Can the level of sustainability impact firms' credit risk?
A study on European firms

Marco Silvestri

Dissertation written under the supervision of professor
Mário Henrique Machado Meira

Dissertation submitted in partial fulfilment of requirements for the MSc in Finance at the Universidade Católica Portuguesa, 30/05/2023.

Abstract

Sustainability has become a topic of increasing relevance. This dissertation investigates the impact of sustainability on the credit risk of European firms over the period of 2005 to 2021, aiming to answer the research question of whether the level of sustainability can impact firms' credit risk. Firms' Total ESG Scores and their corresponding Pillar Scores are used as sustainability measures for the analysis. To proxy credit risk, S&P ratings, converted into default probabilities using European transition matrices, are employed, thereby circumventing the problem of non-equidistant scaling of credit ratings. The final dataset consists of 412 European firms.

The multivariate regression results show that a higher level of sustainability can reduce a firm's credit risk. However, these results are conditional on the rating category. Only firms with an investment-grade rating seem to benefit from a higher level of sustainability. Yet the impact of sustainability on their credit risk is not particularly large. Furthermore, the results of a sectoral analysis show that sustainability only has an impact on credit risk in certain industry sectors and that not all firms in the respective industries benefit equally. Finally, a temporal analysis shows that the impact of sustainability varies over time.

Keywords: sustainability, ESG, credit risk, probability of default

Title: Can the level of sustainability impact firms' credit risk? A study on European firms

Author: Marco Silvestri

Resumo

A sustentabilidade tem vindo a tornar-se um tema de crescente relevância. Esta dissertação investiga o impacto da sustentabilidade no risco de crédito das empresas europeias durante o período de 2005 a 2021, com o objectivo de responder à questão de investigação de saber se o nível de sustentabilidade tem impacto no risco de crédito das empresas. Para a análise, os Total ESG Scores das empresas e os correspondentes Pillar Scores são utilizados como medidas de sustentabilidade. Para representar o risco de crédito, são utilizadas as notações da S&P, convertidas em probabilidades de incumprimento utilizando matrizes de transição europeias, contornando assim o problema do escalonamento não equidistante das notações de crédito. O conjunto final de dados é constituído por 412 empresas europeias.

Os resultados da regressão multivariada mostram que um nível mais elevado de sustentabilidade pode reduzir o risco de crédito de uma empresa. No entanto, estes resultados são condicionados pela categoria de notação. Apenas as empresas com uma notação de grau de investimento parecem beneficiar de um nível mais elevado de sustentabilidade. No entanto, o impacto da sustentabilidade no seu risco de crédito não é particularmente grande. Além disso, os resultados de uma análise sectorial mostram que a sustentabilidade só tem impacto no risco de crédito em determinados sectores industriais e que nem todas as empresas dos respectivos sectores beneficiam da mesma forma. Por último, uma análise temporal mostra que o impacto da sustentabilidade varia ao longo do tempo.

Palavras-chave: sustentabilidade, ESG, risco de crédito, probabilidade de incumprimento

Título: Pode o nível de sustentabilidade afectar o risco de crédito das empresas? Um estudo sobre empresas europeias

Autor: Marco Silvestri

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

CRAs	....	Credit Rating Agencies
S&P	....	Standard & Poor’s
TESG-Score	....	Total ESG Score
ENV-Score	....	Environmental Pillar Score
SOC-Score	....	Social Pillar Score
GOV-Score	....	Governance Pillar Score
PD	....	Probability of default
CSR	....	Corporate Social Responsibility
CDS	....	Credit Default Swap
AR	....	Abnormal Returns
IV	....	Idiosyncratic Volatility
WC/TA	....	Working-Capital-To-Total-Assets
RE/TA	....	Retained-Earnings-To-Total-Assets
EBIT/TA	....	EBIT-To-Total-Assets
ME/TL	....	Market-Equity-To-Total-Liabilities
S/TA	....	Sales-To-Total-Assets
NI/TA	....	Net-Income-To-Total-Assets
TL/TA	....	Total-Liabilities-To-Total-Assets
CA/CL	....	Current-Assets-To-Current-Liabilities
OLS	....	Ordinary Least Squares
FE	....	Fixed Effects
GICS	....	Global Industry Classification Standard

1. Introduction

Credit ratings have always been an essential source of information for investors and lenders to assess the credit risk of firms. Ratings are issued by independent Credit Rating Agencies (CRAs) such as Standard & Poor's (S&P), Moody's, and/or Fitch and are based on an analysis of the financial position, business activities, risks, and future prospects of a firm. A good credit rating increases the attractiveness of the debtor on the capital market and can facilitate access to more favorable loans or investments. In contrast, a poor rating can affect the confidence of investors and lenders and result in higher interest rates or stricter credit conditions (S&P Global Ratings, 2022).

Recent years have witnessed a growing awareness of sustainability in society. One major driver of this increased sustainability awareness is undoubtedly climate change, which has become a global challenge and has raised awareness of the need for sustainable practices (The World Bank, 2023). This societal shift has led investors and lenders to attach greater importance to investing in firms that meet environmental and social criteria and behave ethically. Thus, firms are pressured to act more sustainably and improve their business practices to attract or retain investors. Investors and lenders often use ESG Scores to assess sustainability criteria in firms. ESG stands for Environmental, Social, and Governance, and ESG Scores evaluate the sustainability practices and strategies of a firm in these three areas (Li et al., 2021).

The shift toward greater sustainability awareness has also prompted CRAs to consider ESG criteria when evaluating credit risk. This is indicated by the principles for the incorporation of environmental, social, and governance credit factors into credit ratings published by S&P in 2021 (Lemos-Stein et al., 2021). Nevertheless, the exact methodology of how CRAs incorporate sustainability in the form of ESG into their credit rating assessments and to which extent ESG factors impact the credit risk of firms remains a black box (S&P Global Ratings, 2022). Consequently, it is relevant to investigate the impact of ESG on credit risk.

This dissertation aims to answer the research question of whether the level of sustainability can impact the credit risk of firms, focusing on European firms. This is a relevant research question due to the lack of studies examining this impact on European firms. By analyzing the association between ESG Scores and default probabilities of 421 European firms from 2005 to 2021, this dissertation shows that firms with a higher level of sustainability can achieve lower default probabilities. Thus, sustainability has a decreasing effect on credit risk. There may be several explanations for this. For example, polluting firms achieve a higher level of environmental sustainability by reducing carbon emissions or ensuring proper waste disposal. This can avoid fines for violating environmental regulations, promising better future prospects for financial stability and ultimately reducing credit risk. In addition, by creating safer working conditions, firms achieve a higher level of social sustainability, thereby improving their reputation and being less exposed to regulatory scrutiny. This can avoid legal costs, productivity losses, or potential business interruptions, which reduces credit risk.

The effect of sustainability on credit risk seems conditional on the rating category. While the results from the joint analysis of investment-grade and speculative-grade firms do not hold after adding additional control variables, the results for investment-grade firms do hold. Investment-grade firms seem more likely to benefit from a higher level of sustainability. More precisely, investment-grade firms can reduce their credit risk by increasing their Total ESG Score (TESG-Score), Environmental Pillar Score (ENV-Score), or Social Pillar Score (SOC-Score), even if the impact on their probability of default (PD) is not particularly large. A one percentage point increase in either of these scores leads, on average and *ceteris paribus*, to a decrease in the PD by 0,000305, 0,000274, or 0,000247 percentage points, respectively. Interestingly, the Governance Pillar Score (GOV-Score) alone does not appear to have a significant impact on the PD. However, the impact of sustainability depends not only on the rating category but also on the industry in which firms operate. This is shown in a sectoral analysis. A temporal analysis further reveals that the impact of sustainability on credit risk is dynamic. In particular, the impact seems to have increased significantly during the financial crisis. Moreover, it appears to have steadily decreased for investment-grade firms in recent years. Overall, this dissertation contributes to the literature by further analyzing the impact of sustainability on corporate credit risk at a European level and for a more recent period while incorporating a distinction by investment-grade rating.

The dissertation is structured as follows: Chapter 2 provides an overview of the relevant literature on the impact of sustainability on credit risk. Next, Chapter 3 presents the data collection process and the methodology used to answer the research question. This is followed by the presentation of the results in Chapter 4, which are subsequently discussed and compared to the results of the existing literature in Chapter 5 before concluding this dissertation with a summary of the findings and main limitations.

2. Literature Review

The study of Graham et al. (2001) was the first to examine the impact of environmental sustainability on credit risk. The authors explain the impact of off-balance sheet environmental liabilities on the ratings of newly issued bonds. Off-balance sheet environmental liabilities refer to estimated costs for the cleanup of toxic waste contamination that will be charged to the responsible firms in the future under an U.S. environmental program. The results indicate that analysts are incorporating environmental obligations into the bond rating process and that firms can improve their creditworthiness by behaving more sustainably.

Over time, the terms sustainability, Corporate Social Responsibility (CSR), and ESG have gained considerable importance and are increasingly being studied by researchers. For ease of understanding, the term sustainability serves as a comprehensive framework that encompasses and is influenced by both ESG and CSR. Like ESG, CSR is a way for firms to demonstrate their commitment to promoting sustainable business practices. These terms are often used interchangeably in the literature (Clément et al., 2023; Gillan et al., 2021). For simplicity, this interchangeable usage is adopted in this dissertation too. However, according to Kiesel & Lücke (2019), most empirical research focuses on the issue of ESG and credit risk. The increased focus on this topic could be related to the fact that nowadays, firms publish significantly more ESG-related information than in the past. While only 20% of the firms in the S&P 500 published ESG data in sustainability reports in 2011, this share was around 86% in 2018 (Gillan et al., 2021).

As a plethora of data is disclosed today, and there are various data sources, the variables used to examine the impact of sustainability on credit risk often vary widely. Jiraporn et al. (2014) use strength and concern ratings from the database 'KLD' for each of seven CSR criteria. Out of these ratings, the authors create a final CSR score, which is used to measure the sustainability of a firm. As a proxy for credit risk, S&P ratings are used and converted to an ordinal scale for their regression, i.e., the ratings from D to AAA are transformed into respective numbers from 1 to 22. Caiazza et al. (2023) use the Total ESG Score and the corresponding Pillar Scores 'Environmental', 'Social', and 'Governance' to measure sustainability. As a proxy for credit risk, the authors collect 5-year Credit Default Swap (CDS) spreads from Refinitiv. Furthermore, Capasso et al. (2020) depart from classical ESG/CSR scores and examine the impact that the level of corporate carbon emissions has on credit risk. As a proxy for credit risk, they use firms' distance-to-default, which the authors calculate using the Merton model. Although all mentioned authors use different variables for sustainability and proxies for credit risk, they are consistent in their results. All authors achieve significant results showing a negative relationship between sustainability and credit risk. Ultimately, they conclude that the more sustainable a firm is, the better its credit rating and, thus, its creditworthiness.

The results of the aforementioned authors are weakened by the study of Kiesel and Lücke (2019). Kiesel and Lücke (2019) examine the extent to which ESG influences credit risk. For this purpose, they analyze 3719 rating reports from Moody's on U.S. and European firms. The authors conclude that while the impact of ESG factors on corporate creditworthiness is positive, it accounts for only a small portion of the factors considered by CRAs in credit ratings. More specifically, they determine an ESG integration share of 2.68% for their dataset. The authors break this integration share further down and report that corporate governance has the largest impact on credit ratings (2.51 %), followed by a small impact from environmental aspects (0.16%) and an even smaller impact from social aspects (0.01%). Interestingly, the study by Aslan et al. (2021) contradicts these findings completely. Their results show that after the influence of the Total ESG Score, the Social Score has the largest impact on credit risk (and ultimately on credit ratings), followed by the Environmental Score. After introducing variables suitable for determining a credit rating, the influence of the Governance Score on credit risk was no longer significant, while the other scores still were.

The results of Bhojraj and Sengupta (2003) and Ashbaugh-Skaife et al. (2006) regarding the impact of corporate governance on credit risk differ from those of Aslan et al. (2021). Unlike all studies presented so far, Bhojraj and Sengupta (2003) and Ashbaugh-Skaife et al. (2006) focus exclusively on the impact of corporate governance on U.S. firms' credit risk by analyzing the impact of corporate board and shareholder structure and various other governance characteristics on ordinally scaled credit ratings. The authors find that most of the governance characteristics have a significant positive impact on firms' creditworthiness. The presented studies show various inconsistencies potentially linked to the use of varying methods and variables for assessing the impact of ESG on credit risk, thus underlining the need for further research in this area.

