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Η σημασία των διαστάσεων περιβάλλοντος, κοινωνίας και διακυβέρνησης στην αξιολόγηση του κινδύνου πτώχευσης των επιχειρήσεων

Master's Thesis

The relevance of ESG indicators for assessing the risk of corporate failure

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Η παρούσα διπλωματική εργασία με τίτλο «The relevance of ESG indicators for assessing the risk of corporate failure» εκπονήθηκε για την απόκτηση του Διπλώματος Μεταπτυχιακών Σπουδών στη «Διοίκηση Επιχειρήσεων - Master in Business Administration» (ειδίκευση «Χρηματοοικονομική»), που απονέμει η Σχολή Μηχανικών Παραγωγής και Διοίκησης του Πολυτεχνείου Κρήτης.

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1. Μιχάλης Δούμπος, Επιβλέπων
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Ευχαριστίες

Θα ήθελα εγκάρδια να ευχαριστήσω την σχολή, τους καθηγητές και την γραμματεία για την στήριξη σε όλα τα στάδια των μεταπτυχιακών σπουδών μου.

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Περίληψη

Στη παρούσα εργασία γίνεται μια βιβλιογραφική ανασκόπηση της σχέσης των διαστάσεων Περιβάλλοντος, Κοινωνίας και Διακυβέρνησης (ESG) με τον κίνδυνο πτώχευσης των επιχειρήσεων. Στη συνέχεια, παρουσιάζονται αποτελέσματα ποσοτικής έρευνας με σκοπό να εντοπιστούν πιθανές σχέσεις μεταξύ των διαστάσεων ESG και της πιθανότητας πτώχευσης μιας επιχείρησης.

Τα εταιρικά δεδομένα, τα οποία χρησιμοποιούνται σε αυτή την έρευνα παρέχονται από την Refinitiv, όπου δίνονται στοιχεία για 1.893 Ευρωπαϊκές επιχειρήσεις, από 8 διαφορετικούς κλάδους, για ένα διάστημα 5 ετών, συγκεκριμένα από το 2018 έως το 2022. Επίσης, για αυτές τις 1.893 επιχειρήσεις, γίνεται αντιστοίχιση της πιθανότητας πτώχευσης της κάθε εταιρείας, με τη χρήση δεδομένων που παρέχονται από το NUS Credit Research Initiative. Συνεπώς, δημιουργείται ένα μοναδικό σύνολο δεδομένων 1.893 επιχειρήσεων, για διάστημα 5 ετών, όπου εξετάζονται οι επιδράσεις των διαστάσεων του ESG πάνω στον κίνδυνο πτώχευσης και ως προέκταση στην πιστοληπτική διαβάθμιση μιας εταιρείας. Επιπλέον, γίνεται διαχωρισμός για εταιρείες κερδοσκοπικής (speculative) και επενδυτικής (investment) βαθμίδας. Έτσι, εξετάζονται σε βάθος οι επιδράσεις του ESG, πάνω σε υγιείς και προβληματικές επιχειρήσεις.

Βάσει του πίνακα πιστοληπτικής διαβάθμισης από το υπόδειγμα StarMine Combined Credit Risk Model, θέτεται ως όριο διαχωρισμού (cut-off point) το 0.19%, που χωρίζει τις BBB- από τις BB+, δηλαδή την επενδυτική από την κερδοσκοπική βαθμίδα. Επομένως, τα δεδομένα χωρίζονται σε δύο σύνολα και εξετάζονται ξεχωριστά στην τελευταία ερευνητική υπόθεση.

Οι 5 ερευνητικές υποθέσεις είναι:

H1: Οι Περιβαλλοντικοί δείκτες επηρεάζουν την πιθανότητα πτώχευσης των επιχειρήσεων.

H2: Οι Κοινωνικοί δείκτες επηρεάζουν την πιθανότητα πτώχευσης των επιχειρήσεων.

H3: Οι δείκτες Διακυβέρνησης επηρεάζουν την πιθανότητα πτώχευσης των επιχειρήσεων.

H4: Διαφέρει η συνδυαστική, από τη μεμονωμένη, χρήση δεικτών Περιβάλλοντος, Κοινωνίας και Διακυβέρνησης, στον τρόπο με τον οποίο επηρεάζουν την πιθανότητα πτώχευσης των επιχειρήσεων.

H5: Οι δείκτες Περιβάλλοντος, Κοινωνίας και Διακυβέρνησης επηρεάζουν διαφορετικά την πιθανότητα πτώχευσης των επιχειρήσεων επενδυτικής και κερδοσκοπικής βαθμίδας.

Η ανάλυση βασίστηκε σε ένα μοντέλο σταθερών επιδράσεων, σύμφωνα με τα αποτελέσματα του στατιστικού ελέγχου Durbin-Wu-Hausman. Έτσι, με την χρήση μοντέλων διαστρωματικών χρονολογικών σειρών σταθερών επιδράσεων, γίνεται ο έλεγχος των 5 ερευνητικών υποθέσεων, ενώ χρησιμοποιείται και κατάλληλη στατιστική μεθοδολογία SCC, για την διόρθωση των σφαλμάτων, ώστε να υπάρχουν συνεπή και έγκυρα αποτελέσματα.

Τα αποτελέσματα της έρευνας ανέδειξαν την κρισιμότητα του κλαδικού διαχωρισμού για τους δείκτες ESG, ιδίως για μοντέλα εκτίμησης πιθανότητας πτώχευσης. Αρχικά, για κάθε ερευνητική υπόθεση, χρησιμοποιήθηκε ένα συγκεντρωτικό μοντέλο, χωρίς κλαδικό διαχωρισμό, όπου οι δείκτες ESG ήταν φαινομενικά στατιστικά σημαντικοί. Ωστόσο, όταν υπολογίστηκαν ξεχωριστά τα μοντέλα ανά κλάδο, παρατηρήθηκε ότι στατιστικά σημαντικοί δείκτες ESG σε έναν κλάδο συχνά δεν είναι σημαντικοί σε άλλους κλάδους. Ενώ, επανειλημμένα υπήρξαν περιπτώσεις, όπου δείκτες ESG είχαν αντίθετο πρόσημο με στατιστικά σημαντικούς συντελεστές, μεταξύ διαφορετικών κλάδων. Συμπεραίνοντας ότι η χρήση ενός ενιαίου πλαισίου ESG θα έχει ως αποτέλεσμα την υπερεκτίμηση ή την υποεκτίμηση της πιθανότητας πτώχευσης.

Η παρούσα έρευνα, συνεισφέρει στην υπάρχουσα βιβλιογραφία ESG και κινδύνου πτώχευσης, καθώς είναι η πρώτη έρευνα, η οποία εξετάζει συγκεκριμένα, πως η επίδραση του δείκτη ESG αποτυπώνεται στην πιθανότητα πτώχευσης και την πιστοληπτική ικανότητα μιας εταιρείας, χρησιμοποιώντας βαθμολογίες πιθανότητας πτώχευσης από διαφορετικό πάροχο δεδομένων (NUS Credit Research Initiative) από τον πάροχο ESG (Refinitiv), ώστε να βρεθούν δίκαια και ανεπηρέαστα αποτελέσματα.

Μια ακόμη πρωτοτυπία αυτής της έρευνας, αφορά τον ξεχωριστό έλεγχο επιχειρήσεων επενδυτικής και κερδοσκοπικής βαθμίδας. Με αυτόν τον τρόπο, εξετάζονται οι επιδράσεις του ESG σε υγιείς και προβληματικές επιχειρήσεις αντίστοιχα. Τέλος, τίθενται νέα ερωτήματα για μελλοντικές έρευνες.

Abstract

In this thesis a literature review is presented on the relationship between the Environment, Social and Governance (ESG) dimensions and default risk. Subsequently, quantitative research results will be presented to identify possible relationships between the ESG dimensions and company's probability of default. The company data used in this research were collected from the Refinitiv database and they involve a sample of 1,893 European companies over a 5-year period, from 2018 to 2022. For these 1,893 companies the probability of default is matched with each company, using data provided by the NUS Credit Research Initiative, thus, creating a unique data set of 1,893 companies for a period of 5 years, where the effects of ESG dimensions are examined both on the risk of default and, by extension, on the credit rating of a company. This research adds to the existing literature on ESG and default risk, by examining the significance of the potential impact of ESG on credit ratings and posing new questions for future research.

Keywords: ESG, ESG policies, default, risk of default, probability of default, corporate failure, European Green Deal, credit rating

Table of Contents

1. INTRODUCTION

The causal relationship between corporations and social welfare has been extensively studied, with thousands of studies from varying fields being published. The terms of Environmental, Social and Governance (ESG) and Corporate Social Responsibility (CSR)[1] used to be known just by a niche market of investors that used these metrics to assess their investments. These metrics were initially created around 1980 (Berg et al., 2022), and then popularized in 2015, along with the Paris Agreement on Climate Change. Furthermore, the 2030 Agenda for Sustainable Development was adopted by all the United Nations member states, in which the 17 Sustainable Development Goals (SDGs) were included. With the ESG ratings being a crucial part of Sustainable or Green Investing, this initial niche market transitioned into the mainstream market (Berg et al., 2022), with the 17 SDGs fast-tracking this growth over the past 7 years.

From a corporate scope, based on annual studies of the Governance & Accountability Institute (G&A)[2], research demonstrates an increasing sustainability reporting trend among U.S. firms, both on S&P 500 and on Russell 1000 companies[3]. Since 2018, S&P 500 companies' sustainability reporting increased from 86% to 96% in 2021. Meanwhile, the Russell 1000 companies' sustainability reporting rose from 60% in 2018 to 81% in 2021. Also, the number of reports in the smallest half by market cap of the Russell 1000 index indicates that corporate sustainability reporting is increasingly being adopted as a best practice by mid-cap companies as well.

Besides the increased interest by investors and corporations, the academic research in ESG/CSR has also largely expanded. In a paper by Friede et al. (2015) it is mentioned that over 2,000 papers have been published in varying fields such as Economics, Management and Finance, with approximately 90% of these studies concluding to a non-negative relation between ESG and Corporate Financial Performance (CFP). Most of these studies focus on the relation amongst ESG and CFP, however, the impact of a firm's ESG practices on its default risk remains an uncharted field in the ESG literature (Li et al., 2022).

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[1] The terms ESG and CSR will be used interchangeably throughout the thesis.

[2] https://www.ga-institute.com/research/ga-research-directory/sustainability-reporting-trends.html

[3] There is a significant overlap between the S&P 500 Index and the Russell 1000 Index. Both indices are weighted by market capitalization and include the top 500 and 1000 publicly traded companies in the United States, respectively. Consequently, a significant portion of the Russell 1000 typically aligns with the S&P 500 Index trends.

The aim of this thesis is to examine whether the inclusion of ESG metrics can be consistently impactful in models that predict the probability of default (PD). The effects of ESG dimensions are examined both on the risk of default and, by extension, on the credit rating of a company. Time fixed effects panel data models are used to estimate if the ESG metrics benefit or worsen the company's PD throughout time. While with the use of StarMine Combined Credit Risk Model (see Appendix Table B), the PDs will be transformed into a letter grade rating to assess the ESG effect on Investment and Speculative grade rated firms separately.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

As previously mentioned, sustainability reporting of the S&P 500 and Russell 1000 companies, increased to 96% and 81% respectively in 2021. Both S&P 500 and Russell 1000 indices are U.S. based. But the U.S. have the second largest assets of sustainable funds worldwide, with the largest being the European sustainable funds, reaching more than 2 trillion dollars (close to 10 times higher than the U.S.) by the last quarter of 2022[4]. Thus, a study focusing on EU based firms would lead to more impactful results.

In 2022, the European Commission created an initiative[5] called "Sustainable finance – environmental, social and governance ratings and sustainability risks in credit ratings " in which they tried to find reliable ways to include ESG ratings in credit ratings . Therefore, research that investigates the ESG effects on credit ratings seems to be a relevant and important topic.

2.1. Literature Review

It has been proposed in numerous research papers that ESG or CSR metrics are correlated with several risk measures (Gillan et al., 2021). Some of those risks were direct, such as systematic risk (Oikonomou et al., 2012; Albuquerque et al., 2019), credit risk (Jiraporn et al. 2014; Seltzer et al., 2020) and legal risk (Schiller, 2018), while other researchers used an indirect route to assess risk, using the debt cost of capital and the equity cost of capital (Chava, 2014; Ng and Rezaee, 2015). All the studies above used a form or metric of risk as the dependent variable, while using ESG as an independent variable.

Even though the ESG literature is a widely researched topic, several blind spots seem to exist on the ESG effects on the PD. A study by Devalle et al. (2017) explored the impact of ESG performance on credit ratings . Their dataset consisted of Italian and Spanish public firms for the fiscal year of 2015. They asserted that ESG factors should be integral to credit analysis and the assessment of borrowers' creditworthiness, given their influence on borrowers' cash flows and the likelihood of default on debt obligations. Their findings indicate that ESG performance, particularly in the realms of

[4] Sustainable funds' asset size by region 2022 | Statista

[5] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13330-Sustainable-finance-environmental-social-and-governance-ratings-and-sustainability-risks-in-credit-ratings_en

social and governance metrics, significantly influences credit ratings with the exception of environmental scores, a result that must be further researched.

Research by Aslan et al. (2021) investigated the correlation between ESG performance and the likelihood of corporate credit default. Utilizing a dataset of publicly listed US firms spanning from 2002 to 2017 and transforming Standard & Poor's credit ratings into default probabilities. Their findings indicate a significant reduction in the probability of corporate credit default for firms exhibiting high ESG performance. Moreover, through an extended time window a notable variation is observed in the influence of ESG and its individual components over time. When a sectoral breakdown was conducted, they further ascertain that the energy sector is particularly impacted by ESG considerations concerning the probability of corporate credit default.

Li et al. (2022) examined how the adoption of ESG practices by Chinese listed companies affects their likelihood of default. Their investigation examined the correlation between default risk and ESG ratings. By using a year-by-season and firm fixed effects approach, they concluded that higher ESG ratings act as a deterrent to firms' default risk. This risk-mitigating effect became more pronounced as the term structure of default risk extends. Notably, it was observed that the impact of ESG ratings on default risk is less significant for manufacturing firms compared to non-manufacturing counterparts. These findings indicate that credit markets accurately reflect a firm's ESG practices, suggesting that investors can enhance credit risk management by considering the ESG performance of companies.

Research by Oikonomou et al. (2014), examined how different aspects of corporate social performance influence the pricing of corporate debt and the evaluation of credit quality for specific bond issues. Their empirical analysis indicates that, as a whole, good performance is rewarded, while corporate social misconduct led to penalties in the form of lower and higher corporate bond yield spreads, respectively. These conclusions hold true when the assigned bond rating for a particular debt issue is categorized as a speculative grade asset.

From all these studies, questions are derived that are worth asking about the ESG effects on a firm’s probability of default. Are all of the ESG pillars affecting a firm’s probability of default? Are all the indicators within the ESG pillars significant? Are all the sectors equally affected by the ESG indicators? And are the ESG indicators effects

consistent across “healthy” (investment grade) and “problematic” (speculative grade) firms? The aim of this thesis is to answer these questions.

