment.

H3c: A company's carbon-risk management is more important for its credit spreads if it operates in a more ambitious climate regulatory environment.

The reminder of this paper is structured as follows. Section 2 describes the data and the methodology applied, results are presented in section 3 and section 4 concludes the paper.

2. Data and Methodology

2.1. Data

Our dataset consists of a global sample[17] of non-financial companies' corporate bonds[18], and non-subordinated corporate bonds with a time to maturity of one to thirty years. We use company credit spreads calculated by subtracting the risk-free rate[19] from the bonds' yield to worst on a given date to proxy for credit-risk. Our analysis builds on three indicators from MSCI to comprehensively measure a company's carbon-risk: The Carbon Emission (CE) score, measuring a company's comprehensive carbon-risk performance, which is based on two sub-scores, namely the Carbon Emission Exposure (CEE) score and the Carbon Emission Management (CEM) score. While the CEE score covers a company's exposure to risk from emitting carbon, the CEM score captures a company's ability to manage and subsequently reduce this risk exposure (MSCI, 2022).

We introduce a dummy-variable (RegEnv) to measure the climate regulatory environments' ambition using the National Policy Score, part of the annual Climate Change Performance Index (CCPI) provided by Germanwatch. The score is calculated by assessing local climate policy

[17] Our sample is based on the following five corporate bond indices: Solactive USD Investment Grade Corporate Index, Solactive USD High Yield Corporate Index, Solactive EUR Investment Grade Corporate Index, Solactive EUR High Yield Corporate Index, Solactive USD EM Corporate TR Index.

[18] We follow the approach by Oikonomou et al. (2014) and exclude financial companies.

[19] The USD and EUR swap curve is used to proxy the risk-free yield curves. We apply the Nelson-Siegel-Svensson model to calculate risk-free yields for all maturities on a monthly basis (see for the Nelson-Siegel-Svensson model Nelson and Siegel (1987) and Svensson (1994)).

experts' evaluation of the comprehensiveness of the most important energy and climate policy measures in their respective country (Germanwatch, 2021).

We incorporate a set of bond and company specific variables to control for different drivers of credit-risk. Bond specific variables include time to maturity, callability and currency. Company specific variables include total assets, EBIT divided by total assets, leverage, free cash flow divided by total assets and equity volatility. Moreover, we account for time, industry, and country fixed effects. Table IV.1 provides a detailed description of the variables.[20]

[20] For a detailed discussion of the control variables see Höck et al. (2020); Oikonomou et al. (2014); Stellner et al. (2015).

Table IV.1: Variable Description

Variable	Description	Source
	Dependent variable	
ln(Credit Spread)	The natural logarithm of the yield to worst in excess of a risk-free rate.	Refinitiv
	Independent variables	
Carbon Emission (CE)	A variable from MSCI ESG measuring a company's carbon risk performance. The score ranges from 0 to 10. A higher value implies a better performance, thus, lower overall carbon risk.	MSCI ESG
Carbon Emission Exposure (CEE)	A variable from MSCI ESG measuring a company's exposure to carbon risk via its business model. The score ranges from 0 to 10. A higher value implies higher exposure.	MSCI ESG
Carbon Emission Management (CEM)	A variable from MSCI ESG measuring a company's ability to manage the risks associated to the company's carbon emissions. The score ranges from 0 to 10. A higher value implies better management.	MSCI ESG
High Exposure	A dummy variable that indicates if a company is highly exposed (1) to carbon risk or not (0). We calculate this dummy based on the median CEE in each year.	MSCI ESG
Climate Regulatory Environment (RegEnv)	A dummy variable based on a company's climate regulatory environment. 1 indicates that the company is exposed to more ambitious domestic climate policies. The score is based on the CCPI National Policy Score in a given year and we classify each country depending on its value compared to the year's median.	Germanwatch
	Control variables	
Time to Maturity	Years until a bond matures.	Solactive
ln(Total Assets)	The natural logarithm of company's total assets.	Refinitiv
EBIT/Total Assets	A company's EBIT divided by its total assets.	Refinitiv
Leverage	A company's total debt divided by its total assets.	Refinitiv
Free Cash Flow/ Total Assets	A company's free cash flow divided by its total assets.	Refinitiv
Equity Volatility	A company's annualized historical five-year equity volatility.	Refinitiv
Currency	Specifies whether the bond is denominated in Euro or in US-Dollar. A value of 1 is assigned to bonds denominated in Euro and 0 for US-Dollar issued bonds.	Solactive
Callable	Specifies whether the bond has an embedded call option or not.	Solactive

Note: This table presents a detailed description of the variables used in our analysis. The last column indicates the source of each variable. In addition to the listed variables, we incorporate time (year), industry (BICS classification) and the location (country) in the analysis.

After matching the data from different sources, the final sample contained 54,456 bond-year observations for the period from 2007 to 2020,[21,22] corresponding to 2,253 companies and 13,202 unique bonds. Table IV.2 provides summary statistics.[23]

Table IV.2: Summary Statistics

	Mean	Median	0.25	0.75	Min	Max	SD
ln(Credit Spread)	0.16	0.24	-0.43	0.84	-9.02	2.37	1.02
CE	7.47	8.16	5.6	10	0	10	2.64
CEE	3.79	2.81	2.22	5	0	10	2.21
CEM	5.21	6	3.7	6.8	0	9.5	1.91
High Exposure	0.49	0	0	1	0	1	0.5
RegEnv	0.41	0	0	1	0	1	0.49
Time to Maturity	9.03	6.17	3.5	9.75	1	30	8.03
Callable	0.5	1	0	1	0	1	0.5
Currency	0.21	0	0	0	0	1	0.41
ln(Total Assets)	17.55	17.58	16.7	18.48	14.58	20.08	1.23
EBIT / Total Assets	0.07	0.07	0.04	0.11	-0.16	0.3	0.07
Leverage	0.54	0.52	0.39	0.64	0.14	1.45	0.22
FCF / Total Assets	0.1	0.09	0.06	0.12	-0.05	0.27	0.05
Equity Volatility	0.25	0.22	0.17	0.29	0.03	0.7	0.12

Note: This table provides the summary statistics for the variables used in our analysis. We present the mean, the median, the 25-percent-quartile (0.25), the 75-percent-quartile (0.75), the minimum (Min), the maximum (Max) and the standard deviation (SD). The number of observations ranges from 43,094 to 54,456. We winsorized Credit Spread, Total Assets, EBIT/Total Assets, Free Cash Flow/Total Assets, Leverage and Equity Volatility at the 1% and the 99% percentile.

[21] While MSCI's CE scores are available from 2007 on, CEE and CEM scores only became available in 2013. This leads to differences in the overall sample depending on the indicators used.

[22] We matched company-specific data using a company's Ultimate Parent ISIN in cases where we were not able to match this data using the company ISIN.

[23] Furthermore, we provide a more detailed description of our sample in Table C.1 and Table C.2 in the Appendix.

2.2. Methodology

We ran yearly pooled OLS regressions to examine the relation between carbon-risk and credit spreads. Our baseline model is as follows:

$$Ln(Credit\ Spread_{i,t}) = \alpha + \beta_1 Score_{i,t} + \beta_2 X_{i,t} + \beta_3 Y_i + \beta_4 FE_i + \varepsilon_{i,t}$$

where $Ln(Credit\ Spread)_{i,t}$ is the natural logarithm of the credit spread of bond *i* in year *t*, $Score_{\ i,t}$ represents a company's carbon performance score (either CE, CEE, or CEM) in year t, $X_{i,t}$ incorporates bond and company specific time varying variables, Y_i includes time-invariant bond and company specific characteristics and FE_i controls for unobserved time, country and industry effects.

3. Findings and Discussion

3.1. The Importance of Carbon Risk, Exposure and Management for Credit Risk

Table IV.3 presents the results of our empirical analysis of the relation between carbon-risk and credit spreads. Column 1 shows that an increase in CE is associated with lower credit spreads on average.[24] In column 2, we replace the CE score with CEE and CEM to evaluate the effects of exposure and management separately. We find that CEE scores are associated with significantly higher credit spreads. Moreover, companies with higher CEM scores have significantly lower credit spreads. To further examine the importance of management skills considering differences in companies' exposure, we split the sample according to the median of the CEE score each year into low (column 3) and high (column 4) exposure. Comparing the absolute magnitude of the CEM coefficient in both columns indicates that the risk mitigating effect of management is more pronounced when the exposure is high.[25] We test the robustness of this finding by introducing an interaction term between exposure and management. While high exposure is associated with higher credit spreads, we find that this interaction is statistically significant and negative (column 5).

[24] Note that the coefficients of our control variables have the expected signs, and are robust in all regressions.

[25] We apply a Wald test to test the coefficients' equality. The resulting Chi^2 value provides evidence for differences in the coefficients' magnitude.

Our results provide further evidence showing that carbon-risk significantly affects credit-risk. We find that a better overall carbon-risk performance, hence lower carbon-risk, reduces credit-risk (confirming H1a) while a company's exposure increases credit-risk (confirming H1b). The later confirms findings by inter alia Capasso et al. (2020). Moreover, we find that management is an effective tool in reducing credit-risk (confirming H1c), which gains importance when the exposure is high (confirming H2).[26] Considering both the CEM coefficient and the interaction, High Exposure x CEM, implies that companies with a high exposure have on average 6.39%[27] lower credit spreads per one unit increase in CEM (compared to -2.96% for low exposed companies) which highlights that our results are not only statistically but also economically significant.