Bannier et al. (2022) emphasize the need for more research on the impact of ESG on the credit risk of European firms, as this topic is not sufficiently addressed in the current literature. The authors examine the relationship between ESG and credit risk for European firms between 2003 and 2018 and also use a sample of U.S. firm data within the same timeframe to provide a geographically comparative analysis. Different from all studies presented so far, Bannier et al. (2022) test the individual impact of all three ESG Pillar Scores on six different proxies for credit risk. Their credit risk proxies include 1- and 5-year CDS spreads, 1- and 5-year default probabilities, Distance-To-Default, and ordinally scaled credit ratings. The results regarding the impact of the Environmental Score and the Social Score on credit risk are mixed. According to their models, better environmental and social performance has a decreasing impact on all kinds of default probabilities and CDS spreads and an increasing effect on Distance-to-Default and, thus, an improving impact on creditworthiness. Surprisingly, using ordinally scaled S&P ratings as a credit risk proxy, the authors find that an improvement in environmental and social performance causes a rating deterioration for European firms. The results of these authors suggest that the variables chosen to measure sustainability and proxy for credit risk play an influential role in examining their association. Furthermore, corporate governance does not significantly impact credit risk in any of their models, neither European nor U.S. firms. This again contradicts some of the previously mentioned U.S. studies.

Regarding the influences of ESG on credit risk in different industries, the results of Chodnicka-Jaworska (2021) are interesting for this dissertation. Her results show that the impact of the environmental performance is much more significant for European firms in the energy and utilities sectors than for other sectors. Moreover, the social performance significantly impacts the European Non-Cyclical Consumer Sector, while the governance performance impacts the Basic Material, Energy, and Technological sectors the most. Brogi et al. (2022) confirm the results of Chodnicka-Jaworska (2021) that the impacts vary by industry sector. The authors focus on U.S., European, and Asian firms and measure the impact of the Total ESG Score and its Pillar Scores on credit risk, using firms' Altman's z-Score as a credit risk proxy. Their findings show that the oil and gas sector, or more generally the energy sector, is particularly influenced by ESG factors. However, according to Brogi et al. (2021), some sectors are barely influenced by ESG, such as the Real Estate or Wholesale Sector.

Apparently, the impact of sustainability on credit risk can be different depending on the market phase. Cardillo and Chiappini (2022) report that the level of sustainability can strengthen resilience in times of turbulent market conditions. They investigate whether sustainability, as measured by the Total ESG Score, can prevent the increase in credit risk, as measured by CDS spreads of European firms, in times of COVID-19. For this purpose, the authors investigate the influence of government decisions regarding government investment and economic support to firms and households or lockdowns on this relationship. Overall, they attribute a key function to sustainability for resilience in times of crisis. More sustainable firms can better withstand policy measures because they reduce their credit risk. These results are supported by Aslan et al. (2021). Considering only the Total ESG Score, as in Cardillo and Chiappini (2022), the results of Aslan et al. (2021) show that the positive impact of sustainability on credit risk is larger in times of crisis than in less turbulent times. Consequently, there seems to be a difference between the impact of sustainability on credit risk during different market conditions. However, although Aslan et al. (2021) focus on U.S. data, the results may also be of interest to this dissertation as the impact of ESG on credit risk will be examined over time.

Finally, the impact of sustainability on credit risk can also depend on the country where firms are located. Stellner et al. (2015) examine the impact of sustainability on firms' credit risk on a macro level. The authors summarize that the impact of ESG is much greater for firms in countries with above-average ESG performance. Moreover, firms with a high ESG performance are more likely to be rewarded with high credit ratings than companies with a below-the-country-average ESG performance. The findings of Stellner et al. (2015), in addition to the previously discussed studies, lead to the impression that the impact of sustainability on credit risk may depend on several criteria that firms are surrounded by.

3. Data & Methodology

3.1 Data

The final dataset consists of 3905 firm-year observations between 2005 and 2021 of 421 publicly listed European firms. In 3379 firm-years, firms had an investment-grade rating by S&P, i.e., a rating of BBB- or better, while in 526 firm-years, they had a speculative-grade rating by S&P, i.e., a rating of BB+ or worse. The focus is exclusively on all S&P-rated constituents of the STOXX Europe 600 Index, as this index includes not only large but also medium-sized and small firms from several Western European countries (Qontigo, 2023). This made it easier to compile a heterogeneous dataset that does not only include large-cap firms, as would be the case if only the major indices of each Western European country were considered. Since not all the data required to answer the research question is available for every firm in the STOXX Europe 600, all S&P-rated constituents of the MSCI Europe Index that were not already included in the dataset were added retrospectively to expand the database. Like the STOXX Europe 600, this index does not only contain large-cap firms (MSCI, 2023). Nevertheless, most of the firms included in the dataset are constituents of the STOXX Europe 600. To compile the dataset, firms' long-term domestic issuer ratings were collected in the first step. This step was the basis for obtaining the dependent variable for the later analysis.

3.1.1 Dependent Variable

All ratings were obtained from Refintiv Eikon. If there were multiple rating changes within a firm-year, the most recently assigned rating in that year was assigned to the respective firm-year. Only S&P ratings were considered, as only these can be converted into default probabilities by using the transition matrices in S&P's Annual Global Corporate Default and Rating Transition Studies. The transition matrices in the S&P studies provide information on the average European one-year PD from 1981 to the year of the respective study for each credit rating.

The conversion of credit ratings into PDs has the advantage that the problem of the non-equidistant scaling of ratings can be circumvented. Non-equidistant scaling refers to the fact that rating transitions do not occur with the same probability in all rating categories and that the magnitude of the change in the PD may not be the same for all transitions. While there is little or no increase in the PD for a downgrade from AAA to AA, the PD typically increases significantly with a downgrade from B to CCC (Aslan et al., 2021; Kraemer et al., 2022). The credit ratings of the respective firm-years were converted using the transition matrices from the S&P studies of the same year. Furthermore, intermediate ratings were adjusted to their respective main rating categories and then matched with the respective PDs. Since the S&P studies from 2007, 2008, and 2010 are not available, the transition matrices of the respective subsequent years were used for those years. The PDs collected are used as a proxy for credit risk in this dissertation.

3.1.2 Independent Variables

This dissertation uses ESG data to measure sustainability. In this context, ESG data comprises the three Pillar Scores ‘Environmental’, ‘Social’, and ‘Governance’ and the ‘Total ESG Score’, which combines all three Pillar Scores into one weighted final score. Each of these scores ranges between 0 and 100. A detailed description of these scores can be found in Appendix A1. All ESG data was downloaded using Refinitiv Datastream. Firm-years with credit ratings but without ESG data were removed from the dataset. The four scores were directly assigned to the respective firm-years without further processing. However, the ESG data in the dataset is lagged by one year with respect to the firm's PD. This is partly because it can help to reduce endogeneity problems and simultaneity bias arising from simultaneous bidirectional causality between ESG issues and credit risk. Moreover, this dissertation primarily examines the relationship between ESG and credit risk, where ESG scores are variables that affect firms' PD (Capelle-Blancard et al., 2019).

3.1.3 Control Variables

In the third step, control variables were collected. For this purpose, abnormal returns and idiosyncratic volatilities were calculated for all firm-years collected so far. Abnormal returns (AR) are the returns of a security or portfolio that are above or below expected returns (Ghosh & Lee, 2000). In this dissertation, the expected returns are calculated using the market model. Furthermore, idiosyncratic volatility (IV) refers to the volatility of a security or portfolio that cannot be explained by the overall market or other factors but is due to idiosyncratic or firm-specific factors (Sassen et al., 2016). Both variables are market-driven and have been studied by authors for their impact on firms' credit risk (Kalimipalli & Nayak, 2012; Shumway, 2001). The results of Shumway (2001) show that market-driven variables are significantly related to the PD and able to predict default.

Since the calculation of IV requires the calculation of AR, the first step was to calculate AR. For this purpose, the daily prices for all firm-years had to be downloaded from Refinitiv Datastream first. Subsequently, all firm-years that had incomplete prices were removed from the downloaded dataset and generally excluded due to their incompleteness. Next, holidays were removed from the dataset, as there are no changes in price on these days. However, the dataset consists of firms from 17 different European countries, all of them having country-specific holidays on which their stock exchanges are closed. Due to the large amount of data, only holidays that apply to all countries, e.g., New Year's Day, were removed from the downloaded dataset. After the dataset was cleaned, the price data was converted into daily log returns using the following formula:

$$(1)\ r_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right)$$

Where:

- r_{it} is the actual return of stock *i* on day *t*;
- P_{it} and P_{it-1} represent the price of the individual stock *i* on day *t* and *t-1*, respectively.

Moreover, to calculate abnormal returns, the following formula was used:

$$(2)\ AR_{it} = r_{it} - E(r_{it})$$

Where:

- AR_{it} is the abnormal return of stock *i* on day *t*;

- r_{it} is the actual return of stock *i* on day *t*;
- $E(r_{it})$ is the expected return of stock *i* on day *t*.

Formula (2) is simplified by substituting the formula of the market model for $E(r_{it})$:

$$(3)\ AR_{it} = r_{it} - (\alpha_i + \beta_i \times r_{mt})$$

Where:

- AR_{it} is the abnormal return of stock *i* on day *t*;
- r_{it} is the actual return of stock *i* on day *t*;
- α_i is the alpha or rather the intercept of stock *i*;
- β_i is the beta value, a measure of the systematic risk of stock *i* compared to the overall market, which is represented by the STOXX Europe 600 Index;
- r_{mt} are the market returns on day *t*.

The daily returns of the STOXX Europe 600 were used for r_{mt} as most firms in the sample are included in this index. Furthermore, the STOXX Europe 600 is a liquid index suitable to represent the overall European market and reflect the development of the European economy, especially due to its industry and country diversity, and its size (Qontigo, 2023). For the estimation of α_i and β_i, the Excel VBA Functions 'Intercept' and 'Slope' were used. To obtain reliable estimations for α_i and β_i, a historical price period of the stock *i* and the market index must be selected that precedes the firm-year for which abnormal returns are calculated. The study by Hollstein (2020) was used as guidance for choosing the right period. Hollstein (2020) presents the optimal choice of a historical period for calculating reliable local and global betas. For further clarification, the optimal beta periods were also applied to the stocks' alphas in this dissertation. However, for the following two reasons, only the results regarding local betas suitable for reliably calculating AR for a 12-month period were considered. Firstly, according to Hollstein (2020), global betas are relevant if the exchanges where the considered stocks are traded are open at different times on a global trading day so that the stock returns of one trading day would correlate with the global market portfolio returns of the previous, current, and next day. This is not the case here, as the focus is solely on Europe. The exchange opening hours of the stocks included in the dataset are well synchronized, implying that the stock returns of one trading day are only correlated with the market portfolio returns of the same day, which is why local betas are sufficient. Secondly, for each firm in the sample, daily AR were calculated per firm-year. Therefore, the results for local betas focusing on a shorter forecasting period would not be adequate. One advantage of the study of Hollstein (2020) is that the author provides optimal historical estimation periods by country. This made it possible to calculate an individual alpha and beta for each stock and firm-year depending on the location of a firm. Since a historical period of 12 months is sufficient for most European countries listed in the study, this period was assumed for countries that the author does not examine. For each firm-year in the dataset, the daily prices needed to calculate alphas and betas were downloaded from Refinitiv Datastream and converted into daily log returns. Next, alphas and betas were estimated before calculating daily AR using formula (3). Finally, by summarizing all daily AR of a firm in a certain firm-year, annual AR were obtained and matched with the other data of that firm-year.

The daily IV of a firm in a certain firm-year is derived by calculating the standard deviation of its daily AR in the same year. By multiplying with the square root of the number of trading days in that particular year, the daily IVs were converted into annual IVs and subsequently matched with the other data of that firm-year.

Lastly, for all firms and their firm-years in the sample, fundamental annual firm data were downloaded from Compustat - Capital IQ. Additionally, the market values of the firms were downloaded from Refinitiv Datastream and matched with the data of Compustat. All market values were assigned in the currency in which the companies published their financial data. Firm-years with incomplete data were excluded from the downloaded dataset. After preparing the data, financial ratios were computed and assigned to the respective firm-years. The following eight financial ratios were calculated: (1) Working-Capital-to-Total-Assets (WC/TA) ratio calculated as Working Capital divided by Total Assets, (2) Retained-Earnings-To-Total-Assets (RE/TA) ratio calculated as Retained Earnings divided by Total Assets, (3) EBIT-To-Total-Assets (EBIT/TA) ratio calculated as EBIT divided by Total Assets, (4) Market-Equity-To-Total-Liabilities (ME/TL) ratio calculated as Market Equity divided by Total Liabilities, (5) Sales-To-Total-Assets (S/TA) ratio calculated as Sales divided by Total Assets, (6) Net-Income-To-Total-Assets (NI/TA) ratio calculated as Net Income divided by Total Assets, (7) Total-Liabilities-To-Total-Assets (TL/TA) ratio calculated as Total Liabilities divided by Total Assets and (8) Current-Assets-To-Current-Liabilities (CA/CL) ratio calculated as Current Assets divided by Current Liabilities. They will serve as control variables in later analysis. A more detailed description of all financial ratios can be found in Appendix A2. The results of Shumway (2001) confirm that the financial ratios used are suitable to assess a firm’s credit risk, which is why they are used as control variables. For the same reasons as for the independent variables, all control variables are lagged by one year compared to a firm's PD.