Over the past decade, the adoption of sustainability reporting has become increasingly common, nevertheless, the ratings that are being used to assess the ESG practices remain a vague black box. Despite all the attention being given to the ESG subject by many scholars and rating providers, some vital issues have not yet been resolved. A study by Li and Polychronopoulos (2020) showed that the ESG ratings significantly differ across Rating Providers. Meaning, data sets that use ESG ratings by different providers are unreliable and even noncomparable to one another. In accordance with the study mentioned above, the research of Berg et al. (2022) shows a significant ESG divergence among the biggest ESG rating providers.

The overuse of similar ESG indicators that end up in an ESG percentage rating could have a green washing effect. Since the percentage coverage of an Environmental and Social (E&S) indicator on certain occasions can be counted multiple times, while other important indicators have less coverage. As mentioned by Schiller (2018) “standard ESG ratings typically conflate both aspects of E&S policy adoption and E&S outcomes, making it difficult to distinguish real E&S performance from green washing”.

The safest approach to try and approach the ESG agenda is to find which ESG indicators affect corporate performance, rather than how a rating agency's ESG score affects the corporate performance. Therefore, in this thesis some of the indicators across the three ESG pillars will be used, instead of the pillars' scores.

Even though the previous methodology to establish causality seems fair, this does not imply that it will be as efficient as the score rating in determining causality. This happens not because the score rating is more meaningful or more complete, but rather it could be a tool that was used and included in the calculation of the probability of default by the same data providers, and thus creating a statistically significant relationship between them. Hence, a distinct source of PD rating from the NUS CRI is used rather than the Refinitiv PD rating.

To summarize, it is expected that not all ESG indicators will be significant in the models, especially across different sectors. The focus of this research is to find which ESG indicators can be actually helpful for companies, regulators, and credit rating agencies to use, in order to estimate a firm’s probability of default. Consequently,

indicators across all the categories of each ESG pillar, as mentioned by Refinitiv, will be used in this thesis.

2.2. EU framework on ESG and credit ratings

According to the European Commission "Credit ratings are important for the calculation of prudential requirements under the EU's Capital Requirements Regulation (CRR) and Solvency II and are used by the European Central Bank for its open market operations. The EU legal framework regulates the Credit Rating Agencies (CRAs) with a view to protecting investors and financial markets by requiring the transparency, independence, and integrity of the credit rating process". As previously mentioned, there is a lack of transparency by ESG rating providers. There is also a lack of independence, since most of the Credit Rating providers also became ESG rating providers (Berg et al., 2022). So, the question worth asking is "can there be a fair sustainability risk measure implemented in credit ratings"?

In the ESG ratings and sustainability risks in credit ratings initiative[6] (2022), it is mentioned that the July 2021 publication of the strategy for financing the transition to a sustainable economy[7] has highlighted the necessity to evaluate potential policy advancements in sustainability and credit ratings . This initiative comprises two distinct components: first, an examination of the operations of ESG ratings providers and second, an analysis of how Credit Rating Agencies (CRAs) factor ESG risks into their credit rating assessments. These measures are anticipated to lead to the European Green Deal[8] goals by enhancing the accuracy of information used by investors, businesses, and other stakeholders when making decisions that impact the shift toward a sustainable economy.

Furthermore, it is also mentioned by the ESG ratings and sustainability risks in credit ratings initiative (2022), that it is crucial to differentiate between ESG ratings and credit ratings . While both are assessments provided by specialized entities and employed by financial institutions and professional investors, ESG ratings do not have a singular definition. Meanwhile, credit ratings are meticulously defined and appraise the

[6] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13330-Sustainable-finance-environmental-social-and-governance-ratings-and-sustainability-risks-in-credit-ratings_en
[7] https://finance.ec.europa.eu/publications/strategy-financing-transition-sustainable-economy_en
[8] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

creditworthiness of companies or financial instruments by offering an evaluation specifically on the risk of a company defaulting. Therefore, the inclusion of a simplistic percentage score measure cannot be the solution to such a complex issue. On the contrary, certain statistically, ethically, and legislatively significant ESG indicators must be used in order to create a fair risk measure.

One aspect that appears to be overlooked or underrepresented in the ESG ratings is the supply chain of a firm. The general idea behind the implementation of ESG ratings was to help with the 17 SDGs as it was previously mentioned. The past couple decades fluid organizations continue to rapidly evolve and develop (Bhimani and Bromwich, 2009), meaning that a larger portion of firms tends to outsource, partially or completely, their manufacturing. Thus, supply chains have to be considered when it comes to ESG ratings.

The ESG rating of affiliated firms should also affect a firm rating. This has mostly to do with the outsourcing of practices to countries where poor environmental and social rights laws exist and are taken advantage by Corporations. For example, a firm that outsources all of its production, could potentially show zero emissions, perfect human rights and labor conditions, while in the company that is outsourcing the production child labor, poor working conditions and extreme pollution towards the environment exists. This is yet another aspect of ESG that must be considered and further researched.

Finally, in the supply chain management literature the idea of environmental supply chain management, where environmental practices are included in the strategic decisions, had gotten attraction since the early 2000s (Handfield et al., 2005). In a more recent SCM study, Dai and Tang (2022) mention that “ESG measures should play a central role in guiding a firms’ day-to-day supply chain management practices”. The appropriate integration of these supply chain effects on ESG ratings is an important aspect that has not gotten enough attention by the ESG literature.

2.3. Hypothesis Development

It is important to note the existence of significant differences concerning the appropriate financial ratio measures between sectors (e.g., ROA ratio differs between industrial manufacturers and service providers) and this might also be the case with ESG measures. Meaning, that sectors should be separated during the analysis. The use of a

sector dummy measure could potentially hide or assume that some sectors are or are not significantly affected by certain ESG measures.

A study by Servaes and Tamayo (2013) indicated that a company's involvement and promotion of CSR initiatives generate positive outcomes, only when these efforts are consistent with the firm's existing reputation. Consequently, companies with unfavorable reputation are unlikely to see immediate gains, such as enhanced shareholder value, from their CSR efforts. In fact, these efforts might be viewed as insincere and potentially lead to adverse consequences. Over time, however, active participation and communication of such initiatives may generate value by influencing how customers perceive the company. Therefore, ESG indicators do not automatically lead to improved financial performance, but there are more subjects such as corporate sincerity and customer awareness that need to be considered. While customer awareness becomes the norm, corporate sincerity is the part that needs to be examined. Above all, we have to keep in mind that corporations can only exist while being profitable, so the costs of ESG transitions must also be taken into consideration.

As posited by Enderle and Tavis (1998), their concept of a balanced business consisted of balancing economic, social, and environmental responsibilities, implying a continuous interaction among them. None of these spectrums of responsibilities can be exploited solely in favor of one another. This concept of a balanced firm should serve as the means to reconcile assessments from within and outside the company. The notion of a "circular interaction" advocated by Enderle and Tavis (1998) is depicted in Figure 1, illustrating how a company could benefit in various spheres of responsibility (e.g., economic for company A, environmental for company B, social for company C).

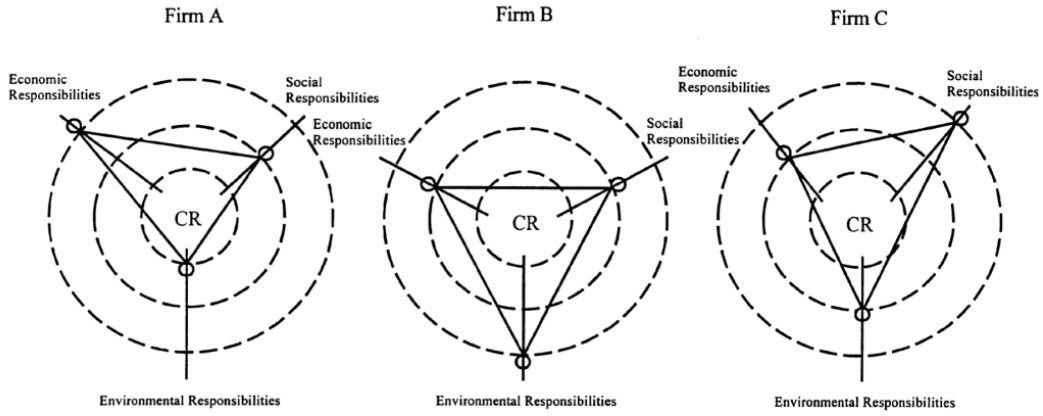

Figure 1: Resource distribution comparison on Economic, Environmental and Social Responsibilities to lead in balanced growth (from Enderle and Tavis, 1998, p.1336).

From the firm's perspective, managers have to deal with various trade-offs while overseeing different responsibilities. This dynamic is reflected in the firm's performance. In this context, when evaluating the firm, the perspective of the stakeholder involved can lead to either an over or under-representation of the firm. A balanced firm will focus on maintaining its evaluation score. In essence, if an inclusive evaluation encompasses not just one-dimensional (primarily financial) progress, but a balanced one, it will inherently address not only the firm's internal and external environments, but also the perspective of the third party which is evaluating the firm, as well as including all stakeholder groups considered in the process (Gaganis et al., 2021). So, to create a balanced firm on the ESG dimensions, the expectations and the current position of the firm is an internal matter that must be considered. Therefore, it is imperative that healthy (investment) and problematic (speculative) firms be separated during the analysis, in order to examine the consistency of the results.

The environmental and social scoring methodology, that Refinitiv uses for the ESG ratings, is a process that standardizes the ESG metrics and evaluates firms based on industry benchmarks. This makes the metrics unusable for out of sample firms. Meaning that they cannot calculate the firm's score without using a comparison methodology. For example, if all firms across the same sector are not involved in any ESG initiative and they have a value of 0 across all the ratings, all of these firms will receive a 50% score, while for the sake of argument, one firm that had only one initiative in this sector will receive a 100% score. This is yet another reason these overall ESG scores are untrustworthy and unreliable. A cross industry analysis of ESG indicators' effect on credit ratings is important, since even the financial ratios are, in most cases, incomparable between different sectors, so why should ESG effects differ? In comparison, ESG effects are expected to differ across sectors since they are very differently affected by legislations, transition costs, social and stakeholder expectations.

Sectors such as energy and industrial tend to also have rough working conditions and a negative overall impact on the environment. Therefore, in such sectors the low scale environmental and social initiatives will likely be perceived as insincere, thus leading to no significant impact. Moreover, the cost of a large scale environmental and social initiative (e.g. complete reform of production) will have significant costs leading to a negative CFP overall impact, at least in the short run, which is examined in this thesis.

On the other hand, sectors such as non-consumer cyclicals, utilities etc. are likely going to be positively affected by low scale environmental and social initiatives while having a low transitioning cost. Hence, it is expected to have a positive CFP.

As it was already mentioned, there have been multiple studies that researched the ESG and or CSR metrics effect on several risk measures, where these studies used a form or metric of risk as the dependent variable while using ESG as an independent variable. Using a similar approach in this research, the dependent variable will be the probability of default given to a company by the NUS Credit Research Initiative, while using company data provided by Refinitiv, that include ESG and financial metrics to predict the company's probability of default. To extend this method the percentage PD will also be transformed into a PD letter rating, as the Refinitiv StarMine Combined Credit Risk Model table suggests.

The objective of this study is to answer whether the ESG metrics affect corporate failure risk and their probability of default. All the above led to the following hypothesis:

H1: Environmental indicators affect a firm's probability of default.

Environmental indicators could lead to an increase in the probability of default. This is likely to be the case on the energy and industrial sectors since the transition costs of these sectors are likely to have a significant negative cost effect on the firm that outweighs the positive public relations effect.

Conversely, environmental indicators could also lead to a decrease in the probability of default. This is likely to be the case for sectors that did not heavily rely on fossil fuels and can easily transition to other forms of energy.

There is also an indicator in the environmental pillar that has a "negative" adaptation to it. This indicator is environmental controversies. It is expected to increase the PD.

H2: Social indicators affect a firm's probability of default.

Social indicators could lead to an increase in the probability of default. New policies might lead to an increase in the cost of wages, production costs etc., that can have a significant cost effect on the firm that outweighs the positive public relations effect.

Social indicators could also lead to a decrease in the probability of default. New policies might also lead to workers to be more efficient and happier, leading to improved social relations and overall performance.

There are specific indicators in the social pillar that have a "negative" adaptation to them. These indicators are bribery corruption and fraud controversies and product quality controversies. Both are expected to increase the PD.

H3: Governance indicators affect a firm's probability of default.

Governance indicators could lead to an increase in the probability of default. This could be the outcome of an inefficient and mismanaged firm that makes decisions that are not in line with shareholders' beliefs.

On the opposite side, governance indicators could also lead to a decrease in the probability of default. This could be the outcome of an efficient and well-managed firm that makes decisions that are in line with shareholders' beliefs.

H4: Combined ESG indicators affect a firm's probability of default.

Overall ESG indicators could lead to a significant effect on the probability of default. According to H1, H2 and H3 there is a chance that there will be mixed positive and negative effects across different sectors and indicators. But the inclusion of all the ESG indicators could potentially alter the results of the individual ESG effect results.

H5: ESG indicators have a different impact on speculative and investment grade firms.

Most studies in the ESG literature, including this one, use data from the largest firms in the world (in this case in the EU). This is not a fair firm sample representation, since firms that already are financially overperforming could start a lot of ESG initiatives and have no significant impact on their overall performance, while firms that are financially underperforming could struggle to include such initiatives. Therefore, by separating investment from speculative grade firms in the analysis, it could potentially show how different the ESG effects are on "healthy" and "struggling" firms, respectively. This could, to an extent, show how different the effects are for large and small firms, since small firms tend to fall into the Speculative grade rankings.

To test whether the effect of every previously mentioned hypothesis is consistent across the rating spectrum, the indicator effects will be tested again for the combined ESG model separately for investment and speculative grade firms across all industries.

Generally, with all the unique effects these qualitative ESG indicators may have on each industry, the presence of mixed effects across sectors could also be a likely outcome for the environmental, social and governance indicators. This applies to all five hypotheses.

3. DATA AND METHODOLOGY

This section documents the variables, data sources, and methods of analysis. Most data sources used are not publicly available. To the best of my knowledge, I am the first to investigate specifically how firm ESG indicator performance influences firm PD using PD scores from a different data provider (NUS Credit Research Initiative) than the ESG provider (Refinitiv) to find more robust, fair, and uninfluenced results.

The Refinitiv dataset consists of 1,893 European companies over a 5-year period, from 2018 to 2022. For these 1,893 companies the probability of default is matched with each company, using PD data provided by the NUS Credit Research Initiative. Thus, creating a unique data set of 1,893 companies for a period of 5 years.

The NUS Credit Research Initiative uses purely financial instruments to determine the firm PD. More precisely they use data common to all firms in the same economy, and firm-specific data. Four elements common to all firms, are: (1) Stock index return (the trailing one-year simple return on a major stock index of the economy), (2) Interest rate (a representative 3-month short-term interest rate standardized from the data available point until now), (3) Financial aggregate DTD[9] (median DTD of financial firms in each economy/country inclusive of those foreign financial firms whose primary stock exchange is in this economy/country) and (4) Non–financial aggregate DTD (median DTD of non–financial firms in each economy/country inclusive of those foreign financial firms whose primary stock exchange is in this economy/country). The six firm characteristics are: (1) volatility-adjusted leverage, (2) liquidity, (3) profitability, (4) relative size, (5) market mis-valuation/future growth opportunities and (6) idiosyncratic volatility.