[26] We provide a correlation matrix of our independent variables in Table A.3 in the appendix. The correlation matrix does not reveal severe correlations between our independent variables.

[27] The value is calculated as follows: (exp (-0.03 - 0.036) -1) * 100.

Table IV.3: Relationship between Carbon Risk, Exposure and Management and Credit Spreads

	(1) CE (Full Sample)	(2) CEE & CEM (Full Sample)	(3) CEM (Low CEE Sample)	(4) CEM (High CEE Sample)	(5) High Exp. & CEM (Full Sample)
CE	-0.036*** (0.003)				
CEE		0.020*** (0.004)			
High Exposure					0.206*** (0.034)
High Exp. X CEM					-0.036*** (0.006)
CEM		-0.048*** (0.003)	-0.032*** (0.005)	-0.058*** (0.005)	-0.030*** (0.004)
Time to Maturity	0.041*** (0.001)	0.043*** (0.001)	0.049*** (0.001)	0.038*** (0.001)	0.043*** (0.001)
ln(Total Assets)	-0.210*** (0.006)	-0.203*** (0.006)	-0.210*** (0.008)	-0.231*** (0.008)	-0.209*** (0.006)
EBIT / Total Assets	-1.841*** (0.097)	-1.879*** (0.107)	-1.935*** (0.182)	-2.032*** (0.123)	-1.957*** (0.108)
Leverage	0.590*** (0.026)	0.582*** (0.028)	0.589*** (0.039)	0.443*** (0.041)	0.555*** (0.027)
FCF / Total Assets	-2.980*** (0.119)	-2.902*** (0.134)	-3.125*** (0.196)	-2.649*** (0.178)	-2.797*** (0.132)
Equity Volatility	1.423*** (0.048)	1.403*** (0.052)	1.184*** (0.080)	1.413*** (0.066)	1.389*** (0.051)
Currency	-0.465*** (0.018)	-0.484*** (0.020)	-0.429*** (0.025)	-0.506*** (0.030)	-0.486*** (0.019)
Callable	0.256*** (0.014)	0.219*** (0.014)	0.260*** (0.019)	0.165*** (0.018)	0.221*** (0.013)
Observations	54,456	43,056	21,896	21,160	43,056
Adj. R^2	0.491	0.495	0.509	0.482	0.551

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon risk related scores (CE, CEE, CEM) and control variables. The CE score measures a company's carbon risk performance, while the CEE score measures the company's exposure to carbon risk and the CEM score captures the ability to manage this risk. The control variables include bond and company specific effects. High Exposure is a dummy variable which indicates if the CEE score of a company is above (High Exposure = 1) or below (High Exposure = 0) the median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients. *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

3.2. The Moderating Role of the Climate Regulatory Environment

The following section highlights the role of companies' climate regulatory environment on the relation between carbon-risk and credit spreads. Table IV.4 expands our analysis by including the interaction between the carbon-risk indicators and the RegEnv dummy-variable. We find an overall positive and significant relation between RegEnv and credit spreads. Column 1 shows a significantly negative interaction between the CE score and the RegEnv dummy. The interaction between CE and RegEnv is negative and statistically different from 0. Hence, a more ambitious climate regulatory environment enhances the risk-mitigating effect of higher CE scores. Next, we present the results of our investigation of the impact of CEM and CEE on credit spreads considering different climate regulatory environments. The CEM coefficient decreases in magnitude (columns 2 and 3) indicating that a more ambitious climate regulatory environment tends to strengthen the impact of good management on credit spreads. Furthermore, we find that the CEE coefficient also decreases in magnitude and statistical significance (columns 2 and 3) indicating that a more ambitious climate regulatory environment mitigates the risk-enhancing effect associated with higher CEE scores. We can confirm the robustness of these findings by analyzing the interaction of a) CEE and the RegEnv dummy-variable and b) CEM and the RegEnv dummy-variable. Column 4 shows a significantly negative interaction between CEM and RegEnv. Hence, good management gains importance in a more ambitious climate regulatory environment. We also find a negative and significant interaction term between CEE and RegEnv implying that the relation between companies' exposure and credit-risk decreases in a more ambitious regulatory environment.

Table IV.4: The Moderating Role of the Climate Regulatory Environment on the Relationship between Carbon Risk, Exposure and Management to Credit Spreads

	(1) CE (Full Sample)	(2) CEE & CEM (Below Median National Climate Policy Score Sample)	(3) CEE & CEM (Above Median National Climate Policy Score Sample)	(4) CEE & CEM (Full Sample)
CE	-0.033*** (0.003)			
RegEnv X CE	-0.009*** (0.003)			
CEE		0.031*** (0.004)	0.009* (0.006)	0.025*** (0.004)
RegEnv X CEE				-0.011*** (0.004)
CEM		-0.046*** (0.004)	-0.051*** (0.004)	-0.042*** (0.004)
RegEnv X CEM				-0.015*** (0.004)
RegEnv	0.193*** (0.025)			0.278*** (0.030)
Time to Maturity	0.041*** (0.001)	0.040*** (0.001)	0.047*** (0.001)	0.043*** (0.001)
ln(Total Assets)	-0.210*** (0.006)	-0.196*** (0.007)	-0.214*** (0.008)	-0.202*** (0.006)
EBIT / Total Assets	-1.853*** (0.097)	-1.821*** (0.120)	-1.995*** (0.163)	-1.867*** (0.107)
Leverage	0.588*** (0.026)	0.610*** (0.030)	0.526*** (0.040)	0.582*** (0.028)
FCF / Total Assets	-2.981*** (0.119)	-3.062*** (0.155)	-2.592*** (0.206)	-2.918*** (0.133)
Equity Volatility	1.429*** (0.048)	1.276*** (0.058)	1.652*** (0.079)	1.407*** (0.052)
Currency	-0.465*** (0.018)	-0.353*** (0.024)	-0.609*** (0.024)	-0.482*** (0.020)
Callable	0.254*** (0.014)	0.163*** (0.015)	0.269*** (0.017)	0.216*** (0.014)
Observations	54,456	23,647	19,409	43,056
Adj. R^2	0.496	0.493	0.526	0.511

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon risk related scores (CE, CEE, CEM), bonds' climate regulatory environment, the interaction between MSCI carbon risk related scores and bonds' climate regulatory environment, and control variables. The CE score measures a company's carbon risk performance, while the CEE score measures the company's exposure to carbon risk and the CEM score captures the ability to manage this risk. The control variables include bond and company specific variables. RegEnv is a dummy variable which indicates if the CCPI National Climate Policy Score is above (RegEnv = 1) or below (RegEnv = 0) median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients. *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

In line with our expectations, we find that a more ambitious climate regulatory environment increases credit spreads. However, it positively affects the importance of companies' carbon-risk performance (confirming H3a) and more specifically their carbon-risk management (confirming H3c) for credit-risk. An average company can benefit from an economically meaningful 5.54% reduction in its credit spread by improving its carbon-risk management (CEM) by one unit given an ambitious climate regulatory environment (compared to 4.11% reduction in its credit spread if the company is exposed to low climate regulatory ambition). However, the importance of exposure to carbon-risk decreases in the presence of more ambitious climate policies. Hence, we cannot confirm hypothesis 3b. The later finding contradicts Seltzer et al. (2021), who find that stricter climate regulatory frameworks amplify the risk-enhancing relation between carbon-risk exposure and credit-risk. However, a more ambitious climate regulatory environment, especially when implemented early, could directly decrease the costs of a low-carbon transition by setting the right incentives, allowing for low-carbon infrastructure to be developed in a timely manner, and reducing the likelihood of a disorderly and costly disruptive transition of the economy (European Systemic Risk Board [ESRB], 2016; NGFS, 2019). Moreover, Ramadorai and Zeni (2019) find that companies' emission abatement plans are affected by their expectations on future climate regulation, implying that companies reduce their emissions, and thus their carbon-risk exposure, when climate policies are expected to be tightened. Furthermore, from a technical perspective, the different results from Seltzer et al. (2021) could be explained inter alia by differences in the geographical focus and in the underlying indicator for the regulatory environment. In contrast to our study, Seltzer et al. (2021) focuses on negative incentives (e.g., state-level fines), while it does not account for positive ones (e.g., subsidies).

We apply two different tests to check the robustness of our findings. As a first step, we re-run or regressions using observations where we are able to match company specific carbon emission scores and financial data using only the company ISIN. Table C.4 and C.5 show that our results remain robust to this modification. Furthermore, our results remain robust if the CEE score is replaced by carbon emission intensity[28] providing further evidence for our conclusions (see Table C.6 and Table C.7).[29]

4. Conclusions and Outlook

After the signing of the Paris Agreement, companies' carbon-risk performance has gained importance in political debates, and investors and companies decision-making. We comprehensively investigate the impact of companies' carbon-risk performance on credit-risk considering the companies' national climate regulatory environment. We extend current literature by analyzing this relationship using a global sample that allows us to holistically analyze the moderating role of national climate policy using multi-dimensional carbon-risk indicators including carbon-risk exposure and management. Our findings highlight that a) a better carbon-risk performance leads to lower credit spreads, b) while a higher exposure leads to larger credit spreads and good management reduces credit spreads. The importance of carbon-risk management increases with the company's carbon-risk exposure. Finally, we find that companies in more restrictive regulatory environments have higher credit spreads. However, the importance of a company's carbon-risk performance and its related management capabilities increases in a more ambitious climate regulatory environment. Hence, increasing carbon-risk performance and especially carbon-risk management enables companies to (partially) mitigate the general increase in credit spreads related to a more ambitious climate regulatory environment.