Table 1: Summary Statistics

This table shows the mean, standard deviation, minimum, 25th percentile, median, 75th percentile, and maximum of each variable collected.

Variable	Observations	Mean	S.D.	Quartiles				
				Min	,25	Median	,75	Max
Dependent Variable in %								
PD	3905	0,2594	1,5635	0,00	0,05	0,06	0,11	33,06
Independent Variables								
TESG-Score	3905	66,6433	14,8515	23,05	56,99	68,84	78,19	92,29
ENV-Score	3905	68,5780	19,9645	14,86	55,38	73,27	84,32	97,24
SOC-Score	3905	68,6039	18,3418	19,82	56,80	72,07	83,50	96,48
GOV-Score	3905	63,3244	18,9178	17,96	48,99	66,07	79,27	95,73
Market-Driven Variables in %								
AR	3905	-2,0360	28,5569	-90,0638	-19,0276	-1,9018	14,8090	98,0798
IV	3905	24,2970	10,0498	11,1758	17,1316	21,6039	28,5824	72,1416
Financial Ratios in %								
WC/TA	2216	6,0223	10,8504	-18,9106	-1,8012	4,7828	12,7365	40,6839
RE/TA	2216	19,6710	18,5541	-49,8581	6,5321	20,1164	31,2428	91,0080
EBIT/TA	2216	7,7444	4,3665	-2,0778	4,9758	7,0487	9,7966	29,7930
ME/TL	2216	134,1283	95,6853	11,6982	64,0750	107,8217	181,2633	556,1953
S/TA	2216	73,1328	35,7848	13,2526	48,4839	65,7895	91,2916	203,6819
NI/TA	2216	4,3195	3,9018	-10,3402	2,1267	3,9907	6,3615	21,9777
TL/TA	2216	63,8211	12,4509	32,8072	54,9024	63,5234	72,5326	97,0284
CA/CL	2216	128,4080	48,9840	44,9849	93,8354	118,9349	152,7453	329,9725

The summary statistics for all variables collected are presented in Table 1. Table 1 shows the mean, standard deviation, minimum, 25th percentile, median, 75th percentile, and maximum of each variable collected. All variables except independent variables are expressed as percentages. To avoid the influence of outliers, most continuous variables in the dataset are winsorized at the 1st and 99th percentiles. Only the four sustainability scores are winsorized at the 5th and 95th percentiles.

3.2 Methodology

The impact of sustainability on credit risk is analyzed as follows: First, an ordinary least squares (OLS) regression is performed using the following formula:

$$(4)\ PD_{it} = \beta_0 + \beta_1 \times Sustainability\ Score_{it-1} + \beta' \times Control_{it-1} + \varepsilon_{it}$$

An OLS regression is chosen since this technique has also been used in other studies on this topic (Aslan et al.,2021; Brogi et al.,2022). In the formula, the subscripts *i* and *t* denote the firm and the year, respectively. β_1 is the coefficient of interest reflecting the impact of a lagged *Sustainability Score* on the dependent variable PD. Since the four lagged sustainability scores are individually regressed on the PD, this results in four different β_1's. *Control* is a *1 x k* vector with *k* different control variables, while β' is the corresponding *k x 1* coefficient matrix. Only the two market-driven control variables, AR and IV, are regressed on firms' PD along with each of the four sustainability scores. The exclusive use of market-driven control variables is based on the study by Shumway (2001), which shows that market-driven variables can outperform the accuracy of accounting variables in predicting the PD. In addition, firms for which accounting data is unavailable can remain in the dataset. Lastly, β_0 is a constant, and ε is the error term.

Second, fixed effects (FE) are gradually added to the equation. First, only industry-FE, then only year-FE, and finally, both year- and industry-FE together. Thus, equation (4) changes as follows:

$$(5)\ PD_{it} = \beta_0 + \beta_1 \times Sustainability\ Score_{it-1} + \beta' \times Control_{it-1} + \alpha_j + \alpha_k + \varepsilon_{it}$$

where α_j are year-FE, and α_k are industry-FE. To implement industry-FE, all firm-years in the dataset were assigned to an industry according to the Global Industry Classification Standard (GICS), which defines a total of 11 industries. Since the present dataset represents panel data, where it can be assumed that there are fixed industry and time characteristics that affect firms'

PD (Baltagi, 2005), industry- and year-FE are always jointly considered in all subsequent models.

Third, as in Balasirishwaron et al. (2022), observations with speculative-grade ratings are filtered out of the dataset to analyze the specific impact of sustainability on the credit risk of investment-grade firms. This step reduces the total number of observations examined from 3905 to 3379.

Fourth, and only in this step, further firm-specific controls in the form of financial ratios are included in the analysis to check the validity of previous results. As in Aslan et al. (2021), financial firms are excluded from the dataset here due to their substantially higher leverage and sensitivity to financial risks. In addition to analyzing the entire data set (excluding financial firms/ firms with missing accounting data), a distinction is also made by investment-grade firms.

Finally, the impact of the four sustainability scores on the PD is examined in more detail for individual industries and over time. Separate results for investment-grade observations are also presented here. An examination of speculative-grade observations is neglected because the existing observations for some years and sectors are insufficient for a temporal or sectoral analysis.

4. Analysis & Results

For all equations presented in this chapter, standard errors are clustered at a firm level. According to Petersen (2009), OLS standard errors tend to be biased when working with panel data, as often there are dependencies between a firm's residuals over time. By clustering at the firm level, unbiased standard errors with correct confidence intervals can be obtained. In the following analysis, the sustainability score coefficients are always expected to have a negative sign, which means that sustainability has, on average and *ceteris paribus*, a decreasing impact on a firm's PD.

Table 2: Impact of ESG on PD

*This table shows the impact of the TESG-Score and the three Pillar Scores on the firms' PD without considering FE. Clustered standard errors at a firm level are presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	(2)	(3)	(4)
Dependent Var.:	**PD**	**PD**	**PD**	**PD**
TESG-Score$_{it-1}$	-0,00341*			
	(0,00180)			
ENV-Score$_{it-1}$		-0,00442***		
		(0,00166)		
SOC-Score$_{it-1}$			-0,00194	
			(0,00145)	
GOV-Score$_{it-1}$				-0,000494
				(0,00188)
AR$_{it-1}$	0,00136	0,00139	0,00136	0,00137
	(0,00141)	(0,00140)	(0,00141)	(0,00141)
IV$_{it-1}$	0,0362***	0,0363***	0,0362***	0,0364***
	(0,00926)	(0,00923)	(0,00930)	(0,00928)
Constant	-0,390*	-0,316*	-0,485**	-0,591***
	(0,207)	(0,171)	(0,228)	(0,216)
Industry-FE	No	No	No	No
Year-FE	No	No	No	No
Observations	3905	3905	3905	3905
Adj. R-Squared	0,056	0,058	0,055	0,055

Table 2 presents the results of the first four models examining the impact of each sustainability score on the PD. AR and IV are included as control variables. No industry- or year-FE are considered yet. As can be seen, only two of the four coefficients are statistically significant. The coefficient of the ENV-Score shows strong statistical significance at the 1% significance level, while the coefficient of the TESG-Score shows significance at the 10% significance level. Since the TESG-Score is composed of the three Pillar Scores, its significance can most likely be attributed to the ENV-Score. As expected, both sustainability score coefficients have a negative sign. This indicates that, on average, improving one of these sustainability scores can help a firm reduce its credit risk.

The ENV-Score has the largest impact on a firm's PD. Its coefficient indicates that, everything else constant, a one percentage point increase in the ENV-Score reduces the firm's PD, on average, by 0,00442 percentage points. In comparison, a one percentage point increase in the TESG-Score reduces the PD, on average, by 0,00341 percentage points, *ceteris paribus*. It is not surprising that the impact of the ENV-Score is greater than that of the TESG-Score.

Since the TESG-Score is a weighted mix of the three Pillar Scores, it seems plausible that its impact is somewhere in between the impacts of the three Pillar Scores.

Although the market-driven controls are not variables of interest in this dissertation, it is interesting to see that AR, which is supposed to reflect the firm's past performance, does not seem to impact a firm's PD as the coefficient is in none of the models significant. This is contradictory to the study of Shumway (2001), which presents significant results showing that firms with higher past AR have lower PD than firms with lower past AR. However, in all four models, the IV coefficient is highly significant at the 1% significance level showing that, on average and *ceteris paribus*, a firm's PD increases with every percent in firm-specific risk.

In the next step, industry- and year-FE are gradually included. First, only industry-FE and then only year-FE. Finally, both FE are included. Table 3 contains the results of all FE models. Models (1) to (4) present the results that consider only industry-FE. Still, not all coefficients of the sustainability scores are significant, suggesting that not all sustainability scores impact a firm's PD. Compared to the previous models without FE, there is a noticeable improvement in statistical significance. Like the ENV-Score coefficient, the TESG-Score coefficient now shows a strong statistical significance at the 1% significance level. Moreover, the SOC-Score coefficient is now significant at the 5% significance level. All three significant sustainability score coefficients are negative and thus in line with the set expectations. Compared to the coefficient in the model without FE, the influence of the TESG-Score has increased considerably. On average and *ceteris paribus*, increasing the TESG-Score by one percentage point now reduces the PD by 0,00508 percentage points. This is an increase of 0,00167 percentage points compared to the coefficient from Model (1) in Table 2. The effect of the ENV-Score has not changed significantly. Increasing the ENV-Score by one percentage point leads on average to a reduction in the PD of 0,00445 percentage points, *ceteris paribus*. Thus, the effect increased by only 0,00003 percentage points. The effect of the SOC-Score is the smallest as increasing the SOC-Score by one percentage point can reduce the PD on average by 0,00313 percentage points, *ceteris paribus*. Since the TESG-Score is a combination of the three Pillar Scores, it is interesting that its impact is larger than what could be obtained through a weighted combination of the impacts of the three Pillar Scores. Thus, combining the Pillar Scores appears to create a synergistic effect, resulting in a stronger impact on the PD.

Table 3: Impact of ESG on PD (FE Models)

*This table shows the impact of the TESG-Score and the three Pillar Scores on the firm's PD considering industry- and year-FE. Clustered standard errors at a firm level are presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent Var.:	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**	**PD**
TESG-Score$_{it-1}$	-0,00508***				-0,00118				-0,00300			
	(0,00194)				(0,00207)				(0,00216)			
ENV-Score$_{it-1}$		-0,00445***				-0,00344**				-0,00329**		
		(0,00158)				(0,00166)				(0,00157)		
SOC-Score$_{it-1}$			-0,00313**				-0,000269				-0,00165	
			(0,00137)				(0,00188)				(0,00177)	
GOV-Score$_{it-1}$				-0,00111				0,000532				0,000130
				(0,00220)				(0,00177)				(0,00209)
AR$_{it-1}$	0,00140	0,00145	0,00139	0,00140	0,00174	0,00175	0,00174	0,00175	0,00177	0,00179	0,00177	0,00178
	(0,00145)	(0,00144)	(0,00145)	(0,00145)	(0,00141)	(0,00140)	(0,00141)	(0,00141)	(0,00144)	(0,00144)	(0,00144)	(0,00144)
IV$_{it-1}$	0,0351***	0,0352***	0,0351***	0,0353***	0,0562***	0,0556***	0,0564***	0,0566***	0,0551***	0,0551***	0,0555***	0,0560***
	(0,00865)	(0,00865)	(0,00870)	(0,00869)	(0,0136)	(0,0134)	(0,0138)	(0,0136)	(0,0130)	(0,0128)	(0,0131)	(0,0129)
Constant	-0,293	-0,352*	-0,413*	-0,565**	-0,815***	-0,699***	-0,867***	-0,915***	-0,683**	-0,695***	-0,757**	-0,858***
	(0,220)	(0,187)	(0,235)	(0,241)	(0,286)	(0,237)	(0,303)	(0,271)	(0,282)	(0,242)	(0,297)	(0,283)
Industry-FE	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes
Year-FE	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3905	3905	3905	3905	3905	3905	3905	3905	3905	3905	3905	3905
Adj. R-Squared	0,075	0,076	0,074	0,073	0,093	0,095	0,093	0,093	0,110	0,111	0,110	0,109

Models (5) to (8) in Table 3 contain the results that consider only year-FE. The results differ substantially from those obtained in the previous models. Only the ENV-Score coefficient shows significance; however, only at the 5% significance level. On average, the increase of the ENV-Score by one percentage point leads to a reduction in the PD of 0,00344 percentage points. This is approximately 23% less than in the model with industry-FE and approximately 22% less than in the model without FE. All other sustainability scores are insignificant, so no significant association between them and the PD is assumed. It appears that the effect of the ENV-Score is offset by the inclusion of the other two sub-scores resulting in the TESG-Score having no significant impact on a firm's PD.