3.1. Data

Since the ESG data that will be used in this research are from the Refinitiv ESG package, all categories from each pillar will be represented by at least one indicator. The indicator selection was a two-step process. In the first step, indicators are selected based on sufficient data by the provider. This occurred because a lot of the ESG indicators had more than half of the sample as missing values. In the second step, the

[9] Firms' distance-to-default (DTD) in a Merton-type model is one of the firm-specific variables. The adopted DTD formulation modifies the standard one to allow a meaningful calculation of DTD for financial firms.

indicators were used in the models and those with the least significant effect on the models were dropped (consistently high p-value).

After the first step, 45 out of the 178 indicators had sufficient data to proceed to the next step. Out of the 45 indicators, 13 of them with the lowest p-values on the models were kept after this data sorting. Out of the 13 indicators, 4 belonged to the environmental pillar (2 resource use, 1 emissions, 1 innovation), 5 belonged to the social pillar (2 workforce, 1 human rights, 1 community, 1 product responsibility) and 4 belonged to the governance pillar (2 management, 1 shareholders, 1 CSR strategy).

The definition and indicator categories used for the measurement of the ESG pillars provided by Refinitiv Asset4 package are presented in Panel A of Table 1. In Panel B, the indicator distribution of the ESG pillars is presented, while the detailed indicators that are used in this thesis are presented in Panel C.

Table 1: The definition and indicator categories used for the measurement of the ESG pillars provided by Refinitiv Asset4 package.

Panel A

ESG Pillars	Definition	Data source
Environmental	For the Environmental Pillar, the Refinitiv Asset4 Environmental indicators are used. The environmental pillar covers 3 categories: resource use, emissions and innovation. Data largely derived from corporate, public reporting (annual reports, corporate social responsibility (CSR) reports, company websites, and global media sources).	Refinitiv
Social	For the Social Pillar, the Refinitiv Asset4 Social indicators are used. The social pillar covers 4 categories: work force, human rights, community and product responsibility. Data largely derived from corporate, public reporting (annual reports, corporate social responsibility (CSR) reports, company websites, and global media sources).	Refinitiv
Governance	For the Governance Pillar, the Refinitiv Asset4 Governance indicators are used. The governance score covers 3 categories: management, shareholders and CSR strategy. Data largely derived from corporate, public reporting (annual reports, corporate social responsibility (CSR) reports, company websites, and global media sources).	Refinitiv

Panel B

Pillar	Category	Indicators	Weights
Environmental	Resource use	20	11%
	Emissions	22	12%
	Innovation	19	11%
Social	Workforce	29	16%
	Human Rights	8	4.50%
	Community	14	8%
	Product Responsibility	12	7%
Governance	Management	34	19%
	Shareholders	12	7%
	CSR Strategy	8	4.50%
Total		**178**	**100%**

Table 1 continued

Panel C				
ESG pillar	**Category**	**Indicator**	**Definition**	**Measurement**
Environmental Indicators	Resource use	Resource Reduction Targets	Does the company set specific objectives to be achieved on resource efficiency?	Dummy Variable
	Resource use	Renewable Energy Use	Does the company make use of renewable energy?	Dummy Variable
	Emissions	Environmental Controversies	Is the company under the spotlight of the media because of a controversy linked to the environmental impact of its operations on natural resources or local communities?	Dummy Variable
	Innovations	Environmental Products	Does the company develop new products that are marketed as reducing noise emissions?	Dummy Variable
Social Indicators	Workforce	Health Safety Policy	Does the company have a policy to improve employee health & safety within the company and its supply chain?	Dummy Variable
	Workforce	Policy Employee Health Safety	Does the company have a policy to improve employee health & safety?	Dummy Variable
	Human Rights	Policy Child Labor	Does the company have a policy to avoid the use of child labor?	Dummy Variable
	Community	Bribery Corruption and Fraud Controversies	Is the company under the spotlight of the media because of a controversy linked to bribery and corruption, political contributions, improper lobbying, money laundering, parallel imports or any tax fraud?	Dummy Variable
	Product Responsibility	Product Quality Controversies	Have there been controversies linked to the elements driving product quality and responsibility published since the last fiscal year company update?	Dummy Variable
Governance Indicators	Management	Corporate Governance Board Committee	Does the board or board committees have the authority to hire external advisers or consultants without management's approval?	Dummy Variable
	Management	Policy Board Independence	Does the company have a policy regarding the independence of its board?	Dummy Variable
	Shareholders	Shareholder Rights Policy	Does the company have a policy for ensuring equal treatment of minority shareholders, facilitating shareholder engagement or limiting the use of anti-takeover devices?	Dummy Variable
	CSR Strategy	CSR Sustainability Reporting	Does the company publish a separate sustainability report or publish a section in its annual report on sustainability?	Dummy Variable

***Note**: Dummy Variable receives a value of 1 when the answer is "Yes" or a value of 0 when the answer is "No"*

Besides the ESG Data, financial ratios will also be used in order to estimate the probability of default. These are the return on assets ratio (ROA), the accounts receivable turnover (AR Turnover), the total debt to total assets ratio (Leverage), the working capital to total assets (WC/TA) and the natural logarithm of total assets reported (Size). More information about these financial ratios is presented in Table 2.

Table 2: Names, calculations, and definitions of the Financial Ratios.

Financial Ratios	Calculation	Definition
ROA	$\frac{Net\ Income}{Total\ Assets}$	The term return on assets (ROA) refers to a financial ratio that indicates how profitable a company is in relation to its total assets.
AR Turnover	$\frac{Net\ Credit\ Sales}{Avg\ Accounts\ Receivable}$	The accounts receivables turnover ratio measures the number of times a company collects its average accounts receivable balance. It is a quantification of a company's effectiveness in collecting outstanding balances from clients and managing its line of credit process.
Leverage	$\frac{Total\ Liabilities}{Total\ Assets}$	Total debt to total assets is a leverage ratio that defines how much debt a company owns compared to its assets.
WC/TA	$\frac{Working\ Capital}{Total\ Assets}$	A metric that measures the proportion of a company's total assets that is financed by its working capital.
Size	$log(Total\ Assets\ Reported)$	Firm Size value is calculated by calculating the natural logarithm formula of total assets. Natural logarithm is used to reduce the difference that is too high between companies that still have small assets and companies that have large assets so that the total assets are normally distributed.

All the variables mentioned in Table 3 and Table 4 will be used as independent variables in the models that are presented in chapter 4. For the dependent variable, the data used is the probability of default provided by the NUS Credit Research Initiative. The available options from their package are the 1, 3, 6, 12, 24, 36, 60 months ahead probability of default, for an extensive period of months and years. By matching the companies and dates I use the average 12 month ahead PD, for an extend of 6-month period. This happens because the financial reports tend to be delayed approximately 6 months after the dates they are mentioning. Therefore, an average of six 12-month ahead of the financial report date PDs are used to capture the probability of default.

Having conducted the extensive variable introduction, the descriptive statistics reports follow at tables 3 and 4, representing the combined data set statistics within a sample period of 2018 through 2022. On table 3, the return on assets ratio (ROA), the accounts receivable turnover (AR Turnover), the total debt to total assets ratio (Leverage), the working capital to total assets (WC/TA) and the natural logarithm of total assets reported (Size), are all winsorized at the 1% and 99% levels, in order to mitigate the effects of outliers by replacing them with less extreme values.

Table 3: Descriptive statistics for numerical variables.

Independent Variables	**Min.**	**1stQu.**	**Median**	**Mean**	**3rdQu.**	**Max.**	**Skewness**
ROA	-0.291	0.011	0.041	0.040	0.077	0.281	-0.767
AR Turnover	2.100	4.006	5.447	7.166	7.790	25.011	2.128
Leverage	0.040	0.457	0.585	0.586	0.715	2.717	0.739
WC/TA	-0.257	0.011	0.114	0.137	0.246	0.708	0.634
Size	17.740	19.690	20.950	21.070	22.300	25.530	0.327
Dependent Variable							
Log (PD)	-14.509	-7.992	-7.015	-7.164	-6.194	-1.882	-0.630
PD	0.00005	0.034	0.090	0.215	0.204	15.233	10.806

Note: *PD is presented in basis points, meaning 100 bp is equal to 1%.*

As observed by the table above, from the financial ratios only the Size is symmetric. The rest of the numerical variables are either moderately or highly skewed. More precisely, the ROA and the logarithm of the probability of default (Log (PD)) are moderately negatively skewed, while the Leverage and the WC/TA are moderately positively skewed. Meanwhile AR Turnover and the probability of default are all highly positively skewed.

The use of the logarithm of the probability of default is a commonly used method that transforms a numerically small and highly skewed dataset to a numerically larger and less skewed dataset, as shown in the table above.

In the following table, the answers to the questions about the ESG indicators, shown in Panel C of Table 1, will be cumulatively presented for the 5-year period.

Table 4: Descriptive statistics for factor variables.

ESG Indicators	FALSE		TRUE		NA's
	N	N (%)	N	N (%)	N
Resource Reduction Targets	3,263	50.42%	1,846	28.52%	1,363
Renewable Energy Use	1,804	27.87%	3,295	50.91%	1,373
Environmental Controversies	5,026	77.66%	83	1.28%	1,363
Environmental Products	2,308	35.66%	2,788	43.08%	1,376
Health Safety Policy	305	4.71%	4,804	74.23%	1,363
Policy Employee Health Safety	336	5.19%	4,771	73.72%	1,365
Policy Child Labor	1,445	22.33%	3,648	56.37%	1,379
Bribery Corruption & Fraud Controversies	831	12.84%	4,275	66.05%	1,366
Product Quality Controversies	4,899	75.70%	210	3.24%	1,363
Corp. Governance Board Committee	4,248	65.64%	861	13.30%	1,363
Policy Board Independence	2,330	36.00%	2,778	42.92%	1,364
Shareholder Rights Policy	255	3.94%	4,854	75.00%	1,363
CSR Sustainability Reporting	557	8.61%	4,550	70.30%	1,365

***Note**: Later on in the thesis, the use of these dummy variables will be conditioned whether the ESG indicator is true then the dummy is equal to 1, otherwise it is equal to 0.*

As previously mentioned, sector differentiation must be used since different sectors face different risks. The sector distribution will be presented in the following table.

Table 5: Total of EU firms observed, separated by sector and year.

Sector	Year				
	2018	2019	2020	2021	2022
Basic Materials	9	145	149	151	148
Consumer Cyclicals	24	299	322	321	320
Consumer Non-Cyclicals	9	123	137	136	133
Energy	7	71	71	70	71
Healthcare	9	127	134	135	135
Industrials	32	423	445	446	439
Technology	25	281	295	298	302
Utilities	4	53	59	57	57
Total Observations	119	1,522	1,612	1,614	1,605

***Note:** The number of firms that are accounted for in this table, are firms that the probability of default was provided by the NUS and then was successfully matched with the rest of the data provided by Refinitiv.*

As observed in table 5, the dataset consists of firms that belong in eight sectors over a five-year period. It is noticeable that the most commonly represented sectors are industrials, consumer cyclicals and technology, with several hundreds of firms per year, across all European countries. On the other hand, the less represented sectors are utilities and energy, both individually not surpassing a hundred firms per year.

The European Commission[10] on 5 January 2023, issued the Corporate Sustainability Reporting Directive (CSRD), which renewed and strengthened the rules concerning the social and environmental information that companies have to report. A broader set of large companies, as well as listed SMEs, will now be required to report on sustainability.

As mentioned at the European commission press release[11] in June 2022, by the 2024 fiscal year (for reports published in 2025) all large companies will be covered by the CSRD agreements (listed and unlisted EU companies), meeting at least two of the three following criteria: firms with at least 250 employees and/or net turnover of € 40 million and/or €20 million annual total balance sheet.

All the firms in this research are considered large, since they employ 250 to 721,000 employees and have total assets reported that range from 50 million to 122 billion euros. So, the results of this research are important for ESG regulators, EU firms, investors and researchers, since the conclusions will be applicable for all EU firms, that will be soon, if not already, affected by the CSRD.

3.2. Methodology

In order to provide sufficient evidence of statistical significance for the H1 hypothesis there has to be a panel data model that checks if firm environmental indicators are statistically significant to the firm's probability of default. A statistically significant environmental indicator supports hypothesis H1.

Similarly, for the H2 hypothesis a panel data model is constructed to check if firm social indicators are statistically significant to the firm's probability of default. A statistically significant social indicator supports hypothesis H2.

Moreover, a panel data model is constructed to check if firm governance indicators are statistically significant to the firm's probability of default. A statistically significant governance indicator supports hypothesis H3.

[10] https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en
[11] https://www.consilium.europa.eu/en/press/press-releases/2022/06/21/new-rules-on-sustainability-disclosure-provisional-agreement-between-council-and-european-parliament/

Finally, to support the H4 hypothesis, a panel data model is constructed, that combines all the previously mentioned ESG indicators from the H1, H2 and H3 hypothesis. This model highlights the combined firm ESG indicators effects on the company's probability of default, given that the previous indicator effects may vary by the inclusion of all the ESG dimensions.

The results for the H1, H2, H3 and H4 hypothesis are presented in the next section in tables 10, 11, 12 and 13, respectively. To be able to select the appropriate model in this analysis, it is important to acknowledge the potential influence of unobserved heterogeneity in the panel data. With the 5-year panel data model, one of two assumptions can be used. Either, the random effects assumption, that suggests the individual-specific effects are uncorrelated to the independent variables. Or the fixed effects assumption, suggesting these individual-specific effects are correlated with the independent variables.

To determine which assumption results to more efficient estimators, both models are subjected to the Durbin–Wu–Hausman test. This test is utilized to distinguish between the fixed and random effects models.

Table 6: Durbin–Wu–Hausman test for fixed and random effects models.

	X^2	df	p-value
(H1) Environmental	559.75	9	< 0.001
(H2) Social	1056.4	10	< 0.001
(H3) Governance	34755	9	< 0.001
(H4) ESG	864.79	18	< 0.001

From the table above, the Hausman test concludes, at a 0.1% significance, that the null hypothesis is rejected; therefore, fixed effects estimates are consistent, while the random effects estimates are not consistent. Hence, the FE model should be used.

For the fixed effects model three methods can be used. these three methods are (oneway) individual fixed effects, (oneway) time fixed effects and (twoways) individual and time fixed effects. All three methods were applied, but the Bayesian Information Criterion (BIC) was used in order to select the most efficient model out of these. The BIC (Schwarz, 1978) is a statistical criterion used in model selection and evaluation. It is particularly helpful in detecting one out of several candidate models that best balances goodness-of-fit and model complexity.

Table 7: BIC across all five models and across all three types of fixed effects.