Our findings are important for policy makers, investors, and companies. In accordance with the Task Force on Climate-Related Disclosures recommendation (Task Force on Climate-related Financial Disclosures [TCFD], 2017), the results of our study should encourage policy makers to focus on both a company's carbon-risk exposure and management when designing future climate-related regulatory policies. Furthermore, investors should assess a company's carbon-risk not only based on a company's emissions but also on its management abilities, while also taking the regulatory environment into account. Finally, companies highly exposed to carbon-

[28] Carbon emission intensity is measured using the sum of scope 1 and scope 2 carbon emission divided by sales.

[29] We re-run the regressions using emission intensity on the smaller sample resulting from our first robustness check. The results remain robust.

risk and ambitious climate policies can benefit from lower credit spreads by improving carbon-risk management.

Our study is subject to certain limitations. First, given that the CEE score and CEM score are only available from 2013 onwards, our results are mainly based on data from 2013 to 2020. Second, similar to Lopatta et al. (2022), our results are based on publicly listed companies. The robustness of this studies' findings could be checked by analyzing non-listed companies when appropriate measures for these companies become available.

Furthermore, future research could extend this study by analyzing the impact of regulatory shocks on the pricing of credit-risk to further investigate the role of investor's expectations regarding regulatory developments.

V. The Effect of Sustainability on the Credit Risk Exposure of Corporate Bond Portfolios

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Abstract: Demand for sustainable fixed-income investment solutions is surging, though there is insufficient research on the impact of sustainability on the risk characteristics of fixed-income portfolios. Thus, this study examines the impact of sustainability on the credit risk exposure of corporate bond portfolios by analyzing the return time series of a sustainable and a non-sustainable portfolio with the two-factor Fama and French bond model. The portfolios are derived from a U.S. corporate bond sample covering 2014 to 2018. The findings reveal that the sustainable portfolio has a significantly lower credit risk, and neither portfolio generates a significant risk-adjusted outperformance. Thus, the performance differences between both portfolios can be attributed to their different exposures to credit risk. This is the first study investigating this relationship on a portfolio level, which provides investment professionals with important insights on integrating sustainability strategies into their investment process.

Keywords: Sustainability, Credit Risk Management, Corporate Bonds

1. Introduction

The demand for sustainable investment solutions is surging: the volume of sustainably invested assets increased by 34% between 2016 and 2018. Thus, in 2018, sustainable investments added to USD 30,683 billion (GSIA, 2018). This growth in sustainable investments is mainly attributable to a changing public awareness regarding sustainability, which also shapes the political agenda. For instance, the Paris Climate Agreement and the Sustainable Development Goals from the 2030 Agenda of the United Nations are two global political initiatives expected to have a major impact on asset managers and asset owners' investment behavior, reinforcing the inflows into sustainable strategies.

Most studies investigating the impact of sustainability on the risk and return characteristic of financial instruments focus on listed equity, even though fixed-income accounts for almost 40% of all sustainably invested assets (Friede et al., 2015; GSIA, 2018). Furthermore, most studies regarding the relationship between sustainability and credit risk investigate whether a company's sustainability impacts its default risk premium (e.g. Graham and Maher, 2006; Klock et al., 2005; Oikonomou et al., 2014). The only study analyzing the impact of sustainability on a portfolio level for bonds was conducted by Polbennikov et al. (2016). Their findings suggest that more sustainable corporate bond portfolios have slightly higher returns. However, there is no research on how sustainability affects the risk characteristics of bond portfolios. Hence, this study investigates whether the systematic credit risk of corporate bond portfolios is affected by sustainability.

This topic is explored by comparing the credit risk exposures of a sustainable and non-sustainable portfolio from 2014 to 2018 with the Fama and French two-factor model. The portfolio constituents are derived from a broad sample covering approximately 5,000 corporate bonds, mainly from U.S. companies. Moreover, the portfolio creation process, which is based on the best-in-class principle, is designed to generate portfolios with different levels of sustainability but no difference in the sector and country allocation, the option-adjusted duration, and the credit rating.

The results reveal that more sustainable corporate bond portfolios have a lower systematic credit risk exposure. Furthermore, the findings indicate that only the exposure to the credit risk factor drives the return differences of both portfolios over time. Hence, neither portfolio generates an outperformance on a risk-adjusted basis. These results suggest that the systematic credit risk exposure of corporate bond portfolios is affected by the integration of sustainability into the investment process.

This is the first study to investigate the effect of sustainability on the systematic credit risk of corporate bond portfolios, adding a new perspective to the current academic discussion. Additionally, the results of this study can help investment professionals find an efficient solution to effectively manage credit risks in their corporate bond portfolios by integrating sustainability criteria into their investment process.

The remainder of this paper has the following structure. The next chapter outlines the hypothesis development and briefly reviews the related literature. The chapter is followed by a description of the data sample and empirical analysis methodology. Chapter 4 presents the results and highlights the main findings of the regression analysis. Robustness checks confirm the main results in chapter 5. Finally, this paper concludes with a summary of the key findings and gives an outlook on further research needs.

2. Hypothesis Development and Literature Review

2.1 Hypothesis Development

The impact of sustainability on portfolio risk is heavily discussed among investment professionals and academics. Rudd (1981) conducted one of the first studies covering this topic. He argues that any constraint restricting the investable universe results in a diversification penalty and, thus, a higher portfolio risk. Hence, he contends with regard to sustainability-related exclusion strategies that "the inescapable conclusion is that the imposition of the [sustainability] criteria increases investment risk."

Hoepner (2010) challenges this view and emphasizes that the systematic risk of a portfolio has three components: (1) number of holdings, (2) security risk and (3) correlation between the securities. The effect of an exclusion strategy on those three components is described in the following: First, although the exclusion of non-sustainable securities reduces the investment universe, the findings of Bello (2005) suggest that there is no difference in the number of holdings between sustainable and non-sustainable mutual funds. Thus, the argument that implementing sustainability strategies, such as exclusion screening, decreases the number of holdings is rejected by actual mutual fund data. Second, securities from more sustainable companies should be less volatile because they exhibit fewer sustainability-related risks. For instance, the results of Boutin-Dufresne and Savaria (2004) imply that sustainable companies can reduce their firm-specific risk on average by almost 40 percent compared to non-sustainable companies. Third, exclusion strategies aim to exclude investments in controversial business practices that contradict the investor's ethical conviction. As a result, more companies operating in ethically questionable industry sectors, such as alcohol or weapon production, are excluded. This unavoidably leads to a bias in the investment universe, which can affect portfolio construction and lead to a diversification penalty. Thus, implementing an exclusion strategy likely increases the correlation between the securities. Therefore, the final impact of an exclusion strategy on the systematic portfolio risk depends on whether the decrease in security level outweighs the diversification penalty.

In contrast, implementing a best-in-class approach can arguably increase the sustainability of a portfolio without raising the correlation between the securities. A best-in-class approach does not necessarily lead to a bias in the sustainable investment universe. Hence, sustainable portfolios using this approach should exhibit less systematic risk due to a lower security risk, the same number of holdings and the identical inter-security correlation. Hoepner (2010) supports this view: "negative ESG screening likely results in a diversification penalty for active mutual funds, while purely positive or especially best-in-class screening probably leads active funds to experience a diversification bonus."

Even though the presented literature focuses on stocks, the argumentation does not change for bond portfolios. Similar to stocks, the current academic discussion suggests that bonds from more sustainable companies are less risky in terms of default risk and therefore receive better credit ratings and pay lower default risk premiums (e.g. Bauer and Hann, 2010, Bhojraj and Sengupta, 2003 and Oikonomou et al., 2014).

Given the presented line of reasoning, more sustainable corporate bond portfolios, which are created based on the best-in-class approach, are hypothesized to exhibit less systematic default risk.

2.2 Literature Review

The bond-related sustainability literature focuses on the impact of a company's sustainability on credit ratings and default risk premiums (e.g. Bauer and Hann, 2010, Bhojraj and Sengupta, 2003 and Oikonomou et al., 2014) and the effects that moderate this relationship (Stellner et al., 2015). Thus, literature that analyzes the effect of best-in-class strategies on the risk and return characteristic of bond portfolios is limited.

One of the first studies covering this topic for equity portfolios was conducted by Lee and Faff (2009). They reveal that sustainable portfolios have a lower return than non-sustainable portfolios due to a significantly lower idiosyncratic risk. Thus, their findings suggest that there is some undiversifiable idiosyncratic risk, which is priced by market participants. In contrast to our hypothesis, sustainability had no influence on systematic risk.

Polbennikov et al. (2016) conducted the only study that covers the impact of sustainability on bond portfolios. Their results show that bond portfolios of sustainable firms have, on average, lower credit spreads and slightly higher performance than less sustainable portfolios after controlling for systematic risk factors, such as duration, spread and DTS[30] by sector. Their first finding supports the current academic discussion regarding the impact of sustainability on credit spreads, and the second finding indicates the existence of a sustainability premium, which can explain a certain share of bond portfolio returns beyond traditional systematic risk factors.

However, even though Polbennikov et al. (2016) account for systematic risk factors in their return attribution, they do not explore possible differences in the exposure to systematic factors. Thus, this is the first study to analyze the impact of a best-in-class sustainability strategy on the systematic default risk of corporate bond portfolios.