Models (9) to (12) in Table 3 include industry- and year-FE. As in the models with year-FE, only the ENV-Score coefficient is significant at the 5% significance level. Compared to Model (6), the impact of the ENV-Score in Model (10) decreased by 0,00015 percentage points. Everything else constant, an increase of the ENV-Score by one percentage point now leads, on average, to a reduction of a firm's PD by 0,00329 percentage points.

For the sake of completeness, the two control variables should also be addressed. Even with the introduction of different FE, their coefficients in Table 3 consistently remain at the same significance level as in Table 2. AR is statistically insignificant, and IV is continuously statistically significant at the 1% significance level. With the introduction of only year-FE as well as both FE, the impact of IV on the PD has increased significantly. The coefficients from models (5) to (12) in Table 3 are about 0,02 percentage points greater than the coefficients from Table 2. Moreover, the IV coefficients are always positive, implying that the PD increases with each percent increase in firm-specific risk.

***Table 4:* Impact of ESG on PD of Investment-Grade Firms**

*This table shows the impact of the TESG-Score and the three Pillar Scores on the PD of investment-grade firms, considering industry- and year-FE. Clustered standard errors at a firm level are presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	**(2)**	**(3)**	**(4)**
Dependent Var.:	**PD**	**PD**	**PD**	**PD**
TESG-Score$_{it-1}$	-0,000317***			
	(8,45E-05)			
ENV-Score$_{it-1}$		-0,000284***		
		(6,06E-05)		
SOC-Score$_{it-1}$			-0,000235***	
			(7,16E-05)	
GOV-Score$_{it-1}$				-9,42E-05
				(6,26E-05)
AR$_{it-1}$	1,32E-05	1,61E-05	1,25E-05	1,45E-05
	(1,79E-05)	(1,78E-05)	(1,80E-05)	(1,80E-05)
IV$_{it-1}$	0,00116***	0,00120***	0,00118***	0,00120***
	(0,000136)	(0,000134)	(0,000137)	(0,000138)
Constant	0,0929***	0,0882***	0,0887***	0,0819***
	(0,0124)	(0,0118)	(0,0124)	(0,0121)
Industry-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Observations	3379	3379	3379	3379
Adj. R-squared	0,297	0,301	0,295	0,289

Next, only observations with investment-grade ratings will be examined to determine whether the impact of sustainability on credit risk is different for this rating category. Table 4 presents the results. Industry- and year-FE are considered in all models. Indeed, the results differ significantly from those in models (9) to (12) in Table 3. The coefficients of the TESG-Score, the ENV-Score, and the SOC-Score are now highly significant at the 1% significance level. Only the GOV-Score coefficient remains statistically insignificant. Moreover, all signs of the significant coefficients are negative, which aligns with the set expectations. The TESG-Score has the greatest impact on a firm's PD. Everything else constant, a firm's PD decreases, on average, by 0,000317 percentage points for each percentage point by which the TESG-Score increases. The second largest impact on the PD has the ENV-Score. On average, a one percentage point increase in the ENV-Score leads to a 0,000284 percentage points decrease in a firm's PD, *ceteris paribus*. Finally, the increase in the SOC-Score by one percentage point leads, on average, to a 0,000235 percentage points decrease in a firm's PD, *ceteris paribus*. Interestingly, the impact of the TESG-Score on the PD again exceeds the potential impact achieved by weighting the individual Pillar Score impacts. Furthermore, it is noticeable that the impact of the sustainability scores on the PD is, on average, significantly lower than when both rating categories are regressed together. One explanation for the relatively lower impact of sustainability could be that CRAs apply stricter standards when assessing investment-grade firms' credit risk (Alp, 2013). As a result, other traditional criteria describing the current economic situation of an investment-grade firm might receive more weight than sustainability. As for the control variables, the results did not change significantly. AR is insignificant, while IV remains positive and significant at the 1% significance level. It is only noticed that the IV coefficients are also smaller than those in models (9) to (12) in Table 3.

The next step is to include additional control variables in the regressions to ensure the validity of the previous results. More specifically, this step examines whether the results in Tables 3 (Models (9) to (12)) and 4 are preserved when additional variables are introduced. The implementation of additional controls is performed once with the entire dataset and once with investment-grade observations only. As mentioned before, all additional controls are financial ratios that have proven suitable for estimating a firm's PD. For the reasons explained in Chapter 3.2, financial firms are omitted in this step. Moreover, industry- and firm-FE are considered in all models.

***Table 5:* Impact with Additional Controls**

*This table shows the impact of the TESG-Score and the three Pillar Scores on the firms' PD after implementing financial ratios as additional controls. Industry- and year-FE are considered. Clustered standard errors at a firm level are presented in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	**(2)**	**(3)**	**(4)**
Dependent Var.:	**PD**	**PD**	**PD**	**PD**
$TESG\text{-}Score_{it-1}$	-0,00230			
	(0,00183)			
$ENV\text{-}Score_{it-1}$		-0,00203		
		(0,00178)		
$SOC\text{-}Score_{it-1}$			-0,00183	
			(0,00122)	
$GOV\text{-}Score_{it-1}$				0,000270
				(0,00107)
AR_{it-1}	0,000342	0,000342	0,000335	0,000325
	(0,00191)	(0,00191)	(0,00192)	(0,00192)
IV_{it-1}	0,0417***	0,0416***	0,0417***	0,0426***
	(0,0116)	(0,0115)	(0,0116)	(0,0115)
WC/TA_{it-1}	-0,0143	-0,0142	-0,0143	-0,0147
	(0,0110)	(0,0109)	(0,0109)	(0,0109)
RE/TA_{it-1}	0,00198	0,00187	0,00200	0,00173
	(0,00416)	(0,00416)	(0,00411)	(0,00407)
$EBIT/TA_{it-1}$	-0,00609	-0,00619	-0,00629	-0,00627
	(0,0134)	(0,0133)	(0,0133)	(0,0134)
ME/TL_{it-1}	-0,000383	-0,000396	-0,000383	-0,000354
	(0,000630)	(0,000649)	(0,000623)	(0,000621)
S/TA_{it-1}	0,00037	0,000303	0,000372	0,000400
	(0,000905)	(0,000929)	(0,000892)	(0,000892)
NI/TA_{it-1}	0,00115	0,000952	0,00138	0,00119
	(0,0112)	(0,0112)	(0,0111)	(0,0113)
TL/TA_{it-1}	0,00711*	0,00713*	0,00716*	0,00700*
	(0,00406)	(0,00406)	(0,00405)	(0,00407)
CA/CL_{it-1}	0,00349	0,00348	0,00350	0,00364
	(0,00253)	(0,00248)	(0,00254)	(0,00255)
Constant	-1,194*	-1,206*	-1,224*	-1,359*
	(0,721)	(0,684)	(0,730)	(0,744)
Industry-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Observations	2216	2216	2216	2216
Adj. R-Squared	0,101	0,101	0,101	0,100

Table 5 presents the results for the entire dataset. As can be seen from Table 5, the ENV-Score coefficient has become insignificant compared to the coefficient of Model (10) in Table 3. Therefore, the previous result regarding the impact of the ENV-Score is invalid. The other three sustainability scores are still insignificant, indicating that they are not significantly associated with a firm's PD. Looking at the control variables, the IV coefficient is still positive and significant at the 1% significance level. Therefore, this result is valid as well as logical. It can be assumed that the higher the firm-specific risk of a firm, the higher its PD. Of the newly added control variables, only the TL/TA coefficients show a weaker significance at the 10% significance level. The coefficients are positive, which means that, on average, the increase of this ratio follows an increase of the PD, *ceteris paribus*. Since this ratio reflects a firm's debt ratio, it appears reasonable that the PD increases the higher a firm's debt.

A completely different picture emerges in Table 6, which shows the results for the investment-grade observations. As in Table 4, the coefficients of the TESG-Score, the ENV-Score, and the SOC-Score are negative and significant at the 1% significance level, while the GOV-Score coefficient remains insignificant. Therefore, it can be assumed that the results in Table 4 are valid and that the three significant sustainability scores are significantly associated with the lower PD of investment-grade firms. With the inclusion of the additional control variables, the coefficients of the TESG-Score, the ENV-Score, and the SOC-Score only changed slightly. Compared to the coefficients in Table 4, the coefficient of the TESG-Score has decreased by 0,000012 percentage points, while that of the ENV-Score has decreased by 0,000010 percentage points. By contrast, the coefficient of the SOC-Score increased by 0,000012 percentage points. Comparing all significant sustainability scores, the TESG-Score still has the greatest impact on a firm's PD. Of the Pillar Scores, the ENV-Score continues to have the greatest impact on the PD.

***Table 6:* Impact with Additional Controls (Investment-Grade Firms Only)**

*This table shows the impact of the TESG-Score and the three Pillar Scores on the PD of investment-grade firms after adding financial ratios as additional controls. Industry- and year-FE are considered. Clustered standard errors at a firm level are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	**(2)**	**(3)**	**(4)**
Dependent Var.:	**PD**	**PD**	**PD**	**PD**
TESG-Score$_{it-1}$	-0,000305***			
	(0,000113)			
ENV-Score$_{it-1}$		-0,000274***		
		(8,18E-05)		
SOC-Score$_{it-1}$			-0,000247***	
			(9,46E-05)	
GOV-Score$_{it-1}$				-4,11E-05
				(7,36E-05)
AR$_{it-1}$	9,70E-06	1,03E-05	8,69E-06	1,00E-05
	(2,15E-05)	(2,13E-05)	(2,14E-05)	(2,17E-05)
IV$_{it-1}$	0,00107***	0,00108***	0,00107***	0,00115***
	(0,000193)	(0,000187)	(0,000198)	(0,000195)
WC/TA$_{it-1}$	-0,000468	-0,000451	-0,000494	-0,000502
	(0,000335)	(0,000329)	(0,000330)	(0,000340)
RE/TA$_{it-1}$	-0,000261***	-0,000279***	-0,000258***	-0,000287***
	(9,96E-05)	(9,92E-05)	(9,83E-05)	(0,000102)
EBIT/TA$_{it-1}$	-0,00164***	-0,00165***	-0,00166***	-0,00165***
	(0,000512)	(0,000506)	(0,000512)	(0,000519)
ME/TL$_{it-1}$	-2,42E-05	-2,58E-05	-2,36E-05	-2,05E-05
	(1,97E-05)	(1,99E-05)	(1,95E-05)	(2,03E-05)
S/TA$_{it-1}$	4,97E-05	3,84E-05	5,18E-05	5,71E-05
	(5,17E-05)	(5,17E-05)	(5,16E-05)	(5,23E-05)
NI/TA$_{it-1}$	-0,000686*	-0,000697*	-0,000695*	-0,000678*
	(0,000392)	(0,000391)	(0,000395)	(0,000393)
TL/TA$_{it-1}$	-1,53E-05	-2,31E-05	-1,29E-05	-2,48E-05
	(0,000163)	(0,000161)	(0,000162)	(0,000166)
CA/CL$_{it-1}$	0,000114*	0,000109*	0,000119*	0,000121*
	(6,52E-05)	(6,44E-05)	(6,49E-05)	(6,55E-05)
Constant	0,117***	0,116***	0,113***	0,101***
	(0,0271)	(0,0263)	(0,0274)	(0,0263)
Industry-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Observations	1865	1865	1865	1865
Adj. R-Squared	0,414	0,418	0,415	0,407

Looking at the control variables in Table 6, the IV coefficient is still positive and significant at the 1% significance level. Therefore, it can be assumed that the higher the firm-specific risk of a firm, the higher its PD. Of the newly added control variables, the coefficients of the RE/TA ratio and the EBIT/TA ratio show strong statistical significance at the 1% significance level. In addition, their coefficients are all negative, which indicates that, on average, an increase in one (or both) of these ratios is followed by a decrease in the PD, *ceteris paribus*. For a better understanding, the RE/TA ratio indicates the extent to which a firm retains its profits to finance assets instead of paying dividends and incurring debt. The EBIT/TA ratio, in turn, is a profitability indicator. Against this background, it seems coherent that the two ratios have a decreasing effect on the PD the higher they are. Furthermore, the coefficients of the NI/TA ratio and the CA/CL ratio show a weaker significance at the 10% significance level. Since the coefficient of the NI/TA ratio is negative, the increase of this ratio results, on average and *ceteris paribus*, in a reduction of the PD. Given that this ratio is a profitability indicator as well, it seems plausible that an increase in profitability leads to a decrease in the PD. By contrast, the coefficient of the CA/CL ratio has a positive sign. On average, and all else being equal, an increase in this ratio is accompanied by an increase in the PD. Since an excessively high ratio of current assets to current liabilities indicates that a firm's assets are not used efficiently, it seems plausible that this coefficient is positive and has an increasing effect on the PD. However, its impact is the smallest of all significant control variables. Of all controls, the EBIT/TA ratio has the most significant impact on the PD.