Type of Fixed Effects	Financial Ratios	E (H1)	S (H2)	G (H3)	ESG (H4)
Time	19,107.40	15,007.89	15,077.09	15,091.66	14,991.61
Individual	26,068.45	22,237.31	22,223.21	22,255.49	22,260.56
Individual & Time	25,483.34	21,665.24	21,656.27	21,680.35	21,689.52

Note: *All the models mentioned above are cumulative models, meaning that the complete dataset is used, without sector specifications.*

Across all the types of fixed effects, time fixed effects is the best performing effect, since it always has the lowest score. Therefore, the time fixed effects is the model that will be presented in this thesis. The individual E, S, G Pillars inclusion to the financial ratios (19,107.40) seems to improve the model since the E (15,007.89), S (15,077.09) and G (15,091.66) BIC scores are all smaller than the base model. Finally, the ESG (14,991.61) score for time fixed effects is the smaller one, overall, meaning that from all the models above it is the most efficient one. Thus, the inclusion of certain ESG indicators may help determine the firm's probability of default. This is consistent in all the types of fixed effects as shown in Table 8, although the significance of each indicator may vary across the models.

Time effects allow us to control unobserved heterogeneity over time. This can be important if there are unobserved factors that are affecting the dependent variable differently throughout time. A study by the European Securities and Markets Authority[12] in 2021 mentioned that "corporate ratings were rapidly downgraded following the onset of the pandemic, with non-financial corporates particularly affected. Underlying this were strong impacts on businesses in sectors particularly vulnerable to declining economic activity, such as the energy, and consumer cyclicals sectors". Accordingly, the inclusion of time effects on credit ratings is vital. There are in fact many variables that change over time, but not across entities such as UN Sustainability Agreements, national and European policies, that do affect companies. Time effects also can help to improve the efficiency of the model by reducing the number of parameters that need to be estimated.

[12] https://www.esma.europa.eu/sites/default/files/trv_2021_2-covid-19_and_credit_ratings.PDf

With the data being a short panel, meaning large individual firm observations (N) and small time period sample (T), the time effects lead also to a lower impact on the degrees of freedom of each model.

On the other hand, the inclusion of firm (individual) fixed effects could be an unrealistic assumption. All companies, when rated by CRA's, are examined under the same estimation model. The notion that companies have time-invariant individual characteristics, that are unmatched and unrelated across entities when it comes to Credit ratings , is a difficult argument to support.

The (unbalanced) time fixed effects model:

A panel data regression model indexes all variables by an i and a t, where i denotes the cross-section dimension (firms) and t represents the time-series dimension (years). The general framework of a one-way error unbalanced panel data model is:

$$Y_{it} = \beta X_{it} + a_t + u_{it},$$

$$\text{for } i = 1, \dots, n \text{ and } t = 1, \dots, T_i$$

Where Y_{it} is the dependent variable, β is $K \times 1$ and X_{it} is the i-th observation, on K explanatory variables. While a_t is the intercept of the relationship between the independent variables in year t (it captures the effects of factors that do change over time, but not across entities), and u_{it} is the error term. This model eliminates omitted variable bias, caused by excluding unobserved variables, that evolve over time but are constant across entities.

In order to confirm whether the ESG pillars improve PD predictions, a base model is set, with only the financial ratios as mentioned in the previous section.

The base model with time fixed effects (only financial ratios are used):

$$\mathbf{\log(PD)_{it} = \beta_1 ROA_{it} + \beta_2 ART_{it} + \beta_3 LEV_{it} + \beta_4 WCTA_{it} + \beta_5 SIZE_{it} + u_{it},}$$

for i = 1, . . ., n, and t = 1, . . ., T,

Where return on assets ratio is ROA, the accounts receivable turnover is ART, the total debt to total assets ratio (Leverage) is LEV, the working capital to total assets is WCTA and the natural logarithm of total assets reported is referred to as SIZE.

The Environmental Model with time fixed effects (H1):

$$\mathbf{log(PD)_{it}} = \boldsymbol{\beta_1}\mathbf{ROA_{it}} + \boldsymbol{\beta_2}\mathbf{ART_{it}} + \boldsymbol{\beta_3}\mathbf{LEV_{it}} + \boldsymbol{\beta_4}\mathbf{WCTA_{it}} + \boldsymbol{\beta_5}\mathbf{SIZE_{it}} + \boldsymbol{\beta_6}\mathbf{RRT_{it}} + \boldsymbol{\beta_7}\mathbf{REU_{it}} + \boldsymbol{\beta_8}\mathbf{EC_{it}} + \boldsymbol{\beta_9}\mathbf{EP_{it}} + \mathbf{timeFE_t} + \mathbf{u_{it}},$$

for $\mathrm{i} = 1, \dots, n_{Environmental}$ and $\mathrm{t} = 1, \dots, T_i$

Where resource reduction targets is RRT, renewable energy use is REU, environmental controversies is EC and environmental products is referred to as EP.

The Social Model with time fixed effects (H2):

$$\mathbf{log(PD)_{it}} = \boldsymbol{\beta_1}\mathbf{ROA_{it}} + \boldsymbol{\beta_2}\mathbf{ART_{it}} + \boldsymbol{\beta_3}\mathbf{LEV_{it}} + \boldsymbol{\beta_4}\mathbf{WCTA_{it}} + \boldsymbol{\beta_5}\mathbf{SIZE_{it}} + \boldsymbol{\beta_6}\mathbf{HSP_{it}} + \boldsymbol{\beta_7}\mathbf{PEHS_{it}} + \boldsymbol{\beta_8}\mathbf{PCL_{it}} + \boldsymbol{\beta_9}\mathbf{BCFC_{it}} + \boldsymbol{\beta_{10}}\mathbf{PQC_{it}} + \mathbf{timeFE_t} + \mathbf{u_{it}},$$

for $\mathrm{i} = 1, \dots, n_{Social}$ and $\mathrm{t} = 1, \dots, T_i$

Where health safety policy is HSP, policy employee health safety is PEHS, policy child labor is PCL, bribery corruption and fraud controversies is BCFC and product quality controversies is referred to as PQC.

The Governance Model with time fixed effects (H3):

$$\mathbf{log(PD)_{it}} = \boldsymbol{\beta_1}\mathbf{ROA_{it}} + \boldsymbol{\beta_2}\mathbf{ART_{it}} + \boldsymbol{\beta_3}\mathbf{LEV_{it}} + \boldsymbol{\beta_4}\mathbf{WCTA_{it}} + \boldsymbol{\beta_5}\mathbf{SIZE_{it}} + \boldsymbol{\beta_6}\mathbf{CGBC_{it}} + \boldsymbol{\beta_7}\mathbf{PBI_{it}} + \boldsymbol{\beta_8}\mathbf{SRP_{it}} + \boldsymbol{\beta_9}\mathbf{CSRSR}_{\boldsymbol{it}} + \mathbf{timeFE_t} + \mathbf{u_{it}},$$

for $\mathrm{i} = 1, \dots, n_{Governance}$ and $\mathrm{t} = 1, \dots, T_i$

Where corporate governance board committee is CGBC, policy board independence is PBI, shareholder rights policy is SRP and CSR sustainability reporting is referred to as CSRSR.

The ESG Model with time fixed effects (H4):

$$\mathbf{log(PD)_{it}} = \boldsymbol{\beta_1}\mathbf{ROA_{it}} + \boldsymbol{\beta_2}\mathbf{ART_{it}} + \boldsymbol{\beta_3}\mathbf{LEV_{it}} + \boldsymbol{\beta_4}\mathbf{WCTA_{it}} + \boldsymbol{\beta_5}\mathbf{SIZE_{it}} + \boldsymbol{\beta_6}\mathbf{RRT_{it}} + \boldsymbol{\beta_7}\mathbf{REU_{it}} + \boldsymbol{\beta_8}\mathbf{EC_{it}} + \boldsymbol{\beta_9}\mathbf{EP_{it}} + \boldsymbol{\beta_{10}}\mathbf{HSP_{it}} + \boldsymbol{\beta_{11}}\mathbf{PEHS_{it}} + \boldsymbol{\beta_{12}}\mathbf{PCL_{it}} + \boldsymbol{\beta_{13}}\mathbf{BCFC_{it}} + \boldsymbol{\beta_{14}}\mathbf{PQC_{it}} + \boldsymbol{\beta_{15}}\mathbf{CGBC_{it}} + \boldsymbol{\beta_{16}}\mathbf{PBI_{it}} + \boldsymbol{\beta_{17}}\mathbf{SRP_{it}} + \boldsymbol{\beta_{18}}\mathbf{CSRSR}_{\boldsymbol{it}} + \mathbf{timeFE_t} + \mathbf{u_{it}},$$

for $\mathrm{i} = 1, \dots, n_{ESG}$ and $\mathrm{t} = 1, \dots, T_i$

The first letters of each word for the Environmental, Social and Governance factors are used in the model including the previously mentioned financial ratios.

The ESG Model with time fixed effects (H5):

$$\mathbf{log(PD)_{it}} = \boldsymbol{\beta_1}\mathbf{ROA_{it}} + \boldsymbol{\beta_2}\mathbf{ART_{it}} + \boldsymbol{\beta_3}\mathbf{LEV_{it}} + \boldsymbol{\beta_4}\mathbf{WCTA_{it}} + \boldsymbol{\beta_5}\mathbf{SIZE_{it}} + \boldsymbol{\beta_6}\mathbf{RRT_{it}} + \boldsymbol{\beta_7}\mathbf{REU_{it}} + \boldsymbol{\beta_8}\mathbf{EC_{it}} + \boldsymbol{\beta_9}\mathbf{EP_{it}} + \boldsymbol{\beta_{10}}\mathbf{HSP_{it}} + \boldsymbol{\beta_{11}}\mathbf{PEHS_{it}} + \boldsymbol{\beta_{12}}\mathbf{PCL_{it}} + \boldsymbol{\beta_{13}}\mathbf{BCFC_{it}} + \boldsymbol{\beta_{14}}\mathbf{PQC_{it}} + \boldsymbol{\beta_{15}}\mathbf{CGBC_{it}} + \boldsymbol{\beta_{16}}\mathbf{PBI_{it}} + \boldsymbol{\beta_{17}}\mathbf{SRP_{it}} + \boldsymbol{\beta_{18}}\mathbf{CSRSR}_{\boldsymbol{it}} + \mathbf{timeFE_t} + \mathbf{u_{it}},$$

for $i = 1, \dots, n_{Speculative}$ and $t = 1, \dots, T_i$

for $i = 1, \dots, n_{Investment}$ and $t = 1, \dots, T_i$

Finally, the method used to prove whether the ESG indicators effect credit ratings differently amongst investment and speculative grade firms (H5), is by calculating the ESG model again (as presented in H4), but this time separately for the investment and speculative rated firms respectively. A separation cutoff point is used on the credit ratings , separating investment grade (equal or higher than BBB-) and speculative grade (equal or lower than BB+) rated firms.

4. RESULTS

As previously mentioned, time fixed effects will be used to evaluate all five hypothesis H1, H2, H3, H4 and H5, at a 95% confidence interval. First, in table 8, a base model will be presented to interpret the probability of default with only the financial ratios. Second, in table 9, the environmental pillar will be included with the financial ratios. Third, in table 10, the social pillar will be included with financial ratios. Fourth, in table 11, the governance pillar with the financial ratios will be used. Fifth, in table 12, all the ESG pillars combined with the financial ratios will be used to try and predict the probability of default. Finally, in tables 13 and 14, all the ESG pillars combined with the financial ratios will be used to try and predict the probability of default, but this time separately for investment and speculative grade rated firms, respectively.

In all these tables, the eight industries that will be examined are: (1) basic materials, (2) consumer cyclicals, (3) consumer non-cyclicals, (4) energy, (5) healthcare, (6) industrials, (7) technology, (8) utilities and (9) a combined industry model. As it was argued in the hypothesis development section the financial ratios effects, as well as the ESG individual pillar effects on the probability of default, are expected to differ across sectors. Therefore, the combined sector model is used, to showcase important mistakes that could be made by the assumption that all sectors are affected the same, when it comes to the calculation of the probability of default.

Unfortunately, the time fixed effects can make the model more difficult to interpret. Since, the coefficients on the independent variables will now be interpreted as the effect of those variables on the dependent variable for the average time period.

4.1. Base models

The use of a base model, only with the financial ratios, is to compare the potential improvement of the inclusion of the individual and the combined ESG pillars. The return on assets, firm size, and leverage, remain significant across all sectors, with the first two having negative coefficients and the third a positive coefficient, respectively. On the other hand, if AR turnover and working capital divided by total assets, have significant effects on the models, they show consistently positive and negative coefficients, respectively. Concluding with the base model, all the significant effects in the cross-sector models and the combined sector model are at a 1% significance level.

Table 8: Time Fixed Effects for the base models (only the financial ratios).

	Dependent variable: **log(PD)**								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
ROA	-8.040***	-8.444***	-8.705***	-5.967***	-4.750***	-9.205***	-6.532***	-13.563***	-7.390***
	(0.867)	(0.445)	(1.019)	(0.808)	(0.622)	(0.445)	(0.404)	(2.311)	(0.208)
AR Turnover	0.106***	0.019***	0.034***	0.002	0.049**	0.056***	0.005	0.094***	0.032***
	(0.012)	(0.004)	(0.011)	(0.016)	(0.020)	(0.009)	(0.010)	(0.028)	(0.003)
Leverage	3.377***	2.010***	3.419***	1.127***	3.789***	2.437***	1.652***	1.853***	2.382***
	(0.357)	(0.186)	(0.44)	(0.297)	(0.368)	(0.192)	(0.198)	(0.501)	(0.095)
WC/TA	-0.966**	-0.261	-0.051	-1.414***	-0.254	0.106	-0.664***	-0.681	-0.467***
	(0.433)	(0.189)	(0.480)	(0.450)	(0.366)	(0.204)	(0.219)	(0.777)	(0.103)
Size	-0.178***	-0.084***	-0.290***	-0.118***	-0.249***	-0.118***	-0.120***	-0.122**	-0.138***
	(0.031)	(0.020)	(0.040)	(0.037)	(0.038)	(0.018)	(0.020)	(0.051)	(0.009)
Observations	574	1,198	491	258	496	1,625	1,079	209	5,930
R^2	0.410	0.402	0.448	0.413	0.402	0.377	0.298	0.245	0.354
Adjusted R^2	0.401	0.397	0.438	0.392	0.391	0.373	0.293	0.211	0.353

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

4.2. Environmental models

In the next table, environmental indicators are added to the base model. The inclusion of environmental indicators, led to a drop in observations, due to the missing values from the environmental pillar. This drop has a slight effect on certain sectors, decreasing the significance of some financial ratios, maintaining though their positive or negative effects as mentioned previously.

The four environmental indicators added in this model are: resource reduction targets, renewable energy use, environmental controversies and environmental products. According to hypothesis H1, we expected the environmental indicators to be statistically significant, with the possibility to differ across industries, and on certain occasions to present mixed effects.