3. Data and Methodology

The bond sample is derived from the Bloomberg Barclays U.S. Agg Corporate Bond Index[31]. During the analyzed period from 27 December 2013 to 28 December 2018, the index included between 4,843 and 5,862 corporate bonds denominated in U.S. Dollars and mainly issued by

[30] Duration Times Spread (DTS) is used to measure the credit volatility of bond portfolios and is calculated by multiplying the spread duration and credit spread (Ben Dor et al., 2007).

[31] The Bloomberg ticker of the "Bloomberg Barclays U.S. Agg Corporate Bond Index" is "LUACTRUU Index".

U.S. companies. All bonds are at least one year away from final maturity and investment grade bond rating. The only adjustment to this bond sample is that all bonds from companies with no sustainability rating from MSCI ESG Research[32] are excluded.

The sustainable and non-sustainable corporate bond portfolios are generated based on this final sample. To minimize the influences of systematic risk factors, the bonds are grouped according to their industry sector, region of risk, worst credit rating and duration. The grouping factors are described in Table V.1.

Table V.1: Description of the Grouping Factors for the Matching Process

Factor	Description	Groups
Industry Sector	Industry sector based on the Bloomberg Industry Sector Classification System (BICS).	Basic Materials, Communication, Consumer Cyclical, Consumer Non-Cyclical, Energy, Financial, Industrial, Technology, Utility.
Region of Risk	The region where the company has the biggest business risk exposure (based on country of risk).	Africa/ Middle East, Asia Pacific, North America, South and Central America, Western Europe.
Credit Rating	The worst bond credit rating from S&P, Moody's and Fitch.	Better than AA-, from A+ to A-, worse than BBB+.
Duration	The option-adjusted duration (OAD) of a bond.	Below 3%, 3% - 5%, 5% - 7%, 7% - 10%, 10% - 15%, 15% - 20%, above 20%.

After assigning every bond to a group, the bonds within each group are ranked according to their sustainability score. The 25 percent of bonds with the highest sustainability score within each group are assigned to the sustainable portfolio, whereas the 25 percent of bonds with the lowest sustainability score are assigned to the non-sustainable portfolio. In both portfolios, all bonds were equally weighted. This process was repeated for every year to account for changing

[32] For a discussion of the properties and behavior of the MSCI ESG scores, see Polbennikov et al. (2016).

sustainability scores, maturities and newly issued bonds. Table V.2 provides a short overview of the differences in the most important portfolio characteristics to further investigate potential variances in the portfolio composition.

Table V.2: Development of the Differences of the Key Portfolio Characteristics of the Sustainable and Non-Sustainable Portfolio

	2013	2014	2015	2016	2017	2018
Coupon	0.12%	0.18%	0.15%	0.11%	-0.02%	-0.03%
Yield-to-Worst	-0.01%	-0.03%	-0.07%	-0.08%	-0.07%	-0.08%
Credit Spread	-4.97 bp	-4.41 bp	-9.25 bp	-7.88 bp	-7.63 bp	-8.23 bp
Modified Duration	0.02%	-0.01%	0.08%	0.03%	0.01%	0.01%
Spread Duration	0.07%	0.03%	0.11%	0.03%	0.00%	0.02%
DTS	-0.30%	-0.07%	-0.48%	-0.51%	-0.59%	-0.58%

Note: This table shows the differences in the portfolio characteristics of the high and low ESG portfolios at the respective year-ends.

Despite matching the key characteristics of both portfolios, the sustainable portfolio has a lower credit spread during the sample period, which is in line with the results of Polbennikov et al. (2016). As a result of the difference in their credit spread, both portfolios' yield-to-worst and the DTS differ. Because of the matching process, the modified duration and the spread duration are nearly identical between the portfolios. Thus, both portfolios have the same exposure to parallel shifts in interest rate and credit spread curves.

After investigating the main differences in the portfolio composition, the return time series of each portfolio is briefly analyzed. Table V.3 presents the distribution of the weekly returns during the five-year period of both portfolios.

Table V.3: Distribution of the Excess Returns for the Sustainable and Non-Sustainable Portfolio

	Low ESG Portfolio	**High ESG Portfolio**
Minimum	-1.772%	-1.883%
1. Quartile	-0.216%	-0.233%
Median	0.055%	0.054%
Mean	0.053%	0.051%
3. Quartile	0.435%	0.391%
Maximum	1.271%	1.293%

Note: This table shows the distribution of the weekly excess returns of the high and low ESG portfolios from 27 December 2013 to 28 December 2018.

The average return of both portfolios is almost equal. In contrast, the minimum and maximum values suggest that the weekly returns of the more sustainable portfolio deviate more from the mean, indicating higher volatility. In particular, in the weeks where the portfolios do not perform well, the more sustainable portfolio exhibits lower returns. These observations are counterintuitive and conflict with our stated hypotheses, though the differences are only marginal.

To further investigate the differences between the systematic credit risk exposure of both portfolios, we use the two-factor Fama and French approach, which explains the excess return[33] of bond portfolios (r_t) with a term- and default-factor. The term-factor ($TERM_t$) is designed to capture the return resulting from the price change and carry of treasury bonds. It is calculated by subtracting the one-week USD-LIBOR, as a measure of the risk-free interest rate, from the weekly return of a long-term U.S. treasury index. The default-factor (DEF_t) explains all returns attributable to credit spreads. This factor is derived from subtracting a long-term U.S. corporate bond index from the long-term U.S. treasury index[34]. Fama and French (1993) verified that these two factors can explain almost all variations of U.S. investment grade corporate bond portfolios. Hence, this straightforward framework is used to analyze the differences in the

[33] The excess return of a portfolio is calculated by subtracting the one-week USD-LIBOR from the weekly returns of the respective portfolios.

[34] The long-term U.S. treasury index is the "Bloomberg Barclays U.S. Treasury: 7–10 Year TR Index" (LT09TRUU Index) and the long-term U.S. corporate bond index is the "Bloomberg Barclays U.S. Corporate Bond: 7–10 Year TR Index" (I13283US Index).

systematic default risk of more and less sustainable corporate bond portfolios by regressing the excess return time series and the return differences of both portfolios. The model is summarized in the following equitation:

$$r_t = \alpha + \beta_1 * TERM_t + \beta_2 * DEF_t + \varepsilon_t$$

Additionally, the robustness of the findings is analyzed by employing a different model to explain the returns, repeating the regression for alternate periods, varying the cut-off value to classify a bond as sustainable or not and testing the significance of the difference in the default risk factors with a bootstrap-procedure.

4. Results

The regression results for the sustainable and non-sustainable corporate bond portfolio, as well as their return difference using the Fama and French two-factor model, are presented in the following section. The table below summarizes the results of the two-factor regression of the respective return time series.

Table V.4: Results of the Two-Factor Regression Adapted from Fama and French (1993)

	High ESG Portfolio	**Low ESG Portfolio**	**Difference**
Intercept ("Alpha")	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
TERM	0.819*** (0.019)	0.821*** (0.018)	0.002 (0.005)
DEF	0.691*** (0.048)	0.763*** (0.049)	0.072*** (0.011)
Adj. R^2	0.932	0.936	0.235
N	261	261	261

Notes: This table presents coefficients and Newey-West corrected standard errors from the time-series OLS regression of the weekly excess returns from sustainable and non-sustainable corporate bond portfolios, as well as the difference of both return time series on the two Fama and French bond factors. The sample period ranges from 28 December 2013 to 28 December 2018. The data is derived from Bloomberg and MSCI. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

The results in table V.4 show that the regression model can explain over 90 percent of the variation in returns over time for the sustainable and non-sustainable portfolios, as well as almost 25 percent of the variation of their return differences.

The systematic risk factors can explain almost the entire variation of portfolio returns. The term-factor, which reflects the return attributable to the exposure to interest rate risk, is significant and positive for both portfolios. Additionally, the exposure to this risk factor does not differ significantly between the portfolios. Even though the term-factor is positive in the regression of the return differences, it is not significant. More importantly, the default-factor is significant and positive for the two portfolios. Though, in contrast to the term-factor, the regression of the return differences highlights a significant difference in the systematic default risk exposure, which is notably lower for the more sustainable corporate bond portfolio. As previously argued, the lower risk of the more sustainable securities, in combination with the lack of any diversification penalty, leads to significantly lower exposure to the default risk factor at the portfolio level.

Neither the sustainable nor the non-sustainable portfolio has a significant risk-adjusted outperformance. Even though the less sustainable portfolio has a higher yield and thus a higher carry, the regression results highlight that neither portfolio has a significant risk-adjusted outperformance over the other. This result suggests that adopting sustainable practices does not cost any portfolio return.

The hypothesis that sustainable corporate bond portfolios, which are created based on the best-in-class approach, have a lower systematic default risk is confirmed. Therefore, applying a best-in-class approach in the investment process for corporate bonds does not lead to a significant performance penalty because all return differences can be attributed to different exposures to the systematic default risk factor. Thus, a best-in-class strategy is an instrument to control a portfolio's systematic default risk exposure without a loss in diversification through biases in the portfolio allocation. If a best-class approach is implemented, the portfolio manager must understand the bias in the systematic default risk exposure. For instance, bonds with lower credit ratings could be moderately over-weighted in a sustainable corporate bond strategy to contain active systematic default risk exposure.