Besides the general impact of sustainability on credit risk, it is of interest to find out which industries are particularly impacted by sustainability. For this purpose, the dataset is partitioned by GICS sectors to examine the impact of the four sustainability scores on the PD for each industry. In a second step, all observations with speculative-grade ratings are filtered out to analyze the specific impact for investment-grade firms. Table 7 shows the results for the entire dataset, while Table 8 shows the results for investment-grade firms. All models include year-FE.

Table 7: Impact of ESG in Different Industries

*This table shows the impact of the TESG-Score and the three Pillar Scores on the firms' PD in different industries. Year-FE are considered. Clustered standard errors at a firm level are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Materials	**Consumer Staples**	**Consumer Discretionary**	**Energy**	**Utilities**	**Financials**	**Communication Services**	**Industrials**	**Healthcare**	**Information Technology**	**Real Estate**
TESG-Score$_{it-1}$	-0,00767	-0,00402	-0,000580	-0,0284	0,000300	-0,000382	0,00172	0,00217	-0,00490	-0,0159	-0,00296**
	(0,00500)	(0,00466)	(0,00877)	(0,0408)	(0,000496)	(0,000521)	(0,00186)	(0,00628)	(0,00290)	(0,0149)	(0,00136)
ENV-Score$_{it-1}$	-0,0121	-0,00413	0,000827	-0,0128	-7,96E-05	-0,000149	0,0016	-0,00303	-0,00300	-0,0171	-0,00304*
	(0,00915)	(0,00375)	(0,00595)	(0,0214)	(0,000282)	(0,000348)	(0,00226)	(0,00379)	(0,00245)	(0,0167)	(0,00176)
SOC-Score$_{it-1}$	-0,00388	-0,00167	-0,000722	0,0200	0,000313	-0,000567*	0,00216	0,000104	-0,00402*	-0,0212	-0,00142
	(0,00294)	(0,00370)	(0,00460)	(0,0480)	(0,000484)	(0,000290)	(0,00196)	(0,00379)	(0,00233)	(0,0179)	(0,00113)
GOV-Score$_{it-1}$	0,00265	-0,00194	-0,000635	-0,0674	0,000355	-1,20E-05	-0,00115	0,00870	-0,00208	-0,00277	-0,00108
	(0,00429)	(0,00175)	(0,00492)	(0,0499)	(0,000271)	(0,000497)	(0,00127)	(0,00551)	(0,00134)	(0,00968)	(0,000854)
Observations	441	286	327	129	358	880	360	653	200	116	155

Table 8: Impact of ESG in Different Industries (Investment-Grade Firms Only)

*This table shows the impact of the TESG-Score and the three Pillar Scores on the PD of investment-grade firms in different industries. Year-FE are considered. Clustered standard errors at a firm level are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Materials	**Consumer Staples**	**Consumer Discretionary**	**Energy**	**Utilities**	**Financials**	**Communication Services**	**Industrials**	**Healthcare**	**Information Technology**	**Real Estate**
TESG-Score$_{it-1}$	-0,000406	-0,000556	0,0000681	-0,0000281	0,000127	-0,000270*	-0,000300	-0,000244	-0,000793*	-0,000772	-0,000621**
	(0,000343)	(0,000437)	(0,000477)	(0,000599)	(0,000132)	(0,000140)	(0,000266)	(0,000159)	(0,000397)	(0,000453)	(0,000280)
ENV-Score$_{it-1}$	-0,000330	-0,000268	-8,75E-05	0,000708	0,000118	-0,000204**	-0,000458***	-0,000234*	-0,00100***	-0,00139*	-0,000340
	(0,000229)	(0,000253)	(0,000242)	(0,000913)	(0,000132)	(9,53E-05)	(0,000161)	(0,000120)	(0,000198)	(0,000698)	(0,000210)
SOC-Score$_{it-1}$	-0,000194	-0,000415	6,20E-05	0,000502	3,08E-06	-0,000225**	-0,000290	-0,000159	-0,000691	-0,000526	-0,000547**
	(0,000280)	(0,000372)	(0,000417)	(0,000857)	(0,000175)	(0,000113)	(0,000228)	(0,000151)	(0,000413)	(0,000571)	(0,000202)
GOV-Score$_{it-1}$	-0,000237	-0,000235	0,000197	-0,000932	6,43E-05	-8,76E-05	0,000156	-2,02E-05	-0,000141	-0,000260	-0,000330
	(0,000178)	(0,000275)	(0,000155)	(0,000693)	(0,000123)	(0,000113)	(0,000150)	(0,000163)	(0,000298)	(0,000266)	(0,000221)
Observations	348	247	249	91	351	853	322	535	162	83	138

The industry results for the entire dataset in Table 7 show that only a few industry coefficients are significant. The TESG-Score seems to have only a decreasing impact on the PD of *Real Estate* firms, as only this coefficient is significant. The same applies to the ENV-Score. However, the impact of the ENV-Score on the PD alone appears to be greater than the impact of the TESG-Score. While a one percentage point increase in the TESG-Score decreases a *Real Estate* firm's PD, on average and *ceteris paribus*, by 0,00296 percentage points, a one percentage point increase in the ENV-Score would decrease a *Real Estate* firm's PD, on average and *ceteris paribus*, by 0,00304 percentage points. The SOC-Score, by contrast, seems to impact other industries. In the sectors *Financials* and *Healthcare,* both SOC-Score coefficients show significance at the 10% significance level. The effect is larger in the *Healthcare* sector. On average and all else being equal, increasing the SOC-Score by one percentage point would lower the PD of a *Healthcare* firm by 0,00402 percentage points, while it would lower the PD of a financial firm by 0,000567 percentage points. Finally, the GOV-Score does not seem to significantly impact a firm's PD in any of the examined industries, as none of the coefficients are statistically significant.

A different picture emerges when looking at the industry results for investment-grade firms in Table 8, which show that sustainability has an impact in clearly more industries. As in Table 7, all significant coefficients are negative. Consequently, an increase in the respective sustainability score leads, on average, to an improvement in the creditworthiness of an investment-grade firm in the respective industry. Looking at the TESG-Score coefficients, the coefficient for the *Real Estate* sector is still significant at the 5% significance level. On average, a one percentage point increase in the TESG-Score lowers the PD of an investment-grade *Real Estate* firm by 0,000621 percentage points, *ceteris paribus*. However, sustainability seems to have the largest impact on the PD of investment-grade firms in the *Healthcare* sector. In comparison, the coefficient for this sector shows lower significance at the 10% significance level, but the effect is 0,000172 percentage points larger than in the *Real Estate* sector. On average, a one percentage point increase in the TESG-Score leads to a 0,000793 percentage points decrease in the PD, *ceteris paribus*. As with the *Healthcare* sector, the TESG-Score coefficient is significant at the 10% significance level for the sector *Financials*. However, the impact of sustainability seems to be lowest there compared to the other two sectors. Increasing the TESG-Score by one percentage point decreases the PD, on average, by 0,000270 percentage points, all else being equal.

Looking at the individual Pillar Scores in Table 8, the environmental performance appears to significantly impact the PD of investment-grade firms in the five sectors *Communication Services*, *Healthcare*, *Financials*, *Industrials*, and *Information Technology*. The coefficients in the sectors *Communication Services* and *Healthcare* show a strong significance at the 1% significance level, while the coefficient in the sector *Financials* is significant at the 5% significance level, and those in the sectors *Industrials* and *Information Technology* are significant at the 10% significance level. Since all five coefficients have a negative sign, an increase in the ENV-Score results, on average and *ceteris paribus*, in a decrease and, thereby, an improvement in the PD. However, the effect of the environmental performance on the PD appears to be greatest in the *Information Technology* sector. On average, a one percentage point increase in the ENV-Score leads to a 0,00139 percentage points decrease in the PD, *ceteris paribus*. Compared to the *Information Technology* sector, the impact of the environmental performance is, on average, 0,00039 percentage points smaller in the *Healthcare* sector, 0,000932 percentage points smaller in the *Communication Services* sector, and 0,001156 percentage points smaller in the *Industrials* sector. The impact on the PD is the smallest in the *Financials* sector. On average, a one percentage point increase in the ENV-Score leads to a 0,000204 percentage points decrease in the PD, *ceteris paribus*. Thus, this effect is 0,001186 percentage points lower than in the *Information Technology* sector. However, the large difference between the *Financials* and *Information Technology* sectors highlights the extent to which the impact on the PD can vary between sectors. Looking at the SOC-Score coefficients, the influence of the social performance on the PD appears to be significant in the sectors *Financials* and *Real Estate*. Both coefficients for these sectors are negative and significant at the 5% significance level. However, the *Real Estate* sector is more influenced. While a one percentage point increase in the SOC-Score lowers the PD of an investment-grade *Real Estate* firm, on average, by 0,000547 percentage points, the PD of an investment-grade firm from the financial sector would decrease, on average, by less than half, in both cases *ceteris paribus*. Finally, the governance performance of an investment-grade firm does not appear to have a significant impact on the PD in any of the eleven industries, as none of the GOV-Score coefficients are statistically significant.

In addition to the industry-specific influence of sustainability on the PD, it is also of interest how the impact of sustainability has changed over time. For this purpose, the coefficients of the TESG-Score and its three Pillars are plotted annually from 2006 to 2021. Figure 1 and Figure 2 show the time evolution of the four sustainability score coefficients for the entire dataset and investment-grade firms, respectively. An annually expanding time window starting in 2005 is used to plot the coefficients, i.e., a subsample is formed for each year by grouping the respective year's observations with the previous years' observations. The thin error bars in the figures represent the 95% confidence interval. AR and IV are included as control variables in all regressions. In addition, all models are controlled for industry- and year-FE. Since year-FE are considered, 2005 represents the base year and is therefore not included in either figure.

***Figure 1:* Impact of ESG on PD over time**

This figure shows the time evolution of the sustainability score coefficients from 2006 to 2021. To plot the coefficients, an annually expanding time window approach is used, i.e., a subsample is formed for each year by grouping the observations of that year with the observations of previous years. The entire data set is considered here. The thin error bars represent the 95% confidence interval. AR and IV are included as control variables. Industry and year-FE are considered.