The only unexpected effect is the coefficient of environmental controversies for the technology sector, which seems to reduce the PD. Even though, in the consumer cyclicals sector, the opposite effect is observed. This could be interpreted as the outcome of an inelastic demand that is intertwined with the technology sector. On the other hand, consumer cyclicals have a much more elastic demand and could be affected by the public's perception. Thus, creating a mixed effect result. The decrease in the PD from the environmental controversies is in line with a study by Aouadi and Marsat (2018), where they conclude, that in some cases ESG controversies positively affect firm value. However, in this research, by separating the sectors, I argue that this effect is not consistent across sectors.

For the rest of the environmental indicators seem to decrease the probability of default when they are statistically significant. Generally, it seems that each individual sector is affected in a unique manner by these indicators. From the combined sectors model (9), resource reduction targets, renewable energy use and environmental controversies are statistically significant. This observation has not been the case for any of the eight sectors individually, meaning that none of these three combined indicators have been significant at the same time. Illustrating how flawed it can be not separating the sectors.

All these results partially confirm the H1 hypothesis, that environmental indicators can be statistically significant on the PD, but the significance is inconsistent across industries.

Table 9: Time fixed effects for the environmental models.

	Dependent variable: log(PD)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Resource Reduction Targets	-0.255	-0.014	-0.307	-0.543	-0.131	-0.081	-0.131	0.260	-0.163**
	(0.13)	(0.12)	(0.16)	(0.28)	(0.24)	(0.09)	(0.13)	(0.24)	(0.06)
Renewable Energy Use	-0.682***	-0.255*	-0.298	-0.084	-0.378	-0.318**	-0.204	-0.027	-0.308***
	(0.18)	(0.11)	(0.22)	(0.23)	(0.24)	(0.09)	(0.12)	(0.39)	(0.05)
Environmental Controversies	-0.045	0.651*	-0.802	-0.005	1.106	0.334	-0.832***	0.479	0.477***
	(0.26)	(0.29)	(0.47)	(0.32)	(0.93)	(0.44)	(0.23)	(0.29)	(0.14)
Environmental Products	-0.192	0.029	-0.278	-0.160	-0.363	-0.017	-0.07	-0.102	0.029
	(0.23)	(0.11)	(0.19)	(0.23)	(0.28)	(0.08)	(0.12)	(0.30)	(0.06)
ROA	-7.342***	-8.858***	-9.240***	-6.294***	-3.282**	-9.500***	-6.839***	-12.753***	-7.489***
	(1.64)	(1.02)	(2.02)	(1.22)	(1.20)	(0.85)	(0.92)	(3.48)	(0.48)
AR Turnover	0.115***	0.025***	0.039*	-0.007	0.022	0.062***	-0.004	0.154**	0.038***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)	(0.05)	(0.00)
Leverage	3.449***	1.777***	3.616***	0.980	4.327***	2.647***	1.592***	0.785	2.367***
	(0.60)	(0.37)	(0.82)	(0.56)	(0.71)	(0.31)	(0.32)	(0.94)	(0.21)
WC/TA	-0.867	-0.245	-0.426	-1.624*	0.091	0.021	-0.520*	0.622	-0.475*
	(0.82)	(0.34)	(0.74)	(0.69)	(0.56)	(0.34)	(0.34)	(1.14)	(0.20)
Size	-0.070	-0.077	-0.243**	-0.054	-0.133	-0.086*	-0.089*	-0.089	-0.100***
	(0.07)	(0.04)	(0.09)	(0.07)	(0.09)	(0.04)	(0.04)	(0.09)	(0.02)
Observations	488	933	395	219	414	1,254	783	182	4,668
R^2	0.464	0.425	0.488	0.473	0.395	0.428	0.311	0.260	0.374
Adjusted R^2	0.449	0.417	0.472	0.442	0.376	0.422	0.300	0.202	0.372

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

4.3. Social models

In the upcoming table, social indicators are added to the base model. The inclusion of social indicators, led to a drop in observations, due to the missing values from the social pillar. This drop seems to have a slight effect on certain sectors decreasing the significance of some of the financial ratios, but they maintain their positive or negative effects as previously mentioned.

The five social indicators added in this model are: health safety policy, policy employee health safety, bribery corruption and fraud controversies and product quality controversies. According to hypothesis H2, it was expected for the social indicators to be statistically significant, while they differ across industries. And on certain occasions to present mixed effects.

it should be noted that policy employee health safety variable was dropped in basic materials, energy and utilities, due to a lack of data on these sectors.

As it is presented in the social model table, health safety policy and product quality controversies have no significant effect on any sector. On the other hand, indicators such as policy child labor and policy employee health safety have a statistically significant effect on certain sectors, reducing the probability of default (negative coefficient). Meanwhile, bribery corruption & fraud controversies increases the probability of default (positive coefficient), only at the all-sectors model.

Most sectors seem to not be affected by any social indicator that was used in this research, with only the consumer non-cyclicals, healthcare and the all-sectors models having just one significant indicator each, while having none in common.

These results partially confirm hypothesis H2, that social indicators can be statistically significant on the PD, but the significance is inconsistent across industries. Assuming that the combined sector model is effective for all the individual sectors, this would essentially lead to a wrong calculation in all eight of the sectors.

Table 10: Time fixed effects for the social models.

	Dependent variable: **log(PD)**								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Health Safety Policy	0.503	0.132	-0.697	0.543	0.299	-0.465	-0.158	-0.702	-0.127
	(0.98)	(0.43)	(0.66)	(0.42)	(0.42)	(0.63)	(0.24)	(0.80)	(0.19)
Policy Employee Health Safety	**Dropped**	0.005	-0.056	**Dropped**	-0.681**	0.211	-0.164	**Dropped**	0.073
		(0.22)	(0.40)		(0.22)	(0.59)	(0.20)		(0.15)
Policy Child Labor	-0.469	-0.059	-0.400*	-0.257	-0.096	-0.076	0.151	-0.199	-0.037
	(0.25)	(0.12)	(0.20)	(0.29)	(0.21)	(0.09)	(0.12)	(0.27)	(0.06)
Bribery Corruption & Fraud Controversies	0.449	0.260	0.295	0.008	0.531	0.245	0.348	0.044	0.345***
	(0.24)	(0.15)	(0.26)	(0.23)	(0.36)	(0.15)	(0.28)	(0.30)	(0.08)
Product Quality Controversies	-0.321	0.244	-0.520	0.339	0.156	-0.220	-0.368	-0.560	-0.200
	(0.30)	(0.17)	(0.32)	(0.28)	(0.54)	(0.21)	(0.31)	(0.63)	(0.14)
ROA	-7.599***	-8.839***	-9.546***	-6.496***	-3.553**	-9.559***	-7.019***	-13.076***	-7.699***
	(1.84)	(0.99)	(2.12)	(1.26)	(1.28)	(0.90)	(0.88)	(3.66)	(0.48)
AR Turnover	0.115***	0.024***	0.038*	-0.002	0.030	0.060***	0.001	0.139*	0.038***
	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.06)	(0.00)
Leverage	3.563***	1.854***	3.365***	1.075	4.075***	2.612***	1.482***	0.784	2.365***
	(0.57)	(0.37)	(0.86)	(0.55)	(0.73)	(0.31)	(0.32)	(0.95)	(0.21)
WC/TA	-0.586	-0.239	-0.705	-1.514	-0.006	0.081	-0.638	0.475	-0.435*
	(0.85)	(0.32)	(0.69)	(0.84)	(0.57)	(0.35)	(0.33)	(1.13)	(0.19)
Size	-0.203***	-0.107*	-0.296***	-0.123	-0.244**	-0.127***	-0.149***	0.025	-0.155***
	(0.06)	(0.04)	(0.07)	(0.08)	(0.08)	(0.04)	(0.04)	(0.09)	(0.02)
Observations	488	933	396	218	414	1,255	783	182	4,669
R^2	0.429	0.420	0.486	0.445	0.382	0.420	0.315	0.266	0.365
Adjusted R^2	0.413	0.411	0.469	0.413	0.362	0.414	0.304	0.209	0.363

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

4.4. Governance models

In the following table, governance indicators added to the base model. The inclusion of governance indicators led to a drop in observations, due to the missing values from the governance pillar. This drop has a slight effect on certain sectors, decreasing the significance of some of the financial ratios, but they maintain their positive or negative effects as mentioned previously.

The four governance indicators added in this model are: corporate governance board committee, policy board independence, shareholder rights and CSR sustainability reporting. According to hypothesis H3, it was expected in the governance indicators to be statistically significant and on certain occasions to present mixed effects.

policy board independence and CSR sustainability reporting, reduce PD (negative coefficient), when significant, whereas shareholders rights increase PD (positive coefficient), when significant.

When in fact, Corporate Governance Board Committee is the first indicator that shows mixed effects, depending on the sector, it can have either positive or negative effect, while being statistically significant. This indicator in the energy sector increases the probability of default, while in basic materials, industrials and utilities it reduces it.

The corporate governance board committee having mixed effects has an important implication in the combined sectors model. Now the combined sectors model not only wrongfully assumes significance in sectors such as consumer cyclicals, healthcare, and technology, but also reverses the effect that this indicator has on the energy sector.

These results confirm hypothesis H3, that social indicators can be statistically significant on the PD, although the significance is inconsistent across industries and there are occasional mixed effects for the same indicator across sectors. Assuming that the combined sector model is effective for all the individual sectors, this would essentially lead to a wrong calculation in all eight of the sectors.

Table 11: Time fixed effects for the governance models.

	Dependent Variable: log(PD)								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Corp. Governance	-0.317	-0.085	-0.181	0.361	0.251	-0.326	-0.201	-0.361	-0.195*
Board Committee	(0.25)	(0.18)	(0.28)	(0.25)	(0.24)	(0.17)	(0.26)	(0.29)	(0.09)
Policy Board	-0.151	-0.146	-0.353*	-0.234	0.089	-0.145	-0.015	-0.629**	-0.142**
Independence	(0.16)	(0.10)	(0.17)	(0.25)	(0.20)	(0.09)	(0.11)	(0.20)	(0.05)
Shareholder Rights	0.383	0.271	0.615	-0.262	-0.274	0.296	0.189	**Dropped**	0.289*
Policy	(0.50)	(0.26)	(0.41)	(0.26)	(0.21)	(0.20)	(0.21)		(0.12)
CSR Sustainability	-1.002*	0.290	-1.236**	0.113	-0.032	-0.111	-0.164	0.354	-0.049
Reporting	(0.43)	(0.33)	(0.40)	(0.36)	(0.24)	(0.12)	(0.14)	(0.39)	(0.09)
ROA	-7.652***	-8.971***	-9.457***	-6.066***	-3.916**	-9.600***	-7.082***	-11.367***	-7.810***
	(1.80)	(1.00)	(1.79)	(1.35)	(1.27)	(0.89)	(0.90)	(3.05)	(0.48)
AR Turnover	0.112***	0.024***	0.037*	-0.004	0.046	0.064***	-0.001	0.123*	0.037***
	(0.02)	(0.01)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.06)	(0.00)
Leverage	3.783***	1.773***	3.713***	0.908	4.061***	2.664***	1.508***	0.727	2.365***
	(0.62)	(0.37)	(0.79)	(0.61)	(0.74)	(0.31)	(0.32)	(0.98)	(0.21)
WC/TA	-0.579	-0.325	-0.404	-1.712*	-0.057	-0.012	-0.544**	0.101	-0.462*
	(0.85)	(0.32)	(0.67)	(0.85)	(0.58)	(0.34)	(0.33)	(1.05)	(0.19)
Size	-0.151**	-0.072*	-0.306***	-0.128	-0.224**	-0.096***	-0.109**	0.025	-0.119***
	(0.05)	(0.04)	(0.08)	(0.07)	(0.07)	(0.03)	(0.04)	(0.06)	(0.02)
Observations	488	935	396	221	414	1,258	785	182	4,679
R^2	0.440	0.422	0.508	0.452	0.373	0.428	0.308	0.326	0.368
Adjusted R^2	0.424	0.414	0.493	0.420	0.355	0.422	0.297	0.278	0.366

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

4.5. ESG models

In the table 12, all the ESG indicators are included and combined with the base model. According to hypothesis H4, it is expected for the environmental, social and governance indicators to be statistically significant, while they differ across industries. Expecting on certain occasions to present mixed effects and the results may also differ from the initial individual pillar model from H1, H2 and H3.

As it appears in this table, the corporate governance board committee stays consistent after the inclusion of the environmental and social panel and still shows mixed effects, leading to an increase of PD in the energy sector and a decrease of PD in basic materials, industrials and utilities. On the other hand, policy employee health safety is consistently insignificant. When significant, resource reduction targets, renewable energy use, environmental products, product quality controversies and policy board independence tend to reduce the firms PD. On the contrary, again when significant, health safety policy, bribery corruption and fraud controversies and shareholders rights policy still tend to increase the firms PD.

The number of indicators demonstrating mixed effects across industries have increased. Environmental controversies are not significant anymore in individual sectors, but remain significant in the combined sector model. Child labor policy, that was found to reduce probability of default in the social model, now increases the PD for the technology sector. CSR sustainability reporting also appears to have mixed effects across industries, in the basic materials and consumer non-cyclicals sector it reduces the PD, whereas in the consumer cyclicals sector it increases the PD. While the financial ratios, when significant, retain their attributes as it was mentioned in the base model.

These results confirm hypothesis H4. First, ESG indicators can be statistically significant on the PD. Second, that the significance is inconsistent across industries. Third, there are occasional mixed effects for the same indicator across sectors. Also, the significance on certain indicators dropped when other aspects of ESG are included in the analysis (i.e., CSR sustainability reporting is significant on the governance model for the basic materials sector, meanwhile on the ESG model the significant effect disappears). Finally, the assumption that the combined sector model is equally effective for all individual sectors, would be misleading and should be considered overall invalid.

Table 12: Time fixed effects model for the ESG models.