5. Robustness Checks

Several robustness checks are calculated to validate the results. First, the return time series is analyzed using a different model, which was first introduced by Elton et al. (1995). Second, the regressions are calculated for alternate periods to determine if there is any variation in the results over time. Third, the cut-off value to classify a bond as sustainable or not is changed to analyze whether varying levels of sustainability affect the results. Finally, in addition to the analyses of the return differences, a bootstrap procedure is used to test if the difference in the default risk factors is significant.

Robustness Check 1: Four-factor model by Elton et al. (1995)

This section addresses whether the results change when a different factor model is applied to explain the excess returns of the sustainable and the non-sustainable portfolios. In contrast to the two-factor model by Fama and French (1993), the four-factor model by Elton et al. (1995) incorporates market risk factors as well as two distinct bond risk factors. The first two systematic risk factors refer to the equity ($EQUITY_t$) and bond market ($BOND_t$). The last two factors cover systematic default risk ($DEF\ (2)_t$) and a premium for optionality ($OPTION_t$).[35] The following equitation describes the model:

$$r_t = \alpha + \beta_1 * EQUITY_t + \beta_2 * BOND_t + \beta_3 * DEF\ (2)_t + \beta_4 * OPTION_t + \varepsilon_t$$

The most important modification from the two-factor model is that Elton et al. (1995) measure the default risk factor differently. They use the difference in returns from a U.S. high yield corporate bond index and a U.S.-intermediate treasury bond index to gauge the systematic default risk factor. The results are summarized in Table V.5.

[35] The respective factors are measured as follows: (1) EQUITY = S&P 500 TR Index (SPXT Index) – return from a risk-free investment (1-week USD LIBOR), (2) BOND = Bloomberg Barclays U.S. Agg Index (LBUSTRUU Index) – return from a risk-free investment (1-week USD LIBOR), (3) DEF (2) = Bloomberg Barclays U.S. Corporate Bond High Yield Index (LF98TRUU Index) – Bloomberg Barclays U.S. Intermediate Treasury Index (LT08TRUU Index), (4) OPTION = Bloomberg Barclays U.S. MBS Fixed Rate Index (LD10TRUU Index) – Bloomberg Barclays U.S. Treasury 1–5y Index (LTR1TRUU Index).

Table V.5: Results of the Four-Factor Regression by Elton et al. (1995)

	High ESG Portfolio	Low ESG Portfolio	Difference
Intercept (“Alpha”)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
EQUITY	-0.005 (0.005)	-0.003 (0.005)	0.002 (0.002)
BOND	1.347*** (0.036)	1.339*** (0.036)	-0.008 (0.012)
DEF (2)	0.120*** (0.018)	0.140*** (0.019)	0.020*** (0.006)
OPTION	-0.380*** (0.069)	-0.377*** (0.023)	0.002 (0.023)
Adj. R^2	0.940	0.935	0.172
N	261	261	261

Notes: The table presents coefficients and Newey-West corrected standard errors from the time-series OLS regressions of the weekly excess returns from sustainable and non-sustainable corporate bond portfolios, as well as the difference of both return time series on the four-factor model by Elton et al. (1995). The sample period is from 2014 to 2018, and the data is derived from Bloomberg and MSCI. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

This model has the same fit as the two-factor model and explains more than 90 percent of the variation in excess returns from both corporate bond portfolios. The bond-related risk factors are highly significant, whereas the equity-market factor has no significant explanatory power. Additionally, the default risk factor is significant for the return difference between the corporate bond portfolios. This finding indicates less sustainable portfolios have a significantly higher systematic default risk exposure, as well. Hence, sustainable corporate bond portfolios have a significantly lower systematic default risk, irrespective of the regression model.

Robustness Check 2: Analyzing the stability over different periods

After testing the validity of the proposed relationship with a different model, it is analyzed if the impact of sustainability on the systematic credit risk exposure is stable over time. For this purpose, we divide our original sample into two sub-samples that cover early and late periods. One contains the data for the first two and a half years (early period), and the other covers the last two and a half years (late period). The results for both samples are presented in Table V.6.

Table V.6: Results of the Two-Factor Regression for Early and Late Periods

	Early Period			**Late Period**		
	High ESG Portfolio	**Low ESG Portfolio**	**Difference**	**High ESG Portfolio**	**Low ESG Portfolio**	**Difference**
Intercept (“Alpha”)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000* (0.000)	0.000 (0.000)
Term-Factor	0.794*** (0.029)	0.801*** (0.029)	0.007 (0.005)	0.856*** (0.029)	0.851*** (0.020)	-0.004 (0.008)
Default-Factor	0.650*** (0.067)	0.712*** (0.090)	0.063*** (0.013)	0.751*** (0.066)	0.841*** (0.055)	0.090*** (0.020)
Adj. R^2	0.927	0.932	0.168	0.941	0.944	0.341
N	130	130	130	130	130	130

Notes: This table presents coefficients and Newey-West corrected standard errors from the time-series OLS regression of the weekly excess returns from the sustainable and non-sustainable corporate bond portfolios, as well as the difference of both return time series on the two Fama and French bond factors for different periods. The early sample period is from January 2014 to June 2016, whereas the late sample period is from June 2016 to December 2018. The data is derived from Bloomberg and MSCI. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

The results are nearly identical to the findings based on the aggregate sample, though the absolute default risk exposure for both portfolios and the difference in the default risk exposure increased over time. These results highlight the rising impact of sustainability on the systematic default risk exposure, potentially stimulated by greater public attention to sustainability issues (Leiserowitz et al., 2018). However, the general effect does not change over time: more sustainable corporate bond portfolios have a lower exposure to systematic credit risk.

Robustness Check 3: Variation of the degree of sustainability

The original portfolio creation process classified the issuers of bonds with a cut-off value from 25 percent (75 percent) as sustainable (non-sustainable). In other words, a bond is allocated to the sustainable portfolio if the issuer is among the sample’s 25 percent most sustainable companies. The relationship’s stability over different cut-off values and, thus, varying levels of sustainability are tested. Therefore, we change the cut-off values to 12.5 percent (87.5 percent) and 33.3 percent (66.6 percent), respectively. The results for the higher cut-off value (12.5 percent) and the lower cut-off value (33.3 percent) are displayed in the table below:

Table V.7: Results of the Two-Factor Regression of the Excess Returns for Different Sustainability Cut-off Values

	Higher Cut-off Value (12.5 percent)			**Lower Cut-off Value (33.3 percent)**		
	High ESG Portfolio	**Low ESG Portfolio**	**Difference**	**High ESG Portfolio**	**Low ESG Portfolio**	**Difference**
Intercept (“Alpha”)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Term-Factor	0.806*** (0.021)	0.807*** (0.019)	0.001 (0.006)	0.820*** (0,019)	0.826*** (0,019)	0.007* (0.0372)
Default-Factor	0.628*** (0.053)	0.739*** (0.059)	0.111*** (0.017)	0.695*** (0.048)	0.771*** (0.053)	0.075*** (0.009)
Adj. R^2	0.928	0.934	0.298	0.933	0.938	0.297
N	261	261	261	261	261	261

Notes: This table presents coefficients and Newey-West corrected standard errors from the time-series OLS regression of the weekly excess returns from the sustainable and non-sustainable corporate bond portfolios with higher and lower cut-off values, respectively, as well as the difference of both return time series on the two Fama and French bond factors. The sample period is from 2014 to 2018, and the data is derived from Bloomberg and MSCI. *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively.

Irrespective of the cut-off value, the more sustainable corporate bond portfolio has a lower exposure to systematic credit risk. Thus, the previous results are confirmed by these findings. Furthermore, the effect is more pronounced if a stricter cut-off value is applied. In contrast, the difference between the systematic default risk exposures decreases if the cut-off values are less strict. Hence, the results suggest that an increasing sustainability difference leads to higher differences in credit risk exposure.

Robustness Check 4: Measuring the significance based on bootstrapped default risk factor exposures

This robustness check challenges the study methodology by modifying the significance test for the difference between default risk factor exposures. To test if the differences in the default risk exposure are significant, the regression is repeated 10,000 times using resampled time series. Based on this procedure the default risk exposure distributions for the sustainable and non-sustainable corporate bond portfolios are calculated, which are displayed below.