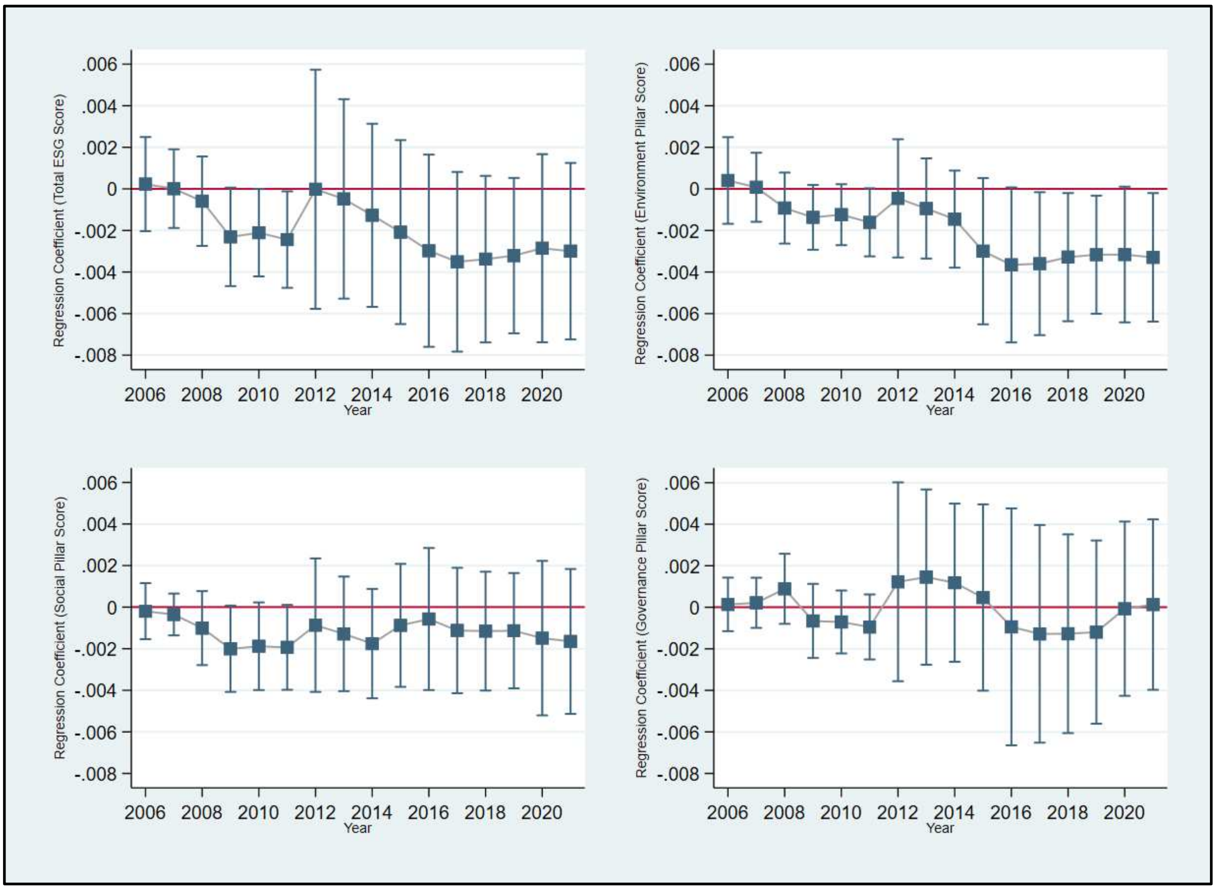
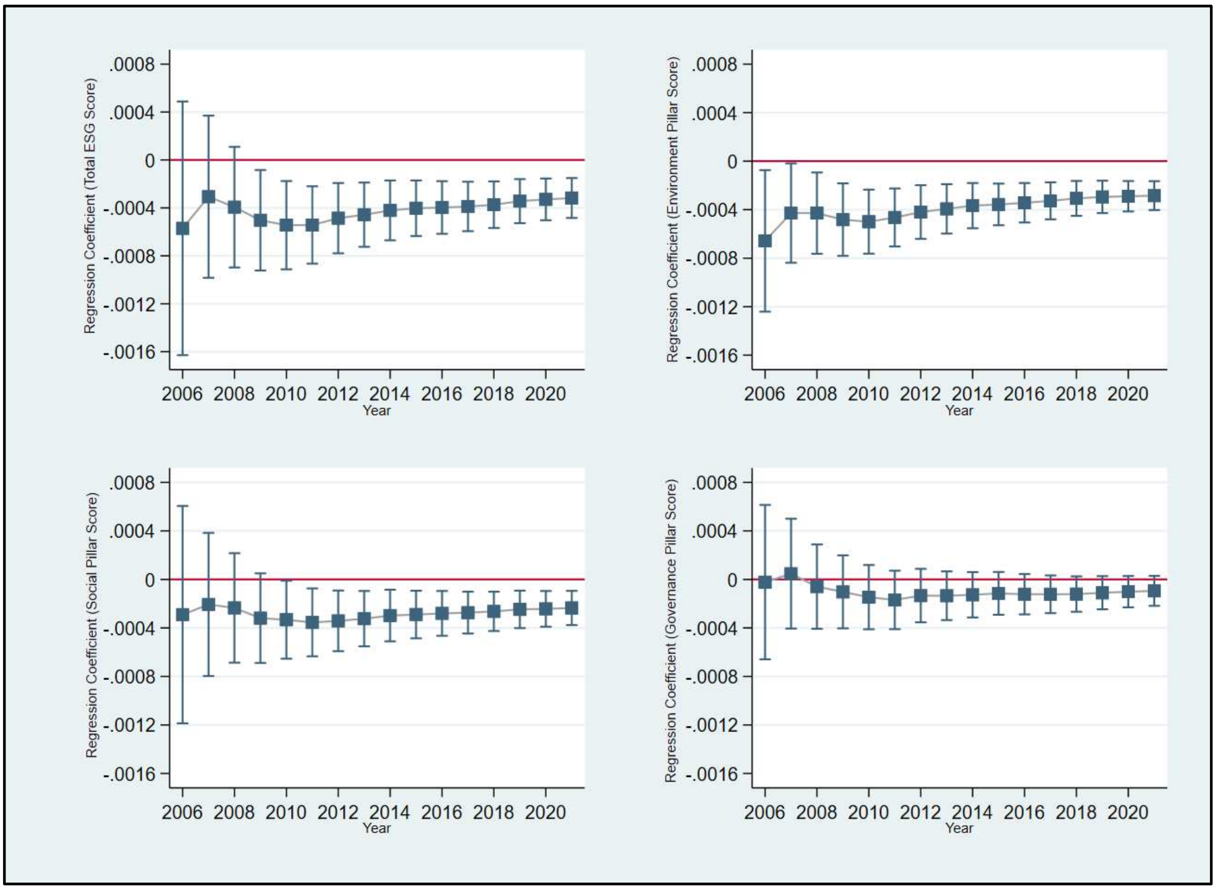


Figure 1 shows that the sustainability score coefficients fluctuate over time, confirming that CRAs readjust the weighting of sustainability in their credit risk evaluations (Lemos-Stein et al., 2021). Focusing on the TESG-Score coefficient, it can be observed that its magnitude significantly declined during the financial crisis from 2007 to 2009, which implies an increased effect of sustainability on credit risk. From 2009 to 2011, this increased effect persisted as the coefficient level was roughly maintained. This period was particularly marked by the European debt crisis (Brunnermeier & Reis, 2019). At that time, CRAs seem to have focused more on sustainability when evaluating credit risk. However, in 2012, the coefficient increased significantly and almost reached a value of zero, which greatly reduced the decreasing effect of sustainability on credit risk. In the following years, the coefficient decreased steadily and reached a new minimum in 2017. Looking at the end of the study period, the impact of the TESG-Score was lower during the COVID-19 crisis in 2020 and 2021 than in 2017 but still larger than during the financial and euro debt crisis. The trend after 2021 indicates that the importance of sustainability for CRAs is increasing as the coefficient seems to decrease.

When looking at the individual Pillar Scores, it is noticeable that the time evolution of the ENV-Score coefficient is almost the same as that of the TESG-Score. The only difference is that the ENV-Score coefficient already reached the second minimum in 2016. This is not the case for the SOC-Score coefficient. Although the SOC-Score coefficient declined significantly during the financial crisis, too, it is less volatile overall. Its value, and thus the impact of the social performance on the PD, fluctuates between 0 percentage points and -0,002 percentage points over the entire study period. The time evolution of the GOV-Score coefficient is again quite different from that of the other Pillar Score coefficients. Figure 1 shows that its value fluctuates sinusoidally around zero.

Figure 2: **Impact of ESG on PD over time (Investment-grade firms)**

This figure shows the time evolution of the sustainability score coefficients from 2006 to 2021. To plot the coefficients, an annually expanding time window approach is used, i.e., a subsample is formed for each year by grouping the observations of that year with the observations of previous years. Only investment-grade firms are considered here. The thin error bars represent the 95% confidence interval. AR and IV are included as control variables. Industry and year-FE are considered.



There is less fluctuation when looking at the time evolution of the sustainability score coefficients for investment-grade firms in Figure 2. The history of the TESG-Score coefficient shows that sustainability had the greatest impact on the PD in 2006. Although the impact of the TESG-Score on the PD decreased significantly at the beginning of the financial crisis in 2007, it almost returned to its 2006 level in the course of the financial crisis and the European debt crisis. However, from 2010 to 2021, the coefficient increased year by year, implying an equal decrease in the influence of sustainability on the PD. In 2010, the coefficient value was -0,000544 percentage points, while in 2021, it was -0,000317 percentage points. This corresponds to a reduction of close to 41%.

Looking at the coefficients of the three ESG components, their development over time is very similar to that of the TESG-Score coefficient. This applies in particular to the ENV-Score coefficient. The only difference in the SOC-Score coefficient is that 2011, rather than

2006, was the year in which the social performance had the greatest impact on the PD. The difference in the GOV-Score coefficient is that the coefficient was positive in 2007. This means that, everything else constant, an improvement in the governance performance led, on average, to an increase in the PD. Moreover, as with the SOC-Score, the governance performance had the most significant impact on the PD in 2011. Finally, it is worth mentioning that the impact of the governance performance did not consistently decrease from year to year, as was the case for the other Pillar Scores, but fluctuated slightly in some years after 2011.

5. Discussion

This chapter aims to discuss the results obtained in light of the results of existing studies. To briefly summarize the analysis of the previous chapter, the results show that if no distinction is made by rating category, only the ENV-Score significantly impacts the PD of European firms. Looking specifically at investment-grade firms, the results show that the PD of these firms is significantly influenced by three sustainability measures: the TESG-Score, the ENV-Score, and the SOC-Score. After adding additional controls, the validity of the first result could not be confirmed, while the validity of the second result could be confirmed. Consequently, this dissertation's results give the impression that the impact of sustainability on credit risk is conditional, i.e., tied to an investment-grade rating. This assumption is tested by examining the impact of the four sustainability scores on the PD of firms with speculative-grade ratings under the same conditions as in Table 4. Unlike investment-grade firms, all sustainability score coefficients are not significant. The results are presented in Appendix A3.

Since most previous studies on this topic have found an unconditional, negative relationship between sustainability and credit risk, this finding is surprising. However, one of the few studies on European firms that do not find an unconditional negative relationship either is that of Stellner et al. (2015). The authors conclude that the higher a firm’s sustainability level is above the national average, the greater the impact of sustainability on credit risk. These results may be applicable to the findings of this dissertation.

***Table 9:* Average Sustainability Scores**

This table shows the averages of the sustainability scores for the entire dataset and by rating category.

Sustainability Score	All Observations	Investment-Grade Observations	Speculative-Grade Observations
Average TESG-Score	66,64	67,36	62,04
Average ENV-Score	68,58	69,67	61,55
Average SOC-Score	68,60	69,47	63,05
Average GOV-Score	63,32	63,77	60,49

Looking at the average sustainability scores in this dissertation's dataset in Table 9, it is noticeable that, on average, firms with investment-grade ratings have a better ESG performance than firms with speculative-grade ratings. Therefore, the impact of sustainability on the PD might be significant for investment-grade firms, as their sustainability performance tends to be above average. In turn, it can be assumed that firms with speculative-grade ratings tend to underperform, which is why no significant impact of sustainability on PD is found for this rating category. Regarding governance, investment-grade firms do not appear to perform significantly better than speculative-grade firms. The lesser difference between the GOV-Score averages of the two rating categories may explain why the impact of this Score on the PD is not significant even for investment-grade firms.

There are different reasons to believe that investment-grade firms have a better ESG performance than speculative-grade firms. One reason is that sustainability often requires large upfront investments that only save money in the long run (Polman & Winston, 2022). Since investment-grade firms have access to cheaper financing (Matthies, 2013), it is easier for them to raise money and invest in sustainability. Another reason is sustainability rankings. Rankings like the 'Sage Sustainable 50' indicate that investment-grade firms are often more sustainable. Each year, the 'Sage Sustainable 50' ranks 50 companies with the best ESG performance. In 2021, 43 of the 50 ranked firms were investment-grade firms, and only 7 were speculative-grade firms (Harper, 2021). In 2022, the number of speculative-grade firms has decreased to 5 (Poreda & Harper, 2023). Nevertheless, it should not be ignored that the study by Stellner et al. (2015) refers to country-specific sustainability averages. Yet, the explanation presented could apply to individual European countries as well. This is a possible topic for future research.

Summarizing the results on the industry-specific impact of sustainability on credit risk, the regression outputs show that, regardless of the rating category, the PDs of firms in the *Real Estate*, *Financials*, and *Healthcare* sectors are significantly impacted by at least one of the sustainability scores examined. Looking only at firms with an investment-grade rating, the PDs of firms in the *Communication Services*, *Industrials,* and *Information Technology* sectors are also impacted by at least one sustainability score in addition to the three aforementioned sectors. However, the results further show that the GOV-Score does not have a significant impact in any industry. Although the literature found on the industry-specific influence of sustainability does not differentiate by rating category, it is still possible to identify both similarities and differences in the results.