	Dependent Variable: log(PD)								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Resource Reduction Targets	-0.207 (0.14)	-0.068 (0.11)	-0.282 (0.17)	-0.540 (0.30)	-0.214 (0.24)	-0.047 (0.09)	-0.127 (0.13)	0.098 (0.23)	-0.159** (0.06)
Renewable Energy Use	-0.662*** (0.18)	-0.291** (0.10)	-0.248 (0.20)	-0.072 (0.24)	-0.423 (0.23)	-0.303*** (0.09)	-0.199* (0.13)	0.053 (0.38)	-0.314*** (0.043)
Environmental Controversies	-0.030 (0.28)	0.385 (0.33)	-0.789* (0.35)	0.030 (0.33)	0.868 (1.02)	0.211 (0.43)	-0.876*** (0.24)	0.411 (0.33)	0.410*** (0.14)
Environmental Products	-0.111 (0.23)	0.020 (0.11)	-0.276 (0.18)	-0.191 (0.24)	-0.353 (0.29)	-0.034 (0.09)	-0.084 (0.13)	-0.054 (0.30)	0.010 (0.06)
Health Safety Policy	1.210 (0.86)	0.132 (0.45)	-1.233* (0.50)	0.224 (0.68)	0.299 (0.40)	-0.292 (0.66)	-0.119 (0.22)	-0.743 (0.69)	-0.107 (0.19)
Policy Employee Health Safety	**Dropped**	-0.060 (0.26)	1.528* (0.73)	**Dropped**	-0.686* (0.31)	0.040 (0.63)	-0.121 (0.16)	**Dropped**	0.100 (0.15)
Policy Child Labor	-0.268 (0.22)	-0.006 (0.12)	-0.244 (0.18)	-0.103 (0.27)	0.098 (0.22)	-0.015 (0.09)	0.199 (0.12)	-0.057 (0.22)	0.036 (0.06)
Bribery Corruption & Fraud Controversies	0.367 (0.25)	0.206 (0.16)	0.309 (0.25)	-0.053 (0.21)	0.408 (0.33)	0.284* (0.14)	0.415 (0.30)	0.061 (0.23)	0.332*** (0.08)
Product Quality Controversies	-0.172 (0.28)	0.198 (0.17)	-0.546 (0.30)	0.354 (0.28)	-0.001 (0.52)	-0.185 (0.20)	-0.299 (0.31)	-0.430 (0.70)	-0.178 (0.13)
Corp. Governance Board Committee	-0.256 (0.25)	-0.062 (0.17)	-0.241 (0.27)	0.324 (0.25)	0.067 (0.21)	-0.327* (0.16)	-0.176 (0.27)	-0.370 (0.31)	-0.200* (0.09)
Policy Board Independence	-0.213 (0.16)	-0.126 (0.10)	-0.378* (0.16)	-0.275 (0.26)	0.095 (0.20)	-0.129 (0.09)	0.026 (0.11)	-0.592** (0.20)	-0.137** (0.05)

Table 12 continued

	Dependent Variable: log(PD)								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Shareholder Rights Policy	-0.093 (0.53)	0.266 (0.26)	0.638 (0.50)	-0.138 (0.32)	-0.409 (0.28)	0.280 (0.20)	0.239 (0.21)	**Dropped**	0.266* (0.12)
CSR Sustainability Reporting	-0.714 (0.48)	0.419 (0.28)	-1.242* (0.54)	0.194 (0.50)	0.359 (0.24)	0.030 (0.12)	-0.016 (0.16)	0.600 (0.60)	0.092 (0.09)
ROA	-7.342*** (1.67)	-8.710*** (0.98)	-9.046*** (1.70)	-5.883*** (1.27)	-3.355* (1.30)	-9.470*** (0.88)	-6.726*** (0.90)	-12.213*** (3.48)	-7.521*** (0.48)
AR Turnover	0.111*** (0.02)	0.022*** (0.01)	0.031* (0.01)	-0.013 (0.02)	0.028 (0.03)	0.061*** (0.01)	-0.005 (0.02)	0.122 (0.07)	0.037*** (0.00)
Leverage	3.605*** (0.66)	1.786*** (0.36)	3.496*** (0.77)	0.833 (0.62)	4.206*** (0.75)	2.686*** (0.31)	1.614*** (0.34)	0.639 (1.03)	2.395*** (0.21)
WC/TA	-0.864 (0.83)	-0.286 (0.34)	-0.720 (0.68)	-1.734* (0.69)	0.162 (0.57)	0.030 (0.34)	-0.544 (0.35)	0.045 (0.92)	-0.444* (0.19)
Size	-0.055 (0.07)	-0.078 (0.04)	-0.180* (0.09)	-0.056 (0.09)	-0.164 (0.09)	-0.066 (0.04)	-0.109* (0.05)	0.047 (0.08)	-0.103*** (0.02)
Observations	488	932	395	218	414	1,253	782	182	4,664
R^2	0.492	0.436	0.539	0.491	0.408	0.442	0.323	0.349	0.384
Adjusted R^2	0.469	0.422	0.513	0.440	0.376	0.432	0.305	0.268	0.381

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

All the results presented in this thesis, indicate that it is of immense importance to separate sectors, when doing research on the probability of default. In the combined sector model multiple of the ESG indicators appear significant. It should be noted, that when the data was separated into industry models, these effects on the ESG indicators occasionally remain significant, sometimes lose significance or even worse display a significant opposite effect, contradicting the effects suggested in the combined model.

These results have implications for CRAs, that want to include certain aspects of ESG in their credit ratings. As it appears from the results above, there cannot be a "one-size-fits-all" model. On the contrary, separate ESG indicators should be used in accordance with each sector. In this study only 13 out of 178 indicators are used from the Refinitiv package, though covering all ESG pillar categories. Expanding this research with the use of more indicators could potentially interest researchers on academic, corporate, banking, and legislative fields.

One important outcome of the results is that only financial ratios maintained a significant level of importance across all sectors, while none of the ESG indicators had such a consistent significant effect. The simplistic use of a combined sectors model could have led to falsely assume, that there are significant ESG indicators effects on the probability of default, or by extension to any other dependent variable.

4.6. ESG models for investment and speculative grade firms

In this section the effects of ESG indicators are examined separately for investment and speculative grade firms. It is expected for the effects to differ amongst overperforming and underperforming firms. It is expected for investment grade firms to be positively affected from ESG initiatives and be less negatively affected from ESG controversies. On the other hand, for speculative grade firms, we expect the positive effects from ESG initiatives to be less effective, while the negative effects from ESG controversies to be more significant.

To examine whether the effect of every previously mentioned hypothesis is consistent across the rating spectrum, the indicator effects will be tested again for the combined ESG model separately for investment and speculative grade firms, across all industries.

4.6.1. ESG models for investment grade firms

In the next table, all the ESG indicators are included and combined with the base model, only for investment grade firms. According to hypothesis H5, it is expected for the environmental, social and governance indicators to be statistically significant, while they differ across industries. Furthermore, on certain occasions, to present mixed effects and results may also differ from combined ESG model, that was previously presented.

There were some interesting findings across the industry specific models in each one of the environmental, social and governance pillars.

In the environmental pillar, resource reduction targets, renewable energy use and environmental controversies, if significant, reduce the PD.

In the social pillar, bribery corruption and fraud controversies increase PD where the policy employee health safety reduces PD.

In the governance pillar, corporate governance board committee, policy board independence, shareholder rights policy, when significant decrease the PD while CSR sustainability reporting increases PD.

The current results, compared to the ESG model previously presented are already different in certain sectors, with new indicators occurring to be significant, such as resource reduction targets for the consumer non-cyclicals and energy sectors.

The opposite outcome, meaning the previously significant effect becoming non-significant, is also the case in certain occasions, such as policy employee health safety and health safety policy on consumer non-cyclicals, where they were significant on section 4.5, but currently, they are not.

All these findings are adding to the existing ESG literature. This is the first mention of effects being compromised by the current PD state of the firm. In the next section, the results are also important, revealing whether the results are consistent with the 4.6.1 or 4.5 section or still different.

Table 13: The ESG effects on investment grade firms

	Dependent variable: **log(PD)**								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Resource Reduction Targets	-0.133	0.115	-0.337*	-0.598**	-0.047	-0.038	0.006	-0.001	-0.067
	(0.157)	(0.124)	(0.181)	(0.234)	(0.233)	(0.095)	(0.144)	(0.179)	(0.057)
Renewable Energy Use	-0.512***	-0.220**	-0.100	0.063	-0.360	-0.261***	-0.084	-0.455	-0.229***
	(0.193)	(0.108)	(0.213)	(0.214)	(0.233)	(0.086)	(0.125)	(0.284)	(0.051)
Environmental Controversies	0.062	0.353	-0.747**	0.270	1.015	0.185	-0.414	0.325	0.400***
	(0.293)	(0.263)	(0.310)	(0.341)	(1.133)	(0.609)	(0.270)	(0.221)	(0.148)
Environmental Products	0.106	-0.002	-0.090	-0.197	-0.116	-0.023	-0.105	0.061	0.062
	(0.276)	(0.127)	(0.175)	(0.176)	(0.281)	(0.088)	(0.128)	(0.199)	(0.060)
Health Safety Policy	0.999	0.790	-0.294	0.196	0.439	-0.190	0.089	-0.091	0.122
	(0.988)	(0.721)	(0.574)	(0.499)	(0.443)	(0.536)	(0.251)	(0.398)	(0.175)
Policy Employee Health Safety	**Dropped**	-0.504	0.022	**Dropped**	-0.863**	0.088	-0.232	**Dropped**	-0.096
		(0.468)	(0.942)		(0.342)	(0.490)	(0.203)		(0.132)
Policy Child Labor	-0.140	0.102	-0.109	-0.211	0.302	0.044	0.154	-0.137	0.095*
	(0.209)	(0.152)	(0.205)	(0.210)	(0.222)	(0.093)	(0.116)	(0.155)	(0.055)
Bribery Corruption & Fraud Controversies	0.411	0.183	0.353	-0.156	0.697**	0.077	0.304	0.154	0.330***
	(0.296)	(0.210)	(0.244)	(0.283)	(0.318)	(0.149)	(0.303)	(0.186)	(0.086)
Product Quality Controversies	-0.027	0.064	-0.390	0.509	-0.404	0.073	-0.086	-0.368	-0.215
	(0.275)	(0.190)	(0.321)	(0.329)	(0.545)	(0.186)	(0.317)	(0.417)	(0.140)
Corp. Governance Board Committee	-0.272	-0.186	-0.368*	-0.026	0.031	-0.469**	-0.171	-0.420**	-0.306***
	(0.265)	(0.232)	(0.213)	(0.189)	(0.184)	(0.200)	(0.298)	(0.210)	(0.094)
Policy Board Independence	-0.229	0.003	-0.505***	0.012	0.127	-0.098	0.053	-0.580***	-0.085
	(0.174)	(0.118)	(0.167)	(0.181)	(0.191)	(0.085)	(0.107)	(0.175)	(0.053)

Table 13 continued

	Dependent variable: log(PD)								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Shareholder Rights Policy	-0.330	0.150	0.351	**Dropped**	-0.544***	0.158	0.356	**Dropped**	0.112
	(0.500)	(0.287)	(0.464)		(0.191)	(0.193)	(0.236)		(0.126)
CSR Sustainability Reporting	-0.286	0.652*	-0.225	0.079	0.492**	0.007	0.022	0.228	0.161*
	(0.731)	(0.335)	(0.785)	(0.442)	(0.248)	(0.112)	(0.165)	(0.349)	(0.093)
ROA	-5.949***	-7.963***	-6.045***	-4.392**	-4.346***	-8.449***	-5.498***	-0.852	-5.947***
	(1.869)	(1.391)	(1.662)	(1.991)	(1.242)	(1.253)	(0.921)	(3.348)	(0.548)
AR Turnover	0.114***	0.020***	0.027**	0.012	0.025	0.032*	-0.019	0.026	0.030***
	(0.024)	(0.007)	(0.013)	(0.016)	(0.033)	(0.017)	(0.015)	(0.037)	(0.005)
Leverage	3.278***	1.476***	3.796***	0.494	3.001***	2.405***	1.409***	1.906***	2.222***
	(0.801)	(0.455)	(0.842)	(0.569)	(0.673)	(0.348)	(0.392)	(0.527)	(0.207)
WC/TA	-0.637	-0.076	-0.050	-0.714	-0.603	0.499	-0.489	0.831	-0.110
	(0.911)	(0.377)	(0.693)	(0.602)	(0.573)	(0.330)	(0.338)	(0.818)	(0.185)
Size	-0.083	-0.095**	-0.228***	-0.022	-0.260**	-0.069*	-0.153***	0.114	-0.134***
	(0.070)	(0.047)	(0.079)	(0.063)	(0.101)	(0.040)	(0.046)	(0.088)	(0.021)
Observations	365	636	309	118	350	903	644	146	3,471
R^2	0.373	0.307	0.434	0.373	0.347	0.323	0.269	0.366	0.269
Adjusted R^2	0.337	0.282	0.392	0.251	0.306	0.307	0.244	0.264	0.264

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

4.6.2. ESG models for speculative grade firms

In the next table, all the ESG indicators are included and combined with the base model, only for speculative grade firms. According to hypothesis H5, it is expected for the environmental, social and governance indicators to be statistically significant, while differing across industries. Also, on certain occasions to present mixed effects and results may differ from the combined ESG model that was previously presented.

In the environmental pillar, resource reduction targets, renewable energy use and environmental controversies reduce the probability of default, when significant.

In the social pillar, policy employee health safety, child labor policy and bribery corruption and fraud controversies reduce the PD. The product quality controversies increase the PD. Health safety policy appears to have mixed effects depending on the industry.

In the governance pillar, corporate governance board committee, shareholder rights policy increase the PD, whereas policy board independence and CSR sustainability reporting decrease the PD, when significant.

The effect compared to the ESG models previously presented in sections 4.5 and 4.6.1, are already different in certain sectors, with new indicators occurring to be significant and conversely previously significant indicators becoming non-significant. When comparing the models of this speculative and investment grade firms it is remarkably interesting, that in the governance pillar significant effects occur with the opposite coefficient effect. More precisely, CSR sustainability reporting and corporate governance board committee reduces the probability of default for speculative grade firms, though for investment grade firms it increases it.

It can be concluded, that governance effects significantly differ between investment and speculative grade firms. For the social and environmental pillar, it can also be noted that there is a divergence of significance across the industries amongst the ESG indicators. These results should worry ESG regulators, who are about to include smaller firms into the sustainability reporting standards (since smaller firms tend to belong into the speculative grades). ESG indicator effects on the PD are highly inconsistent across sectors and across speculative and investment grade firms. Including ESG indicators on credit ratings could eventually lead to a domino effect of default of small businesses.