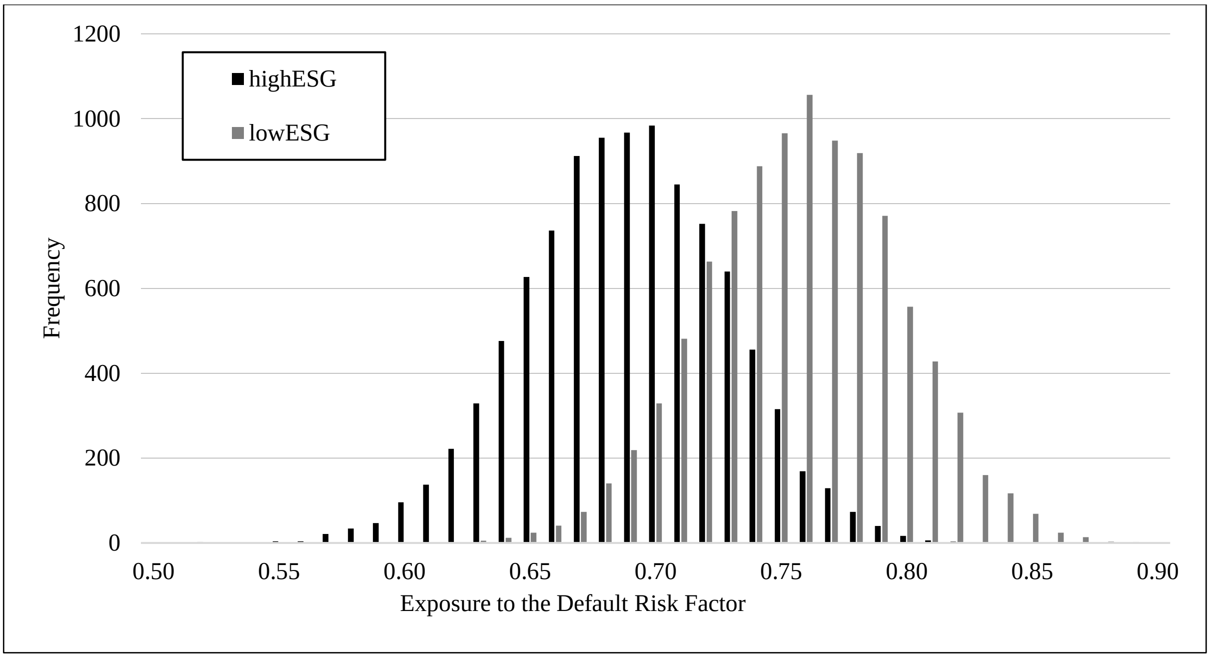

Figure V.1: Histogram of the Bootstrapped Default Risk Factors for the Sustainable and Non-Sustainable Portfolio

The means of the distributions are 0.68 and 0.75 for the sustainable and non-sustainable portfolios, respectively. These values are similar to the results of our original two-factor regressions. Moreover, we analyzed the significance of the differences in means with a two-sided *t*-test which confirmed the previous findings.[36]

Finally, we conclude that the initially stated results are highly robust to different model frameworks, a variation of the considered period, changing levels of sustainability and

[36] The results of Welch's two-sided *t*-test are summarized in the following: $t = -125.28$, $df = 19973$, $p < 2.2e\text{-}16$.

alternative tests for significance. This suggests that more sustainable corporate bond portfolios, created based on the best-in-class approach, have a lower exposure to systematic default risk, which is consistent with the formulated hypothesis.

6. Conclusion

This study aims to give academics and investment professionals important insights into the impact of sustainability on the systematic default risk exposure of corporate bond portfolios. Our findings highlight that the implementation of a best-in-class strategy significantly affects credit risk exposure without any performance or diversification penalty.

However, investment professionals must account for the lower credit risk exposure of more sustainable portfolios to control their active risks. Portfolio managers of sustainable credit strategies must apply a higher weight to companies with lower credit ratings to compensate for the lower credit risk exposure due to the higher sustainability to avoid active credit risk exposure.

Additionally, the findings suggest that varying the degree of portfolio sustainability is reflected by the default risk exposure. Furthermore, the impact of sustainability increased over time, implying an even more important role of sustainability in the future.

This is the first academic study that analyzes the effect of a best-in-class approach on corporate bond portfolios. Our results confirm previous results regarding stocks and expand the existing research on bonds, thus contributing to the current academic discussion.

Further research should investigate the reported relationships for different fixed-income segments, such as high yield or emerging market credit, because the demand from clients in these segments is surging, and the impact of sustainability could be more pronounced due to higher information asymmetries and lower regulations.

Appendix to Chapter II

Definitions of SRI Strategies according to EUROSIF (2012):

Negative Screens: An approach that excludes specific investments or classes of investment from the investible universe such as companies, sectors, or countries.

Positive Screens: Sustainable themed investments, Best-in-Class selection and norms-based screening are defined as positive screens. Sustainable themed investments are investments in themes or assets linked to the development of sustainability. Thematic funds focus on specific or multiple issues related to ESG. Best-in-Class selection is defined as an approach where leading or best-performing investments within a universe, category, or class are selected or weighted based on ESG criteria. Norms-based screening comprise investments if they are screened according to their compliance with international standards and norms.

Engagement and Voting: Engagement activities and active ownership through voting of shares and engagement with companies on ESG matters. This is a long-term process, seeking to influence behavior or increase disclosure.

Integration: The explicit inclusion by asset managers of ESG risks and opportunities into traditional financial analysis and investment decisions based on a systematic process and appropriate research sources.

Table A.1: Descriptive Statistics for Relevant Variables

	Variables	Mean	Median	SD	Minimum	Maximum	N
SRI Strategies	**Negative Screens**	24.525	13.290	27.076	1.844	93.063	62
	Positive Screens	10.777	4.267	11.967	218	30.945	72
	Engagement and Voting	9.640	2.256	11.070	133	27.967	69
	Integration	7.466	5.790	6.884	114	22.250	62
Development Factors	**GDP**	37.894	35.380	11.567	22.682	64.831	78
	Pens	39.065	28.074	42.292	2.395	134.393	57
Cultural Factors	**UAI**	60	59	22	23	94	13
	IDV	70	71	10	51	89	13
	MAS	43	43	27	5	79	13
	PDI	39	35	17	11	68	13

Notes: This table shows key descriptive statistics of all dependent (SRI strategies) and independent (economic, financial and culture factors) variables in our regression analysis for the 13 countries for every second year from 2005 to 2015. The SRI strategies and the economic (GDP) and financial (Pens) variables are denominated in euros and scaled per capita. The cultural factors are based on the methodology from *Hofstede* (1980) and range from 0 to 100.

Table A.2: Average of the Variables on a Country-Level

Variables	AT	BE	CH	DE	DK	ES	FI
Negative Screens	2,446	14,547	93,063	9,985	30,648	1,844	13,290
Positive Screens	392	1,863	1,801	218	30,945	230	11,635
Engagement and Voting	197	2,256	1,709	133	22,611	184	6,854
Integration	114	5,370	3,432	167	8,815	973	5,790
GDP	35,526	33,311	56,602	32,425	43,674	22,682	35,380
Pens	2,395	2,650	99,366	12,926	134,393	2,928	28,074
UAI	70	94	58	65	23	86	59
MAS	79	54	70	66	16	42	26
IDV	55	75	68	67	74	51	63
PDI	11	65	34	35	18	57	33

Variables	FR	IT	NL	NO	SE	UK
Negative Screens	3,532	6,823	41,221	56,344	39,422	5,658
Positive Screens	9,425	3,153	18,215	29,466	28,486	4,267
Engagement and Voting	347	325	27,967	22,305	22,965	17,463
Integration	14,018	927	22,250	6,919	14,500	13,777
GDP	30,817	26,776	37,548	64,831	40,055	33,000
Pens	8,735	4,367	74,670	28,914	55,932	52,496
UAI	86	75	53	50	29	35
MAS	43	70	14	8	5	66
IDV	71	76	80	69	71	89
PDI	68	50	38	31	31	35

Notes: This table presents the average of all dependent (SRI strategies) and independent (economic, financial and culture factors) variables in our regression analysis for the countries in our sample. The SRI strategies and the economic (GDP) and financial (Pens) variables are denominated in euros and scaled per capita. The cultural factors are based on the methodology from Hofstede (1980) and range from 0 to 100. Our sample contains observations from 13 countries for every second year from 2005 to 2015. All SRI strategies are winsorized per country and year at the 10% level in both tails of the distribution.

Table A.3: Pearson Correlation Coefficients for Development Factors and Cultural Factors

	GDP		Pens	
Gross Domestic Product (GDP)	1			
Pensions (Pens)	0.53	***	1	
Uncertainty Avoidance (UAI)	-0.42	***	-0.75	***
Masculinity (MAS)	-0.32	***	-0.38	***
Individualism (IDV)	0.08		0.42	***
Power Distance (PDI)	-0.41	***	-0.41	***

Note: This table presents the Pearson correlation between the economic, financial and culture factors. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

Table A.4: Robustness Test Development Factors

$Strategy_i = \beta_0 + \beta_1 Economic\ Development_i + \beta_2 Financial\ Development_i + \varepsilon_i$				
	Negative Screens	**Positive Screens**	**Engagement and Voting**	**Integration**
GDP	1.828***	0.302	0.247	0.025
	(0.195)	(0.351)	(0.304)	(0.128)
Pens	0.168*	0.215**	0.300***	0.108
	(0.096)	(0.109)	(0.086)	(0.072)
Constant	-51,512.190***	-7,367.572	-10,539.380	3,744.386
	(7,752.156)	(10,219.230)	(10,148.770)	(5,252.550)
FE Country	Yes	Yes	Yes	Yes
FE Year	No	No	No	No
Observations	52	56	53	49
Adj. R^2	0.655	0.27	0.428	0.09
SE of regression	16,617.854	6,704.224	5,494.310	6,842.709
F Statistic	49.446***	11.173***	20.468***	2.213

Notes: This table presents the estimation results from the random effects model on the SRI strategies (Negative Screens, Positive Screens, Engagement and Voting and Integration) on the economic and financial development variables. Arellano-clustered standard errors (in parentheses) are applied to account for heteroscedasticity and autocorrelation. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

Table A.5: Robustness Test Culture Factors

$$Strategy_i = \beta_0 + \beta_1 Uncertainty\ Avoidance_i + \beta_2 Masculinity_i + \beta_3 Individualism_i + \beta_4 Power\ Distance_i + \varepsilon_i$$