The results of Aslan et al. (2021) confirm the findings regarding the influence of the TESG-Score and ENV-Score in the *Real Estate* sector (Table 7). Even though the authors are analyzing U.S. firms, this result seems conclusive considering that the *Real Estate* sector is currently responsible for 40% of global carbon dioxide emissions (Carlin, 2022), making sustainable European *Real Estate* firms less risky if they meet the high environmental standards of the EU (European Union, 2023). However, there are significant differences regarding the impact of the environmental performance in the *Industrials* sector. While the study of Aslan et al. (2021) finds an increasing effect of the ENV-Score on the PD, this dissertation finds a decreasing effect for investment-grade firms (Table 8). Aslan et al. (2021) argue that investments in the environmental performance are costly and therefore increase the PD. Conversely, it can be assumed that the costs in Europe are either not as high as in the U.S. or can be easily borne by financially stable investment-grade firms in this sector so that the positive effects of an improved environmental performance exceed the costs. Yet, it should not be ignored that Aslan et al. (2021) do not distinguish by rating category, so it cannot be ruled out that there is a decreasing impact on credit risk for investment-grade firms in the U.S.

The result regarding the significant impact of the SOC-Score in the *Healthcare* sector (Table 7) is supported by the results of Chodnicka-Jaworska (2021). As *Healthcare* firms provide services to the community or offer products to treat human diseases, it can be argued that social factors are particularly important for them as they need to continuously ensure quality of care or good medical outcomes while providing affordable treatments to the community. Fulfilling this function positively impacts the SOC-Score and, according to S&P, also the PD (Lim & Hortkova, 2019). However, the results for investment-grade firms show that the effect of the SOC-Score is no longer significant (Table 8). One explanation for this could be that, on average, the CRAs' expectations for this group have already been met to such an extent that a further improvement of the SOC-Score no longer has a significant impact on the PD.

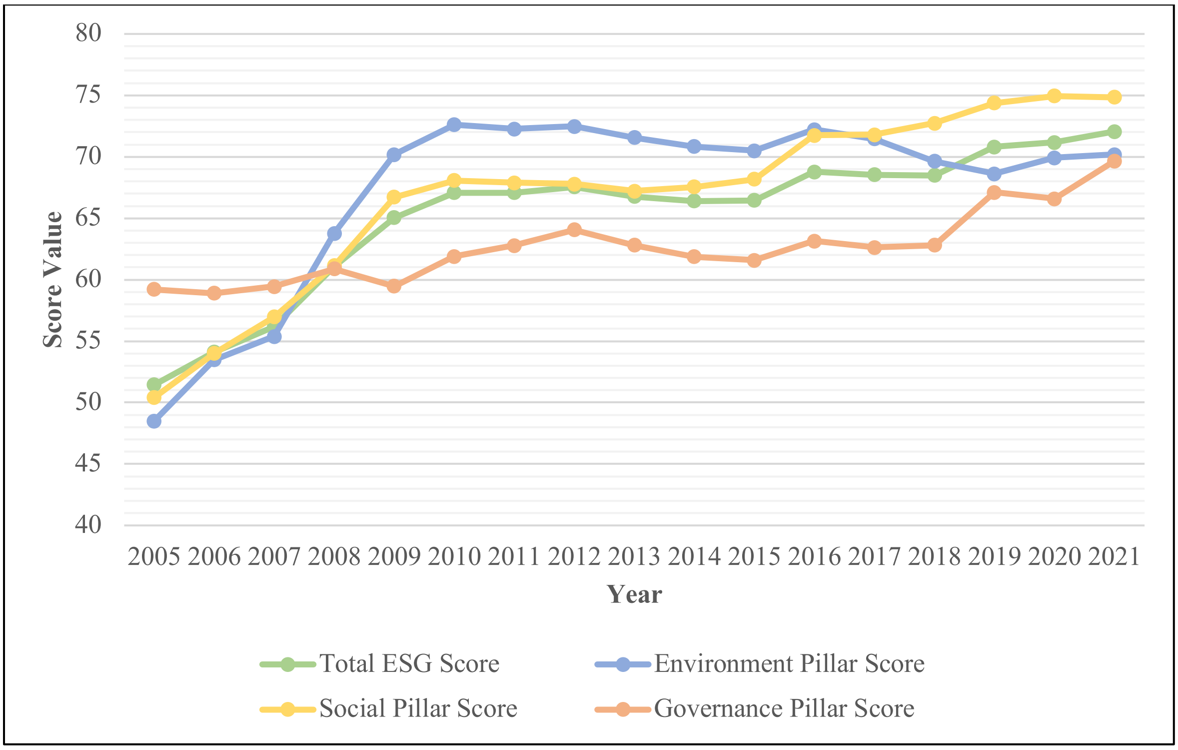
Surprisingly, when comparing this dissertation's findings with those of other studies, the *Energy* sector is not significantly influenced by sustainability. Looking at the results of other European studies, such as those of Chodnicka-Jaworska (2021) or Brogi et al. (2022), a significant influence of a firm's environmental performance on the PD is always shown. Likewise, Aslan et al. (2021) find a significant influence of the environmental performance in the U.S. *Energy* sector. Aslan et al. (2021) argue that the significant negative impact is in line with the expectations of ecological disruption in this sector. However, one argument favoring this dissertation's findings is that the sustainable transformation of the *Energy* sector involves enormous costs (Papadis & Tsatsaronis, 2020). These high costs could eventually offset the increasing effect of sustainability. At the same time, it should be noted that the *Energy* sector in Europe is highly regulated. The study of Hoppe et al. (2018) concludes that the regulatory framework in Europe only allows sustainability innovations to a certain extent. CRAs might consider these circumstances when evaluating the credit risk of an *Energy* firm, which is why sustainability does not significantly impact the PD.

Interestingly, many authors seem to focus on non-financial firms when examining the impact of sustainability on credit risk (Chodnicka-Jaworska, 2021; Höck et al., 2020; Zanin, 2022). However, Table 8 shows that the PD of investment-grade firms in this sector is strongly influenced by sustainability, as three of the four sustainability scores show a significant impact. This result appears to be in line with the important role that sustainable finance has in accelerating the transformation to a more sustainable economy and society (European Commission, 2022; Creditreform, 2020). Future research should include the *Financials* sector in industry-specific analyses to provide further insights. In addition, researchers should attempt to find a consistent standard for classifying industries to make it easier to compare results. For instance, Zanin (2022) uses the NACE standard instead of GICS, while Chodnicka-Jaworska (2021) uses a Refinitiv classification standard. While their standards combine the *Information Technology* and *Communication Services* sectors into one sector, GICS, as shown in this dissertation, considers them as two separate sectors.

Finally, to address the results of the sustainability impact over time, it is striking that in both scenarios examined, the impact of almost all sustainability scores on the PD increased significantly during the financial crisis. This is in line with the findings of Aslan et al. (2021), who report the same in the case of U.S. firms. One reason for the increased impact could be the greater resilience of firms in times of adverse market conditions and the improved sensitivity to government actions that firms with higher sustainability can obtain, as described by Cardillo and Chiappini (2022). The annual average sustainability scores between 2005 and 2021 in Figure 3 show a noticeable improvement in most of the sustainability scores during the financial crisis. This observation supports the assumption that CRAs have attached more importance to sustainability during this crisis.

***Figure 3*: Time Evolution of Sustainability Scores**

This figure shows the time evolution of the sustainability scores during the study period.



The results have also shown that the impact of sustainability on the PD has not increased as much during the COVID-19 crisis in 2020/2021 as during the financial crisis. For investment-grade firms, the COVID-19 crisis does not seem to have caused any noticeable changes in the impact of sustainability at all. Comparing the average annual sustainability scores during the COVID-19 crisis with the scores at the end of the financial crisis in 2009, firms have significantly improved all sustainability scores except for the ENV-Score. Thus, one can argue that, on average, firms have already achieved a high level of resilience compared to the financial crisis, which might be one reason why CRAs did not increase the impact of sustainability as much during the COVID-19 crisis as during the financial crisis. Under the assumption that investment-grade firms perform better than speculative-grade firms in terms of sustainability, this could explain why Figure 2 does not show increased sustainability impacts for investment-grade firms during the COVID-19 crisis. Although Cardillo and Chiappini (2022) find that the impact of sustainability on credit risk increased during the COVID-19 crisis, the authors only examine the years 2020 and 2021 rather than a more extended period, as in this dissertation. Therefore, it is possible that the increased sustainability impact during the COVID-19 crisis was not as significant as during the financial crisis.

A thorough search of the relevant literature did not reveal any other articles examining the impact of sustainability over time. Especially for Europe, this topic seems not to have been addressed yet. This dissertation provides a stimulus for future research to further observe the impact of sustainability on credit risk over time. In particular, examining the period between the financial crisis and the COVID-19 crisis in Europe is interesting for future research, as it is difficult to interpret the changes in the impact of sustainability on credit risk during this period. In addition to the aftermath of the European debt crisis or the adoption of sustainability programs such as the 2015 Paris Agreement, there may be several reasons why CRAs have adjusted the impact of sustainability during this period, as shown in Figure 1.

6. Conclusion

This dissertation investigates the impact of sustainability on the credit risk of European firms over the period 2005 to 2021. For the analysis, firms' Total ESG Scores and their corresponding Pillar Scores, namely 'Environmental', 'Social', and 'Governance', are used as sustainability measures. To proxy credit risk, S&P ratings, converted into default probabilities using European transition matrices, are employed, thereby circumventing the problem of non-equidistant scaling of credit ratings. The dataset consists of 412 European firms, most of which are constituents of the STOXX Europe 600. Overall, this dissertation contributes to the literature by further analyzing the impact of sustainability on corporate credit risk at a European level and for a more recent period while incorporating a distinction by investment-grade rating.

The multivariate regression results reveal that, when making no distinction by rating category, only the Environmental Pillar Score has a negative effect on a firm’s default probability, indicating that an improvement in environmental performance leads to a decrease in default probability. However, when analyzing only investment-grade firms, the outputs show that the Total ESG Score, the Environmental Pillar Score, and the Social Pillar Score significantly impact those firms’ default probability. Thus, an improvement in these scores also leads to an improvement in creditworthiness for this group. While the validity of the first result could not be confirmed after adding additional control variables, the validity of the second result could be confirmed. This suggests that the impact of sustainability is conditional and tied to an investment-grade rating. The assumption was confirmed by analyzing the impact of the sustainability scores on the default probability of speculative-grade firms.

Moreover, a sectoral analysis demonstrates that the default probabilities of firms from the *Real Estate*, *Financials*, and *Healthcare* sectors are significantly influenced by at least one of the examined sustainability measures when no distinction is made by rating category. In contrast, the specific analysis of investment-grade firms shows that, in addition to these sectors, the default probabilities of investment-grade firms from the *Industrials*, *Information Technology,* and *Communication Services* sectors are also significantly influenced by at least one of the sustainability measures. However, the Governance Pillar Score does not exhibit any influence in any industry. A temporal analysis further shows that the influence of sustainability on the default probability varies over time and that the impact increased significantly during the financial crisis. Moreover, the impact seems to have steadily decreased for investment-grade firms in recent years.

The research question can thus be answered affirmatively. The results show that the level of sustainability can impact credit risk. However, as explained, this impact appears to be tied to an investment-grade rating. Firms with investment-grade ratings seem to be able to reduce their credit risk by improving their Total ESG Score or the two Pillar Scores 'Environmental' and 'Social'. There may be several reasons for this. Polluting firms can increase their Environmental Pillar Score by reducing their carbon emissions, thereby avoiding potential fines for violations of environmental regulations. In addition, creating appropriate working conditions can lead to an increase in the Social Pillar Score, and simultaneously firms can improve their reputation and avoid productivity losses. Both sustainability measures would reduce credit risk. Interestingly, the governance performance of a firm alone does not appear to have a significant impact on credit risk. However, the results show that the impact of sustainability on the credit risk of investment-grade firms is not particularly large. Furthermore, the industry-specific analysis demonstrates that not all firms benefit from improving their sustainability, and all do differently. Additionally, the impact of sustainability varies over time; it is not constant.

Despite these contributions, several limitations exist. First, endogeneity bias could still occur due to omitted variables. Since it is not public knowledge how CRAs determine their credit ratings, it remains uncertain whether the used control variables are sufficient to avoid bias in the results. Second, survivorship bias may influence the results, as ESG data from defaulted firms was omitted during the data collection process. Thus, the dataset used in this dissertation consists exclusively of financially stable firms. Third, selection bias may exist since this dissertation mainly focuses on firms (and some selected European countries) from the STOXX Europe 600. Finally, firms with speculative-grade ratings are underrepresented in the dataset, especially in some years and industries, which could bias the results.