Table 14: The ESG effects on speculative grade firms

	Dependent variable: log(PD)								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Resource Reduction	-0.146	-0.286***	-0.113	0.035	0.224	0.048	0.145	0.172	-0.079*
	(0.155)	(0.083)	(0.144)	(0.234)	(0.593)	(0.078)	(0.239)	(0.442)	(0.048)
Targets	-0.341**	0.029	-0.031	-0.133	-0.233	-0.192**	0.044	-0.488	-0.149***
Renewable Energy Use	(0.158)	(0.091)	(0.170)	(0.213)	(0.338)	(0.084)	(0.124)	(0.902)	(0.051)
Environmental	-0.186	0.304	-0.442**	-0.226	-0.901	0.367	**Dropped**	0.124	-0.095
Controversies	(0.282)	(0.267)	(0.217)	(0.421)	(0.736)	(0.389)		(0.358)	(0.122)
Environmental	0.086	-0.084	0.005	-0.178	-0.275	-0.098	0.039	-0.306	-0.096**
Products	(0.137)	(0.089)	(0.151)	(0.179)	(0.278)	(0.092)	(0.100)	(0.409)	(0.048)
Health Safety Policy	0.405	-0.223	-0.428**	0.807	0.427	0.595***	-0.453	-1.413*	-0.145
	(0.317)	(0.337)	(0.199)	(0.498)	(0.370)	(0.200)	(0.276)	(0.719)	(0.250)
Policy Employee	**Dropped**	0.350	**Dropped**	**Dropped**	**Dropped**	-0.776***	0.214	**Dropped**	0.220
Health Safety		(0.297)				(0.130)	(0.271)		(0.238)
Policy Child Labor	0.004	-0.158*	0.080	0.137	-0.672	-0.006	0.088	-0.612	-0.003
	(0.184)	(0.082)	(0.151)	(0.178)	(0.548)	(0.096)	(0.122)	(0.433)	(0.047)
Bribery Corruption &	0.091	0.018	-0.655***	-0.149	-0.534	0.093	-0.551**	-0.772	-0.054
Fraud Controversies	(0.274)	(0.159)	(0.240)	(0.241)	(0.533)	(0.098)	(0.222)	(0.462)	(0.069)
Product Quality	-0.268	0.086	0.094	0.019	0.433	0.323*	-0.488	**Dropped**	0.173
Controversies	(0.432)	(0.164)	(0.243)	(0.293)	(0.568)	(0.172)	(0.404)		(0.151)
Corp. Governance	0.453	-0.053	0.130	0.310**	0.783**	-0.093	0.572	-0.098	0.153**
Board Committee	(0.379)	(0.103)	(0.181)	(0.155)	(0.301)	(0.122)	(0.468)	(0.320)	(0.075)
Policy Board	-0.123	-0.177**	-0.246	0.067	0.225	0.001	0.102	0.639	-0.034
Independence	(0.141)	(0.075)	(0.149)	(0.178)	(0.406)	(0.080)	(0.136)	(0.413)	(0.045)

Table 14 continued

	Dependent variable: **log(PD)**								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
	Basic Materials	**Consumer Cyclicals**	**Consumer Non-Cyclicals**	**Energy**	**Healthcare**	**Industrials**	**Technology**	**Utilities**	**All Sectors**
Shareholder Rights Policy	0.502**	0.360***	0.024	0.548**	-0.230	0.212**	0.036	**Dropped**	0.213***
	(0.238)	(0.112)	(0.241)	(0.239)	(0.960)	(0.107)	(0.253)		(0.082)
CSR Sustainability Reporting	-0.473*	-0.124	-0.640**	-0.653***	-0.111	0.053	-0.130	1.019	-0.155**
	(0.265)	(0.121)	(0.279)	(0.167)	(0.315)	(0.127)	(0.133)	(2.142)	(0.070)
ROA	-3.754**	-3.098***	-3.565**	-3.039***	1.825	-3.477***	-2.299***	-0.873	-2.876***
	(1.748)	(0.491)	(1.433)	(0.868)	(1.791)	(0.638)	(0.575)	(6.025)	(0.310)
AR Turnover	0.026*	0.009**	0.031**	-0.007	-0.073	0.019**	0.018	0.143	0.010***
	(0.014)	(0.005)	(0.014)	(0.026)	(0.066)	(0.009)	(0.014)	(0.087)	(0.003)
Leverage	0.176	0.727***	0.112	0.396	1.321*	0.518*	0.001	1.624	0.532***
	(0.783)	(0.250)	(0.509)	(0.354)	(0.770)	(0.284)	(0.180)	(1.982)	(0.118)
WC/TA	-0.072	0.034	-1.517***	-1.809***	-0.663	-0.861***	-0.681**	-0.248	-0.582***
	(0.614)	(0.321)	(0.468)	(0.426)	(0.538)	(0.262)	(0.339)	(3.710)	(0.158)
Size	0.024	0.022	0.018	-0.041	-0.007	-0.022	0.054	-0.045	0.020
	(0.062)	(0.036)	(0.091)	(0.073)	(0.195)	(0.030)	(0.046)	(0.280)	(0.017)
Observations	123	296	86	100	64	350	138	36	1,193
R^2	0.389	0.343	0.639	0.486	0.559	0.325	0.232	0.519	0.255
Adjusted R^2	0.262	0.293	0.528	0.356	0.353	0.282	0.101	0.010	0.241

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. The SCC has been used to estimate the corrected error terms and level of significance. The R^2, adjusted R^2 and coefficients are calculated from the time FE models.*

5. ROBUSTNESS

In this chapter, the robustness of all the previously presented results are examined. The Breush - Godfrey - Wooldridge test for serial correlation and the Perasan CD test for cross-sectional dependence were used on all the models. A heteroskedasticity and autocorrelation consistent (HAC) as well as a cross-sectional and serial correlation estimator (SCC), are used in all the models. Both HAC and SCC retain the coefficients initially produced, but the significance level of the coefficients may be reduced in the presence of cross-sectional dependence and or serial correlation. So, the significance can be affected, but the interpretation of the coefficients will not change.

In panel data a series of tests must be conducted in order to produce robust results. First, autocorrelation invalidates the usual standard error formulas as well as heteroskedasticity-robust standard errors, since these are derived under the assumption that there is no autocorrelation. When both heteroskedasticity and autocorrelation exist the heteroskedasticity and autocorrelation-consistent (HAC) standard errors need to be used. Clustered standard errors belong to these types of standard errors. They allow for heteroskedasticity and autocorrelated errors within an entity, but not correlation across entities (Newey et al., 1987).

To check for the serial correlation issue, the Breusch-Godfrey test for serial correlation on the time fixed effects estimation is used with the results being presented in the following table.

Table 15: Breusch-Godfrey/Wooldridge test for serial correlation in panel models

	X^2	df	p-value
(H1) Environmental	772.31	1	< 0.001
(H2) Social	776.28	1	< 0.001
(H3) Governance	776.11	1	< 0.001
(H4) ESG	726.49	1	< 0.001

Note: *All the models mentioned above are cumulative models, meaning that the complete dataset is used without sector specifications.*

The null hypothesis in this test is that the autocorrelation of the error term is 0. Given the results above are all at 0.1 % significant, the null hypothesis is rejected. Therefore, there is sufficient evidence that serial correlation exists in these models. So, an HAC model should be used in order to have robust results.

In panel data we also have to make sure that there is no cross-sectional dependence. To check for that the Pesaran CD test for cross-sectional dependence in panels is used.

Table 16: Pesaran CD test for cross-sectional dependence in panel data.

	z	p-value
(H1) Environmental	-2.044	0.041
(H2) Social	-0.977	0.328
(H3) Governance	-1.590	0.112
(H4) ESG	-1.431	0.152

Note: *All the models mentioned above are cumulative models, meaning that the complete dataset is used without sector specifications.*

From the table above, under the null hypothesis of no cross-sectional dependence, only the environmental model seems to present a cross-sectional dependence at a 5% significance. All the other models do not seem to have the same issue.

As mentioned by De Hoyos and Sarafidis (2006), "the impact of cross-sectional dependence in estimation naturally depends on a variety of factors, such as the magnitude of the correlations across cross sections and the nature of cross-sectional dependence itself. If we assume that cross-sectional dependence is caused by the presence of common factors, which are unobserved (and the effect of these components is therefore felt through the disturbance term) but uncorrelated with the included regressors, the standard fixed-effects (FE) and random-effects (RE) estimators are consistent, although not efficient, and the estimated standard errors are biased". Consequently, besides maintaining the FE/RE estimators, I corrected the standard errors by following the approach proposed by Driscoll and Kraay (1998).

In instances of cross-sectional dependence, Driscoll and Kraay (1998) introduce an estimator, that produces consistent to heteroskedasticity and autocorrelation standard errors, which are robust to general forms of spatial and temporal dependence. This estimator, also known as the cross-sectional and serial correlation (SCC) estimator, is favored over Beck and Katz's (1995) Panel Corrected Standard Errors (PCSE) method, due to its ability to address the limitations inherent in the latter approach. The SCC method is particularly preferred for obtaining standard errors, that are not only robust to heteroskedasticity and autocorrelation, but also resilient to cross-sectional dependence. In scenarios involving large datasets (i.e., a small T/N ratio), the Driscoll and Kraay method is preferable over PCSE (Millo, 2017). Consequently, the SCC method was used as a robustness measure.

No notable differences were detected in the significance of the ESG indicators, between the HAC and the SCC estimators (see appendix tables C, D, E, F). So, in this section the time fixed effects model as presented in section 4 and the SCC estimator will be compared. The SCC models are presented in the appendix, instead of the full coefficients and error terms, in this section only the significant effects will be presented at a 95% confidence interval. Where (+) will mean a statistically significant positive effect, (-) will mean a statistically significant negative effect and (0) will mean a non-significant effect. Since the SCC keeps the same coefficients as the Fixed Effects model, the focus of the following tables is directed whether the indicators maintain, lose, or gain significance.

A comparison of the significance of the Time Fixed Effects and the SCC results for the combined ESG pillars is presented in table 17. This table is used to show how vast the difference of the levels of significance is between these two estimating methods.

Even though models initially seemed promising by the FE estimates, the SCC correction showed, that if the model is calculated without serial and cross dependent correlation, then the outputs may be quite different. This is presented for the sole purpose of understanding why using the right model is important, especially when the outcome of the research may affect a firm's overall credit rating.

The combined model shows negative effects on resource reduction targets, renewable energy use, corporate governance board committee and policy board independence, as well as a positive effect on environmental controversies, bribery, corruption and fraud controversies, and on shareholders rights policy.

It is obvious that with the SCC correction, the results became underwhelming, showing that the ESG effects on the risk of default are heavily industry biased and even the coefficients vary in size and in overall positive or negative effect. This result is overly concerning and should be further studied, since this can mean that ESG initiatives that were expected to mitigate risk might on the contrary increase risk and vice versa, ESG initiatives that were expected to increase risk could potentially reduce it.

Table 17: Comparison of the time fixed effects and the SCC results for all ESG pillars.

	Dependent Variable: log(PD)																	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Basic Materials		Consumer Cyclicals		Consumer Non-Cyclicals		Energy		Healthcare		Industrials		Technology		Utilities		All Sectors	
	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC
RRT	-	0	0	0	-	0	-	0	0	0	0	0	0	0	0	0	-	-
REU	-	-	-	-	0	0	0	0	-	0	-	-	-	0	0	0	-	-
EC	0	0	0	0	0	-	0	0	0	0	0	0	0	-	0	0	+	+
EP	0	0	0	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0
HSP	+	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0
PEHS	Dropped	Dropped	0	0	0	+	Dropped	Dropped	0	-	0	0	0	0	Dropped	Dropped	0	0
PCL	0	0	0	0	0	0	0	0	0	0	0	0	+	0	0	0	0	0
BCFC	+	0	0	0	0	0	0	0	0	0	+	+	+	0	0	0	+	+
PQC	0	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	-	0
CGBC	-	0	0	0	0	0	+	0	0	0	0	-	0	0	-	0	-	-
PBI	-	0	-	0	-	-	-	0	0	0	-	0	0	0	-	-	-	-
SRP	0	0	+	0	+	0	0	0	0	0	+	0	0	0	Dropped	Dropped	+	+
CSRSR	-	0	+	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0
ROA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ART	+	+	+	+	+	+	0	0	0	0	+	+	0	0	-	0	+	+
LEV	+	+	+	+	+	+	+	0	+	+	+	+	+	+	0	0	+	+
WC/TA	-	0	0	0	0	0	-	-	0	0	0	0	-	0	0	0	-	-
SIZE	0	0	-	0	-	-	0	0	-	0	-	0	-	-	0	0	-	-

Note: *All (+) or (-) effects are significant at least at a 95% CI. For the Environmental Pillar Resource Reduction Targets is RRT, Renewable Energy Use is REU, Environmental Controversies is EC and Environmental Products is EP. For the Social Pillar, Health Safety Policy is HSP, Policy Employee Health Safety is PEHS, Policy Child Labor is PCL, Bribery Corruption and Fraud Controversies is BCFC and Product Quality Controversies is PQC. For the Governance Pillar, Corporate Governance Board Committee is CGBC, Policy Board Independence is PBI, Shareholder Rights Policy is SRP and CSR Sustainability Reporting is CSRSR.*

6. CONCLUSIONS AND FUTURE RESEARCH

This study has empirically demonstrated the significance of individual sector examination, when it comes to ESG matters, especially concerning the probability of default. First, when a combined model is used for all sectors, the ESG effects are highly likely to indirectly capture sector effects. Provided that between sector distribution of ESG indicators differ, these could be falsely labelled as important indicator effects. Second, as noticed on multiple occasions, significant effects on one sector are not found to be significant on other sectors or even worse, having an opposite significant coefficient, which could lead to the overestimation or underestimation, in this case, of the probability of default, or any other dependent variable.

The inclusion of ESG reports within the range of the financial statements of firms is particularly important, in order to be audited and to be precise. The inclusion of hundreds of indicators is inefficient, as it appears in this study, so legislators ought to detect and maintain a few significant indicators for firms to present on their financial statements or their sustainability reports.

ESG ratings being correlated to credit ratings will eventually become a self-fulfilled prophecy, since it is in the process of becoming a legislative requirement to include ESG ratings in the credit rating calculation.

A consistent differentiation of ESG indicator significance is observed throughout this research, between the combined sector model and the rest of the sector specific models. I emphasize on the necessity of using different models across sectors, which is important from two aspects. First, there is a difference in financial ratio effects on the PD rating of a company across sectors. Second, there is a difference of ESG effects on the PD rating of a company across sectors. Even though adopting a combined model seems much simpler, as it was shown throughout the results of all 5 hypothesis, a combined sector model can be misleading. As presented in chapter 4, the combined sector model regularly showed more ESG indicator significant effects compared to the sector specific models. Sometimes the indicator effect was only significant in the combined model, but not in a single sector model. Revealing that the combined model was indirectly using the indicator distribution to interpret the sector PD distribution and was not having a direct effect on the PD. The direct effect was exposed in the sector specific models, being much more underwhelming than in the combined sector model.

A key takeaway from this study is that ESG indicators can be used to predict the PD, but the indicators are not consistent across industries. As was expected and therefore examined, the effects of ESG indicators vary across industries. Certain indicators had no effect on the PD in any sector, and certain sectors were not affected by any ESG indicator. Demonstrating, that a combined ESG score is an incorrect practice by CRAs.

When the samples used to calculate the ESG effect on PD were split into investment and speculative grade firms, the results shifted, with non-significant indicators becoming significant and vice versa. With a few exceptions, the effects on PD seem to be inconsistent between investment and speculative graded firms. If an ESG indicator is significant for investment grade firms, then it tends to not be significant for the speculative grade firms and vice versa. This is yet another barrier that must be considered by CRAs, banks and legislative authorities.

The overestimation of the increase in PD caused by ESG indicators could lead to an underestimation of a firm's creditworthiness. While the overestimation of the reduction in PD caused by ESG indicators could lead to an overestimation of a firm's creditworthiness. It would wrongfully lead to an increase in cost of loan interest, for the former, and an increase in credit ratings, for the latter. Both could potentially lead once again to a financial crisis, similar to the 2008 global financial crisis, where credit ratings are not meaningful anymore and as a result banks and businesses defaulting.

Concluding, with the CSRD agreement, sustainability reporting will become a new SME obligation. When ESG data on SME firms, will become available, it should be further studied before "responsible" bank lending, ESG regulations and EU legislations, become stricter, causing irreversible damage to SME and speculative grade firms and as a result creating a series of corporate defaults.