	Negative Screens	**Positive Screens**	**Engagement and Voting**	**Integration**
UAI	2.272	99.977	-19.021	36.619
	(707.970)	(109.248)	(129.224)	(153.436)
MAS	-372.284	-459.199***	-292.366***	-160.848**
	(469.947)	(61.843)	(65.754)	(72.762)
IDV	487.135	424.023***	576.744***	515.979***
	(619.171)	(127.562)	(198.754)	(191.080)
PDI	-467.218	-307.652***	-240.513*	22.463
	(625.153)	(109.001)	(144.199)	(170.676)
Constant	24,865.590	8,749.621	-6,120.752	-22,999.050
	(48,148.990)	(10,276.120)	(13,898.490)	(14,973.410)
FE Country	No	No	No	No
FE Year	No	No	No	No
Observations	52	56	53	49
Adj. R^2	0.115	0.687	0.67	0.359
SE of regression	29,981.495	8,252.816	7,804.348	8,174.994
F Statistic	2.663**	31.150***	27.359***	7.716***

Notes: This table presents the estimation results from the ordinary least squares model on the SRI strategies (Negative Screens, Positive Screens, Engagement and Voting and Integration) on the time invariant cultural variables. Arellano-clustered standard errors (in parentheses) are applied to account for heteroscedasticity and auto-correlation. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

Table A.6: Robustness Test Gini Index

$$Strategy_i = \beta_0 + \beta_1 Economic\ Development_i + \beta_2 Financial\ Development_i + \beta_3 Uncertainty\ Avoidance_i + \beta_4 Masculinity_i + \beta_5 Individualism_i + \beta_6 Power\ Distance_i + \beta_7 Gini\ Index_i + \varepsilon_i$$

	Negative Screens	Positive Screens	Engagement and Voting	Integration
GDP	2.107***	0.270*	0.238	0.081
	(0.204)	(0.150)	(0.174)	(0.112)
Pens	0.220**	0.083	0.129**	0.078
	(0.087)	(0.055)	(0.055)	(0.062)
UAI	534.936	489.057***	593.660**	412.543*
	(329.557)	(167.413)	(246.515)	(216.659)
MAS	-445.044**	-644.766***	-596.246***	-351.781**
	(186.252)	(156.030)	(195.973)	(157.262)
IDV	456.498	661.779**	1,036.758***	783.665***
	(322.333)	(283.455)	(325.309)	(242.698)
PDI	-246.536	-599.038**	-759.975**	-321.260
	(321.464)	(237.995)	(304.825)	(276.791)
Gini Index	3,414.749***	1,789.014**	2,667.658**	1,580.467
	(1,267.335)	(788.534)	(1,257.000)	(1,211.556)
Constant	-203,855.900***	-79,995.220**	-137,478.700**	-97,325.830**
	(56,257.460)	(31,071.500)	(54,072.490)	(49,083.350)
FE Country	Yes	Yes	Yes	Yes
FE Year	No	No	No	No
Observations	52	56	53	49
Adj. R^2	0.655	0.55	0.544	0.132
SE of regression	15,971.122	6,932.529	6,035.5	6,796.989
F Statistic	14.846***	10.595***	9.862***	2.040*

Notes: This table presents the estimation results from the random effects model on the SRI strategies (Negative Screens, Positive Screens, Engagement and Voting and Integration) on the economic and financial development (including the Gini index) and culture variables. Arellano-clustered standard errors (in parentheses) are applied to account for heteroscedasticity and autocorrelation. ***, **, * denote statistical significance at the 1%, 5% and 10% level, respectively.

Appendix to Chapter III

Table B.1: Descriptive Statistics of Variables

	Min.	25%	Median	Mean	75%	Max.	Obs.
CDS	3.7	49.2	73.9	122.9	129.7	3551.3	1,562
RET	-0.921	-0.139	0.053	0.093	0.275	8.789	1,756
VOL	0.065	0.207	0.254	0.289	0.333	1.715	1,760
LEV	0.001	0.185	0.257	0.285	0.373	0.966	1,816
PROF	-0.270	0.043	0.065	0.074	0.099	0.445	1,816
Market Cap. (in mn)	525.1	8,029.0	16,255.5	29,035.2	34,391.1	232,241.3	1,749
ENV	1.710	5.468	6.500	6.538	7.500	10.000	1,156

Note: This table shows the key descriptive statistics of all variables used in the regression. The variables are presented without being normalized by logarithms.

Table B.2: Pearson Correlation of Variables

	CDS	RET	VOL	LEV	PROF	Market Cap.	ENV
CDS	1.000	-0.245	0.670	0.130	-0.276	-0.443	-0.016
RET	-0.245	1.000	-0.278	-0.012	0.055	0.108	-0.034
VOL	0.670	-0.278	1.000	-0.048	-0.187	-0.359	-0.019
LEV	0.130	-0.012	-0.048	1.000	0.133	-0.033	0.085
PROF	-0.276	0.055	-0.187	0.133	1.000	0.122	-0.006
Market Cap.	-0.443	0.108	-0.359	-0.033	0.122	1.000	0.000
ENV	-0.016	-0.034	-0.019	0.085	-0.006	0.000	1.000

Note: This table shows the Pearson correlation of all variables used in the regression.

Appendix to Chapter IV

Table C.1: Sectoral Sample Distribution

Sector	Frequency	Share (in %)
Consumer Discretionary	367	16.29
Utilities	347	15.4
Industrials	279	12.38
Materials	249	11.05
Communications	243	10.79
Energy	240	10.65
Consumer Staples	208	9.23
Health Care	168	7.46
Technology	152	6.75
Sum	2,253	100

Note: This table provides the sectoral distribution of the companies in our sample. Macro sectors refer to level 1 of Bloomberg Industry Classification System (BICS). The table displays the frequency and the relative share of each sector.

Table C.2: Geographical Sample Distribution

Country	**Frequency**	**Share (in %)**
United States	1,419	62.98
United Kingdom	137	6.08
Germany	104	4.62
France	89	3.95
Canada	69	3.06
Spain	50	2.22
Italy	40	1.78
Switzerland	37	1.64
Australia	28	1.24
Belgium	28	1.24
Mexico	24	1.07
Rest of the Sample	228	10.12
Sum	2,253	100

Note: This table provides the geographical distribution of the companies in our sample. The table displays the frequency and the relative share of countries with more than 1% relative share.

Table C.3: Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) ln(Credit Spread)	1.00						
(2) Carbon Emission (CE) Score	-0.32*	1.00					
(3) Carbon Emission Exposure (CEE) Score	0.16*	-0.78*	1.00				
(4) Carbon Emission Management (CEM) Score	-0.34*	0.68*	-0.13*	1.00			
(5) Climate Regulatory Environment (RegEnv)	-0.14*	0.09*	0.02*	0.03*	1.00		
(6) Time to Maturity	0.25*	0.05*	-0.02*	0.08*	-0.07*	1.00	
(7) Callable	0.19*	-0.10*	0.09*	-0.17*	-0.07*	0.02*	1.00
(8) Currency	-0.28*	0.17*	-0.06*	0.19*	0.23*	-0.21*	-0.15*
(9) ln(Total Assets)	-0.32*	0.32*	-0.20*	0.39*	0.03*	0.15*	-0.26*
(10) EBIT/Total Assets	-0.20*	0.14*	-0.23*	0.07*	-0.04*	0.07*	-0.05*
(11) Leverage	0.11*	0.13*	-0.18*	-0.01*	-0.02*	-0.05*	0.05*
(12) Free Cash Flow/ Total Assets	-0.15*	0.01*	-0.02*	0.06*	-0.09*	0.06*	0.00
(13) Equity Volatility	0.34*	-0.32*	0.24*	-0.26*	-0.08*	-0.16*	0.09*

Note: This table presents the Bravais-Pearson pairwise correlation coefficients. * denotes statistical significance at the 5% level. In addition to the correlation analysis, we calculated the VIF values which are not concerning.

Table C.3 (continued): Correlation Matrix

Variables	(8)	(9)	(10)	(11)	(12)	(13)
(1) ln(Credit Spread)						
(2) Carbon Emission (CE) Score						
(3) Carbon Emission Exposure (CEE) Score						
(4) Carbon Emission Management (CEM) Score						
(5) Climate Regulatory Environment (RegEnv)						
(6) Time to Maturity						
(7) Callable						
(8) Currency	1.00					
(9) ln(Total Assets)	0.10*	1.00				
(10) EBIT/Total Assets	-0.07*	-0.06*	1.00			
(11) Leverage	-0.01*	-0.15*	0.10*	1.00		
(12) Free Cash Flow/ Total Assets	-0.10*	-0.08*	0.65*	0.06*	1.00	
(13) Equity Volatility	-0.04*	-0.34*	-0.22*	0.07*	-0.10*	1.00

Note: This table presents the Bravais-Pearson pairwise correlation coefficients. * denotes statistical significance at the 5% level. In addition to the correlation analysis, we calculated the VIF values which are not concerning.