References

Alp, A. (2013). Structural Shifts in Credit Rating Standards. *The Journal of Finance*, 68(6), 2435-2470.

Altman, E. I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance*, *23*(4), 589–609.

Ashbaugh-Skaife, H., Collins, D. W., & LaFond, R. (2006). The effects of corporate governance on firms' credit ratings. *Journal of Accounting and Economics*, 42(1–2), 203–243.

Aslan, A., Poppe, L., & Posch, P. (2021). Are sustainable companies more likely to default? Evidence from the dynamics between credit and ESG ratings. *Sustainability*, 13(15), 1–16.

Balasirishwaron, D., Duponcheele, G., & Perraudin, W. (2022). ESG and Credit Rating Correlations.

Baltagi, B. H. (2005). Econometric Analysis of Panel Data: Third Edition.

Bannier, C. E., Bofinger, Y., & Rock, B. (2022). Corporate social responsibility and credit risk. *Finance Research Letters*, 44.

Bhojraj, S., & Sengupta, P. (2003). Effect of Corporate Governance on Bond Ratings and Yields: The Role of Institutional Investors and Outside Directors. *Journal of Business*, 76(3), 455–475.

Brogi, M., Lagasio, V., & Porretta, P. (2022). Be good to be wise: Environmental, Social, and Governance awareness as a potential credit risk mitigation factor. *Journal of International Financial Management and Accounting*, 33(3), 522–547.

Brunnermeier, M. K., & Reis, R. (2019). A crash course on the euro crisis.

Caiazza, S., Galloppo, G., & La Rosa, G. (2023). The mitigation role of corporate sustainability: Evidence from the CDS spread. *Finance Research Letters*, *52*, 1–10.

Capasso, G., Gianfrate, G., & Spinelli, M. (2020). Climate change and credit risk. *Journal of Cleaner Production*, 266, 1–10.

Capelle-Blancard, G., Crifo, P., Diaye, M. A., Oueghlissi, R., & Scholtens, B. (2019). Sovereign bond yield spreads and sustainability: An empirical analysis of OECD countries. *Journal of Banking and Finance*, 98, 156–169.

Cardillo, G., & Chiappini, H. (2022). The Credit Risk of Sustainable Firms during the Pandemic. *Global Business Review*, 23(6), 1462–1480.

Carlin, D. (2022). 40% of emissions come from real estate; here's how the sector can decarbonize. UNEP FI. Retrieved May 2, 2023, from https://www.unepfi.org/themes/climate-change/40-of-emissions-come-from-real-estate-heres-how-the-sector-can-decarbonize/ .

Chodnicka-Jaworska, P. (2021). ESG as a Measure of Credit Ratings. *Risks*, 9(12), 1–26.

Clément, A., Robinot, É., & Trespeuch, L. (2023). The use of ESG scores in academic literature: a systematic literature review. *Journal of Enterprising Communities*, 1–19.

Creditreform (2020). Environmental, Social and Governance Score for Banks. Creditreform Rating AG.

European Commission (2022). Overview of sustainable finance. Retrieved May 3, 2023, from https://finance.ec.europa.eu/sustainable-finance/overview-sustainable-finance_en#:~:text=Related%20links-,What%20is%20sustainable%20finance%3F,sustainable%20economic%20activities%20and%20projects.

European Union (2023). Summaries of EU legislation. Retrieved May 2, 2023, from https://eur-lex.europa.eu/content/summaries/summary-20-expanded-content.html#:~:text=EU%20environmental%20policies%20and%20legislation,move%20toward%20a%20sustainable%20economy.

Ghosh, A., & Lee, C.-W. J. (2000). Abnormal Returns and Expected Managerial Performance of Target Firms. *Financial Management*, *29*(1), 40–52.

Gillan, S. L., Koch, A., & Starks, L. T. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. *Journal of Corporate Finance*, 66, 1–16.

Graham, A., Maher, J. J., & Northcut, W. (2001). Environmental Liability Information and Bond Ratings. *Journal of Accounting, Auditing and Finance*, 16(2), 93–116.

Harper, E. L. (2021). *The Sage Sustainable 50: An Annual Ranking of the Top ESG-Rated Fixed Income Issuers*.

Höck, A., Klein, C., Landau, A., & Zwergel, B. (2020). The effect of environmental sustainability on credit risk. *Journal of Asset Management*, 21(2), 85–93.

Hollstein, F. (2020). Estimating beta: The international evidence. *Journal of Banking and Finance*, 121. + Online Appendix.

Hoppe, T., Butenko, A., & Heldeweg, M. (2018). Innovation in the European Energy Sector and Regulatory Responses to It: Guest Editorial Note. *Sustainability*, 10(2), 1–16.

Jiraporn, P., Jiraporn, N., Boeprasert, A., & Chang, K. (2014). Does Corporate Social Responsibility (CSR) Improve Credit Ratings? Evidence from Geographic Identification. *Financial Management*, 43(3), 505–531.

Kalimipalli, M., & Nayak, S. (2012). Idiosyncratic volatility vs. liquidity? Evidence from the US corporate bond market. *Journal of Financial Intermediation*, 21(2), 217–242.

Kiesel, F., & Lücke, F. (2019). ESG in credit ratings and the impact on financial markets. *Financial Markets, Institutions and Instruments*, 28(3), 263–290.

Kraemer, N. W., Palmer, J., Richhariya, N. M., Iyer, S., Fernandes, L., & Meher, A. (2022). *Default, Transition, and Recovery: 2021 Annual Global Corporate Default And Rating Transition Study*.

Lemos-Stein, G., Kalinina, O. I., & Volland, E.F. (2021). General Criteria: Environmental, Social, And Governance Principles In Credit Ratings. Retrieved May 4, 2023, from https://www.spglobal.com/ratings/en/research/articles/211010-general-criteria-environmental-social-and-governance-principles-in-credit-ratings-12085396 .

Li, T. T., Wang, K., Sueyoshi, T., & Wang, D. D. (2021). ESG: Research Progress and Future Prospects. In *Sustainability*, 13(21), 1–28.

Lim, T., & Horkova, M. (2019). ESG Industry Report Card: Health Care. Retrieved May 2, 2023, from https://www.spglobal.com/en/research-insights/articles/esg-industry-report-card-health-care .

Matthies, A. B. (2013). *Empirical Research on Corporate Credit-Ratings: A Literature Review* (SFB 649).

MSCI (2023). MSCI Europe Index (USD) – Index Factsheet. MSCI. Retrieved May 16, 2023, from https://www.msci.com/documents/10199/db217f4c-cc8c-4e21-9fac-60eb6a47faf0 .

Papadis, E., & Tsatsaronis, G. (2020). Challenges in the decarbonization of the energy sector. *Energy*, 205.

Petersen, M. A. (2009). Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches. *Review of Financial Studies*, 22(1), 435–480.

Polman, P., & Winston, A. (2022). Yes, Investing in ESG Pays Off. Harvard Business Review. Retrieved May 1, 2023, from https://hbr.org/2022/04/yes-investing-in-esg-pays-off .

Poreda, A., & Harper, E. (2023). The Sage ESG 50: An Annual Ranking of the Most Sustainable Corporate Debt Issuers. Retrieved May 2, 2023, from https://www.etftrends.com/esg-channel/the-sage-esg-50-an-annual-ranking-of-the-most-sustainable-corporate-debt-issuers/ .

Qontigo (2023). STOXX Europe 600. Retrieved March 15, 2023, from https://qontigo.com/index/SXXP/ .

Sassen, R., Hinze, A. K., & Hardeck, I. (2016). Impact of ESG factors on firm risk in Europe. *Journal of Business Economics*, 86(8), 867–904.

Shumway, T. (2001). Forecasting Bankruptcy More Accurately: A Simple Hazard Model. *Journal of Business*, 74(1), 101–124.

S&P Global Ratings. (2022). *Guide to Credit Rating Essentials -What are credit ratings and how do they work?*

Stellner, C., Klein, C., & Zwergel, B. (2015). Corporate social responsibility and Eurozone corporate bonds: The moderating role of country sustainability. *Journal of Banking and Finance*, 59, 538–549.

The World Bank (2023). Social Dimensions of Climate Change. Retrieved May 3, 2023, from https://www.worldbank.org/en/topic/social-dimensions-of-climate-change#3 .

Zanin, L. (2022). Estimating the effects of ESG scores on corporate credit ratings using multivariate ordinal logit regression. *Empirical Economics*, 62(6), 3087–3118.

Zmijewski, M. E. (1984). Methodological Issues Related to the Estimation of Financial Distress Prediction Models. *Journal of Accounting Research*, 22, 59–82.

Appendix

***Appendix A1:* Description of Sustainability Scores**

Variable	Description
Environmental Pillar Score	The Environmental Pillar measures a firm's impact on natural systems, including air, land, water, and ecosystems. It assesses how well a company applies best management practices to seize environmental opportunities to create long-term shareholder value. Furthermore, it measures the practices applied to avoid environmental risks (Chodnicka-Jaworska, 2021).
Social Pillar Score	The Social Pillar evaluates a firm's ability to foster trust and loyalty among its stakeholders, including employees, customers, and society at large, through the application of optimal management practices. This Pillar is an indicator of a firm's reputation and the sustainability of its operating license, which are critical factors when determining its ability to create long-term shareholder value (Chodnicka-Jaworska, 2021).
Governance Pillar Score	The Governance Pillar assesses a firm's management and control structures and processes, including those that ensure compliance with laws and ethical standards, to ensure that executives and board members act in the interests of long-term shareholders. This Pillar is an indicator of a firm's ability to manage its rights and responsibilities through incentives and control mechanisms

	to create long-term shareholder value (Chodnicka-Jaworska, 2021).
Total ESG Score	Overall score based on a firm's Environmental, Social, and Governance Pillar Scores (Chodnicka-Jaworska, 2021).

Appendix A2: **Description of Financial Ratios**

Variable	**Description**
Working-Capital-To-Total-Assets ratio	Provides information on a firm's short-term liquidity and financial strength (Altman,1968).
Retained-Earnings-To-Total-Assets ratio	A measure of cumulative profitability over time. A firm's age is implicitly considered in this ratio (Altman, 1968).
EBIT-To-Total-Assets ratio	A measure of the actual productivity of a firm's assets, excluding tax and leverage factors. (Altman,1968).
Market-Equity-To-Total-Liabilities ratio	Indicator of how much a firm's assets can lose in value before its liabilities exceed its assets, making the firm insolvent (Altman, 1968).
Sales-To-Total-Assets ratio	Indicator of the sales-generating power of a firm's assets (Altman, 1968).
Net-Income-To-Total-Assets ratio	Also known as Return on Assets. A measure of profitability. It is used to determine how effectively a firm uses its assets to generate profits (Zmijewski, 1984).
Total-Liabilities-To-Total-Assets ratio	Provides information on the capital structure of a firm. Also known as leverage ratio. The

	higher the leverage ratio, the more debt the firm has (Zmijewski, 1984).
Current-Assets-To-Current-Liabilities ratio	Also known as current ratio. Indicates the ability of a firm to repay its current liabilities with current assets (Zmijewski, 1984).

Appendix A3: Impact of ESG on the PD of Speculative-Grade Firms

*This table shows the impact of the Total ESG Score and the three Pillar Scores on the PD of speculative-grade firms, considering industry- and year-FE. Clustered standard errors at a firm level are shown in parentheses. *, **, and *** indicate significance at the 10%, 5%, and 1% significance level, respectively.*

	(1)	**(2)**	**(3)**	**(4)**
Dependent Var.:	**PD**	**PD**	**PD**	**PD**
ESG it-1	-0,00192			
	(0,0116)			
E it-1		-0,00455		
		(0,00813)		
S it-1			0,00807	
			(0,0113)	
G it-1				-0,00602
				(0,0137)
AR it-1	0,00576	0,00581	0,00584	0,00572
	(0,00495)	(0,00493)	(0,00497)	(0,00492)
IV it-1	0,151***	0,150***	0,150***	0,151***
	(0,0323)	(0,0323)	(0,0318)	(0,0325)
Constant	-2,633*	-2,421*	-3,174**	-2,376*
	(1,378)	(1,271)	(1,453)	(1,297)
Industry-FE	Yes	Yes	Yes	Yes
Year-FE	Yes	Yes	Yes	Yes
Observations	526	526	526	526
Adj. R-Squared	0,197	0,197	0,198	0,198