Table C.4: Relationship between Carbon-Risk, Exposure and Management and Credit Spreads - Using Direct Matches

	(1) CE Full Sample	(2) CEE & CEM Full Sample	(3) Below Median CEE Sample	(4) Above Median CEE Sample	(5) CEE & CEM Full Sample
CE	-0.027***				
	(0.003)				
CEE		0.011**			
		(0.005)			
High Exposure					0.150***
					(0.041)
High Exposure X CEM					-0.033***
					(0.007)
CEM		-0.033***	-0.028***	-0.039***	-0.017***
		(0.004)	(0.006)	(0.006)	(0.005)
Time to Maturity	0.044***	0.046***	0.052***	0.038***	0.045***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(Total Assets)	-0.213***	-0.203***	-0.197***	-0.239***	-0.209***
	(0.007)	(0.007)	(0.010)	(0.010)	(0.007)
EBIT / Total Assets	-1.510***	-1.501***	-1.394***	-1.723***	-1.560***
	(0.109)	(0.122)	(0.198)	(0.142)	(0.122)
Leverage	0.492***	0.452***	0.417***	0.365***	0.429***
	(0.028)	(0.029)	(0.039)	(0.047)	(0.029)
Free Cash Flow / Total Assets	-2.815***	-2.670***	-2.875***	-2.383***	-2.619***
	(0.133)	(0.148)	(0.213)	(0.202)	(0.146)
Equity Volatility	2.254***	2.345***	2.262***	2.170***	2.317***
	(0.066)	(0.072)	(0.115)	(0.090)	(0.072)
Currency	-0.430***	-0.460***	-0.402***	-0.494***	-0.461***
	(0.022)	(0.024)	(0.031)	(0.036)	(0.024)
Callable	0.276***	0.244***	0.250***	0.218***	0.244***
	(0.016)	(0.016)	(0.023)	(0.022)	(0.016)
Observations	38803	30419	15522	14897	30419
Adj. R^2	0.534	0.545	0.510	0.592	0.545

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon-risk related scores (CE, CEE, CEM) and control variables. The CE score measures a company's carbon-risk performance, while the CEE score measures the company's exposure to carbon-risk and the CEM score captures the ability to manage this risk. The control variables include bond and company specific effects. High Exposure is a dummy-variable which indicates if the CEE score of a company is above (High Exposure = 1) or below (High Exposure = 0) the median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients. The sample is restricted to direct matches, i.e., observations where we can directly match company-specific data using the company ISIN.
*, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

Table C.5: The moderating Role of the Climate Regulatory Environment on the Relationship between Carbon-Risk, Exposure and Management to Credit Spreads - Using Direct Matches

	(1) CE Full Sample	(2) Below Median National Climate Policy Score within CEE & CEM Sample	(3) Above Median National Climate Policy Score within CEE & CEM Sample	(4) CEE & CEM Full Sample
CE	-0.024*** (0.003)			
RegEnv X CE	-0.008** (0.003)			
CEE		0.023*** (0.005)	-0.000 (0.006)	0.016*** (0.005)
RegEnv X CEE				-0.009** (0.004)
CEM		-0.032*** (0.005)	-0.034*** (0.005)	-0.022*** (0.004)
RegEnv X CEM				-0.026*** (0.005)
RegEnv	0.128*** (0.026)			0.311*** (0.036)
Time to Maturity	0.044*** (0.001)	0.044*** (0.001)	0.048*** (0.001)	0.046*** (0.001)
Ln(Total Assets)	-0.213*** (0.007)	-0.190*** (0.008)	-0.222*** (0.010)	-0.203*** (0.007)
EBIT / Total Assets	-1.519*** (0.109)	-1.475*** (0.131)	-1.634*** (0.188)	-1.501*** (0.122)
Leverage	0.492*** (0.028)	0.445*** (0.031)	0.449*** (0.043)	0.454*** (0.029)
Free Cash Flow / Total Assets	-2.806*** (0.133)	-2.744*** (0.163)	-2.361*** (0.237)	-2.674*** (0.147)
Equity Volatility	2.265*** (0.066)	2.251*** (0.081)	2.581*** (0.106)	2.361*** (0.073)
Currency	-0.430*** (0.022)	-0.298*** (0.026)	-0.634*** (0.031)	-0.459*** (0.024)
Callable	0.275*** (0.016)	0.157*** (0.017)	0.324*** (0.021)	0.241*** (0.016)
Observations	38,803	16,693	13,726	30,419
Adj. R^2	0.535	0.544	0.553	0.546

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon-risk related scores (CE, CEE, CEM), bonds' climate regulatory environment, the interaction between MSCI carbon-risk related scores and bonds' climate regulatory environment, and control variables. The CE score measures a company's carbon-risk performance, while the CEE score measures the company's exposure to carbon-risk and the CEM score captures the ability to manage this risk. The control variables include bond and company specific variables. RegEnv is a dummy-variable which indicates if the CCPI National Climate Policy Score is above (RegEnv = 1) or below (RegEnv = 0) median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients. The sample is restricted to direct matches, i.e., observations where we can directly match company-specific data using the company ISIN. *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

Table C.6: Relationship between Carbon-Risk, Exposure and Management and Credit Spreads - ln(Emission Intensity)

	(1) ln(Emission Intensity) & CEM Full Sample	(2) Below Median ln(Emission Intensity) Sample	(3) Above Median ln(Emission Intensity) Sample	(4) ln(Emission Intensity) & CEM Full Sample
ln(Emission Intensity)	0.037***			
	(0.007)			
High Exposure				0.237***
				(0.040)
High Exposure X CEM				-0.032***
				(0.007)
CEM	-0.028***	-0.032***	-0.058***	-0.011**
	(0.004)	(0.005)	(0.005)	(0.005)
Time to Maturity	0.043***	0.049***	0.038***	0.043***
	(0.001)	(0.001)	(0.001)	(0.001)
ln(Total Assets)	-0.195***	-0.210***	-0.231***	-0.196***
	(0.008)	(0.008)	(0.008)	(0.008)
EBIT / Total Assets	-1.326***	-1.935***	-2.032***	-1.427***
	(0.140)	(0.182)	(0.123)	(0.140)
Leverage	0.480***	0.589***	0.443***	0.474***
	(0.032)	(0.039)	(0.041)	(0.032)
Free Cash Flow / Total Assets	-2.938***	-3.125***	-2.649***	-2.914***
	(0.162)	(0.196)	(0.178)	(0.161)
Equity Volatility	2.294***	1.184***	1.413***	2.259***
	(0.078)	(0.080)	(0.066)	(0.078)
Currency	-0.522***	-0.429***	-0.506***	-0.528***
	(0.026)	(0.025)	(0.030)	(0.026)
Callable	0.266***	0.260***	0.165***	0.269***
	(0.016)	(0.019)	(0.018)	(0.016)
Observations	26,796	21,896	21,160	26,796
Adj. R^2	0.543	0.482	0.551	0.542

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon-risk related scores (CE, CEM), the natural logarithm of companies' Emission Intensity (Ln(Emission Intensity)), and control variables. The CE score measures a company's carbon-risk performance while the CEM score captures the ability to manage this risk. Emission intensity measures the scope 1 and scope 2 emissions divided by turnover. The control variables include bond and company specific effects. High Exposure is a dummy-variable which indicates if the emission intensity of a company is above (High Exposure = 1) or below (High Exposure = 0) the median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients.
*, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

Table C.7: The moderating Role of the Climate Regulatory Environment on the Relationship between Carbon-Risk, Exposure and Management to Credit Spreads – ln(Emission Intensity)

	(1) Below Median National Climate Policy Score within ln(Emission Intensity) & CEM Sample	(2) Above Median National Climate Policy Score within ln(Emission Intensity) & CEM Sample	(3) ln(Emission Intensity) & CEM Fullsample
ln(Emission Intensity)	0.031***	0.045***	0.038***
	(0.006)	(0.009)	(0.007)
RegEnv X ln(Emission Intensity)			-0.003
			(0.005)
CEM	-0.019***	-0.036***	-0.014***
	(0.004)	(0.005)	(0.004)
RegEnv X CEM			-0.030***
			(0.005)
RegEnv			0.292***
			(0.038)
Time to Maturity	0.039***	0.047***	0.043***
	(0.001)	(0.001)	(0.001)
ln(Total Assets)	-0.177***	-0.218***	-0.195***
	(0.008)	(0.010)	(0.008)
EBIT / Total Assets	-1.468***	-1.215***	-1.331***
	(0.157)	(0.192)	(0.139)
Leverage	0.474***	0.470***	0.482***
	(0.033)	(0.044)	(0.032)
Free Cash Flow / Total Assets	-2.946***	-2.825***	-2.934***
	(0.181)	(0.245)	(0.161)
Equity Volatility	2.164***	2.497***	2.306***
	(0.089)	(0.108)	(0.079)
Currency	-0.386***	-0.635***	-0.521***
	(0.029)	(0.031)	(0.026)
Callable	0.206***	0.312***	0.264***
	(0.017)	(0.021)	(0.016)
Observations	13,287	13,509	26,796
Adj. R^2	0.542	0.544	0.544

Note: This table presents the coefficients of pooled OLS estimations of yearly credit spreads on one of the companies' MSCI carbon-risk related scores (CE, CEM), the natural logarithm of companies' Emission Intensity (Ln(Emission Intensity)), bonds' climate regulatory environment, the interaction between MSCI carbon-risk related scores and bonds' climate regulatory environment, and control variables. The CE score measures a company's carbon-risk performance while the CEM score captures the ability to manage this risk. Emission intensity measures the scope 1 and scope 2 emissions divided by turnover. The control variables include bond and company specific variables. RegEnv is a dummy-variable which indicates if the CCPI National Climate Policy Score is above (RegEnv = 1) or below (RegEnv = 0) median in a given year. Standard errors are clustered at the bond level and presented in parentheses. All regressions include year, industry and country dummies. For reasons of readability, we do not display these coefficients. *, ** and *** indicate statistical significance at 10%, 5% and 1% respectively.

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