There are a couple of limitations in this study. First, even though the constructed models in this thesis are unbiased towards cross sectional correlation, autocorrelation and heteroskedasticity, the results in certain sectors could be biased since the firm sample size was fairly small. For example, utilities and healthcare had a small sample size available, and in the models presented in tables 13 and 14 the sample was separated from speculative to investment grade firms and therefore, became even smaller probably creating unreliable results for these sectors. Second, all the indicators used in this research had yes or no answers, generating a significant information gap. Surely,

the renewable energy use indicator for example, has multiple layers within. One company may solely rely on renewables and another company could rely 50% on renewables. In this study both firms would get the same score, which seems rather unfair. Also, in the instances of bribery corruption and fraud controversies or environmental controversies, there may have been a firm with just one controversy and another firm with hundreds of controversies. Yet both would get the same score, so the effect captured is not painting the whole picture.

When it comes to future research, paths are very wide. As mentioned throughout this thesis, the EU wants to find ways to include ESG in credit ratings , but the results seem to be inconsistent. Since credit ratings are industry-based models, the ESG effects on these models should also be industry-based. Therefore, future research should separate industries when ESG indicators are used. This should not only apply when credit ratings are used as a dependent variable, but also when financial ratios are used as such.

With sustainability reporting being slowly mandated for smaller firms, most ESG studies could be recreated with a larger sample size available and examine if the overall results stay consistent or differ with the inclusion of smaller firms.

The ESG effects are qualitative issues, that in the effort to oversimplify them, credit rating agencies gave them a quantitative score. A question that first must be answered is, that if experts have not managed to create a unanimously adequate a score rating on quantitative data (such as balance sheets, financial ratios, etc.) in order to rank firms, why should it be possible acquire a valid score rating on qualitative data?

How can ESG be defined, and which indicators should be included and with what weight being compared to one another, in order to avoid a green washing effect? The inclusion of hundreds of indicators seems to be absurd, and nearly impossible to audit. So, I suggest that not the same ESG metrics should apply to different industries. Also, policies and controversies should not have the same weight as other indicators, since their presence does not mean that they are applied or true, respectively. Legal convictions and settlements should be included in the ESG indicators for each related pillar.

Finally, both the supply chain management and ESG literature have to proceed together to create a robust ESG rating, which will include properly the outsourcing aspect, since currently it is not being examined properly by the ESG rating agencies.

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APPENDIX

Table A: Total of EU firms observed, separated by country and year.

Country	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Austria	0	23	27	27	27
Belgium	2	34	34	34	33
Czech Republic	2	3	3	2	2
Denmark	0	49	51	50	52
Finland	5	71	70	70	69
France	8	138	142	142	141
Germany	7	213	220	224	222
Greece	2	18	17	17	17
Hungary	0	3	3	3	3
Republic of Ireland	2	28	31	34	32
Italy	7	80	86	87	87
Luxembourg	2	17	19	18	19
Netherlands	9	51	48	46	45
Norway	5	55	55	57	59
Poland	2	24	25	25	26
Portugal	1	12	12	12	11
Romania	0	4	4	4	4
Spain	4	57	58	57	55
Sweden	5	151	162	162	164
Switzerland	5	111	123	123	124
United Kingdom	51	380	422	420	413
Observations	119	1,522	1,612	1,614	1,605

Note: *The number of firms that are accounted for in this table, are for firms that the probability of default was provided by the NUS and then was successfully matched with the rest of the data provided by Refinitiv.*

As observed in Table above, the dataset consists of firms that have their headquarters in twenty-one European countries, in a five-year period. The total number of firms observed becomes more consistent after the year 2018. More precisely, there are 119, 1,522, 1,612, 1,614 and 1,605 EU firms, for the years 2018, 2019, 2020, 2021 and 2022, respectively. It is also noticeable that the most commonly represented European countries are the United Kingdom, Germany, France, Sweden, and Switzerland, having consistently hundreds of firms per year after 2018, while the less represented European countries are Romania, Hungary, and the Czech Republic, all of which do not individually surpass 10 firms per year.

Table B: StarMine Combined Credit Risk Model, letter grading.

IF default probability (%) is greater than…	AND less than or equal to…	THEN Implied Rating is…
0%	0.014%	AAA
0.014%	0.020%	AA+
0.020%	0.028%	AA
0.028%	0.038%	AA-
0.038%	0.052%	A+
0.052%	0.069%	A
0.069%	0.089%	A-
0.089%	0.113%	BBB+
0.113%	0.145%	BBB
0.145%	0.190%	BBB-
0.190%	0.255%	BB+
0.255%	0.354%	BB
0.354%	0.507%	BB-
0.507%	0.757%	B+
0.757%	1.153%	B
1.153%	1.668%	B-
1.668%	2.357%	CCC-
2.357%	3.473%	CCC
3.473%	5.956%	CCC-
5.956%	100%	CC

For the convenience of investors, who are familiar with traditional rating scales, STARMINE also maps the StarMine CCR probability of default to letter grade ratings so that the distribution of StarMine CCR ratings is similar to the distribution of other rating agencies' ratings.

For probabilities of default equal or larger than 0.190%, the firm is considered as an Investment grade firm. Meanwhile, for probabilities of default smaller than 0.190%, the firm is considered as a Speculative grade firm.

Table C: The HAC and SCC estimates for the environmental model.

	Dependent Variable: log(PD)																	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Basic Materials		Consumer Cyclicals		Consumer Non-Cyclicals		Energy		Healthcare		Industrials		Technology		Utilities		All Sectors	
	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC
RRT	-0.26	-0.26	-0.01	-0.01	-0.31	-0.31	-0.54	-0.54	-0.13	-0.13	-0.08	-0.08	-0.13	-0.13	0.26	0.26	-0.16 **	-0.16 **
	(0.14)	(0.13)	(0.11)	(0.12)	(0.17)	(0.16)	(0.28)	(0.28)	(0.23)	(0.24)	(0.10)	(0.09)	(0.14)	(0.13)	(0.22)	(0.24)	(0.06)	(0.06)
REU	-0.68 ***	-0.68 ***	-0.25 *	-0.25 *	-0.30	-0.30	-0.08	-0.08	-0.38	-0.38	-0.32 ***	-0.32 ***	-0.20	-0.20	-0.03	-0.03	-0.31 ***	-0.31 ***
	(0.18)	(0.18)	(0.11)	(0.11)	(0.23)	(0.22)	(0.22)	(0.23)	(0.24)	(0.24)	(0.09)	(0.09)	(0.12)	(0.12)	(0.36)	(0.39)	(0.05)	(0.05)
EC	-0.04	-0.04	0.65 *	0.65 *	-0.80	-0.80	-0.00	-0.00	1.11	1.11	0.33	0.33	-0.83 ***	-0.83 ***	0.48	0.48	0.48 ***	0.48 ***
	(0.27)	(0.26)	(0.29)	(0.29)	(0.47)	(0.47)	(0.31)	(0.32)	(0.88)	(0.93)	(0.44)	(0.44)	(0.24)	(0.23)	(0.26)	(0.29)	(0.14)	(0.14)
EP	-0.19	-0.19	0.03	0.03	-0.28	-0.28	-0.16	-0.16	-0.36	-0.36	-0.02	-0.02	-0.07	-0.07	-0.10	-0.10	0.03	0.03
	(0.24)	(0.23)	(0.11)	(0.11)	(0.20)	(0.19)	(0.22)	(0.23)	(0.26)	(0.28)	(0.09)	(0.08)	(0.12)	(0.12)	(0.33)	(0.30)	(0.06)	(0.06)
ROA	-7.34 ***	-7.34 ***	-8.86 ***	-8.86 ***	-9.24 ***	-9.24 ***	-6.29 ***	-6.29 ***	-3.28 **	-3.28 **	-9.50 ***	-9.50 ***	-6.84 ***	-6.84 ***	-12.75 ***	-12.75 ***	-7.49 ***	-7.49 ***
	(1.69)	(1.64)	(1.09)	(1.02)	(1.98)	(2.02)	(1.24)	(1.22)	(1.18)	(1.20)	(0.87)	(0.85)	(0.90)	(0.92)	(3.29)	(3.48)	(0.48)	(0.48)
ART	0.12 ***	0.12 ***	0.02 ***	0.02 ***	0.04 *	0.04 *	-0.01	-0.01	0.02	0.02	0.06 ***	0.06 ***	-0.00	-0.00	0.15 **	0.15 **	0.04 ***	0.04 ***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)	(0.01)	(0.06)	(0.05)	(0.00)	(0.00)
LEV	3.45 ***	3.45 ***	1.78 ***	1.78 ***	3.62 ***	3.62 ***	0.98	0.98	4.33 ***	4.33 ***	2.65 ***	2.65 ***	1.59 ***	1.59 ***	0.78	0.78	2.37 ***	2.37 ***
	(0.61)	(0.60)	(0.38)	(0.37)	(0.80)	(0.82)	(0.59)	(0.56)	(0.75)	(0.71)	(0.30)	(0.31)	(0.30)	(0.32)	(0.96)	(0.94)	(0.20)	(0.21)
WC/TA	-0.87	-0.87	-0.25	-0.25	-0.43	-0.43	-1.62 *	-1.62 *	0.09	0.09	0.02	0.02	-0.52	-0.52	0.62	0.62	-0.48 *	-0.48 *
	(0.78)	(0.82)	(0.35)	(0.34)	(0.75)	(0.74)	(0.70)	(0.69)	(0.63)	(0.56)	(0.33)	(0.34)	(0.33)	(0.34)	(1.04)	(1.14)	(0.19)	(0.20)
SIZE	-0.07	-0.07	-0.08	-0.08	-0.24 **	-0.24 **	-0.05	-0.05	-0.13	-0.13	-0.09 *	-0.09 *	-0.09 *	-0.09 *	-0.09	-0.09	-0.10 ***	-0.10 ***
	(0.07)	(0.07)	(0.04)	(0.04)	(0.09)	(0.09)	(0.08)	(0.07)	(0.08)	(0.09)	(0.03)	(0.04)	(0.04)	(0.04)	(0.10)	(0.09)	(0.02)	(0.02)

***Note**: Where *** p < 0.001; ** p < 0.01; * p < 0.05. For the Environmental Pillar, Resource Reduction Targets is RRT, Renewable Energy Use is REU, Environmental Controversies is EC, Environmental Products is EP.*

Table D: The HAC and SCC estimates for the social model.

	Dependent Variable: log(PD)																	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Basic Materials		Consumer Cyclicals		Consumer Non-Cyclicals		Energy		Healthcare		Industrials		Technology		Utilities		All Sectors	
	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC
HSP	0.50	0.50	0.13	0.13	-0.70	-0.70	0.54	0.54	0.30	0.30	-0.47	-0.47	-0.16	-0.16	-0.70	-0.70	-0.13	-0.13
	(0.98)	(0.98)	(0.44)	(0.43)	(0.66)	(0.66)	(0.41)	(0.42)	(0.47)	(0.42)	(0.63)	(0.63)	(0.25)	(0.24)	(0.75)	(0.80)	(0.19)	(0.19)
PEHS	**Dropped**	**Dropped**	0.01	0.01	-0.06	-0.06	**Dropped**	**Dropped**	-0.68 **	-0.68 **	0.21	0.21	-0.16	-0.16	**Dropped**	**Dropped**	0.07	0.07
			(0.22)	(0.22)	(0.40)	(0.40)			(0.23)	(0.22)	(0.59)	(0.59)	(0.20)	(0.20)			(0.15)	(0.15)
PCL	-0.47 *	-0.47	-0.06	-0.06	-0.40 *	-0.40 *	-0.26	-0.26	-0.10	-0.10	-0.08	-0.08	0.15	0.15	-0.20	-0.20	-0.04	-0.04
	(0.23)	(0.25)	(0.12)	(0.12)	(0.20)	(0.20)	(0.28)	(0.29)	(0.21)	(0.21)	(0.09)	(0.09)	(0.12)	(0.12)	(0.27)	(0.27)	(0.06)	(0.06)
BCFC	0.45	0.45	0.26	0.26	0.30	0.30	0.01	0.01	0.53	0.53	0.24	0.24	0.35	0.35	0.04	0.04	0.34 ***	0.34 ***
	(0.24)	(0.24)	(0.16)	(0.15)	(0.26)	(0.26)	(0.22)	(0.23)	(0.35)	(0.36)	(0.14)	(0.15)	(0.26)	(0.28)	(0.28)	(0.30)	(0.08)	(0.08)
PQC	-0.32	-0.32	0.24	0.24	-0.52	-0.52	0.34	0.34	0.16	0.16	-0.22	-0.22	-0.37	-0.37	-0.56	-0.56	-0.20	-0.20
	(0.30)	(0.30)	(0.18)	(0.17)	(0.34)	(0.32)	(0.29)	(0.28)	(0.54)	(0.54)	(0.21)	(0.21)	(0.34)	(0.31)	(0.62)	(0.63)	(0.14)	(0.14)
ROA	-7.60 ***	-7.60 ***	-8.84 ***	-8.84 ***	-9.55 ***	-9.55 ***	-6.50 ***	-6.50 ***	-3.55 **	-3.55 **	-9.56 ***	-9.56 ***	-7.02 ***	-7.02 ***	-13.08 ***	-13.08 ***	-7.70 ***	-7.70 ***
	(1.89)	(1.84)	(1.06)	(0.99)	(2.07)	(2.12)	(1.28)	(1.26)	(1.25)	(1.28)	(0.92)	(0.90)	(0.86)	(0.88)	(3.43)	(3.66)	(0.48)	(0.48)
ART	0.12 ***	0.12 ***	0.02 ***	0.02 ***	0.04 *	0.04 *	-0.00	-0.00	0.03	0.03	0.06 ***	0.06 ***	0.00	0.00	0.14 *	0.14 *	0.04 ***	0.04 ***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.02)	(0.06)	(0.06)	(0.00)	(0.00)
LEV	3.56 ***	3.56 ***	1.85 ***	1.85 ***	3.36 ***	3.36 ***	1.07	1.07	4.07 ***	4.07 ***	2.61 ***	2.61 ***	1.48 ***	1.48 ***	0.78	0.78	2.36 ***	2.36 ***
	(0.60)	(0.57)	(0.38)	(0.37)	(0.83)	(0.86)	(0.59)	(0.55)	(0.80)	(0.73)	(0.30)	(0.31)	(0.30)	(0.32)	(1.00)	(0.95)	(0.20)	(0.21)
WC/TA	-0.59	-0.59	-0.24	-0.24	-0.70	-0.70	-1.51	-1.51	-0.01	-0.01	0.08	0.08	-0.64	-0.64	0.48	0.48	-0.43 *	-0.43 *
	(0.82)	(0.85)	(0.33)	(0.32)	(0.72)	(0.69)	(0.85)	(0.84)	(0.64)	(0.57)	(0.34)	(0.35)	(0.33)	(0.33)	(1.07)	(1.13)	(0.19)	(0.19)
SIZE	-0.20 ***	-0.20 ***	-0.11 **	-0.11 *	-0.30 ***	-0.30 ***	-0.12	-0.12	-0.24 **	-0.24 **	-0.13 ***	-0.13 ***	-0.15 **	-0.15 ***	0.02	0.02	-0.15 ***	-0.15 ***
	(0.06)	(0.06)	(0.04)	(0.04)	(0.08)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.04)	(0.04)	(0.05)	(0.04)	(0.10)	(0.09)	(0.02)	(0.02)

Note: *Where *p<0.05, **p<0.01 and ***p<0.001. For the Social Pillar, Health Safety Policy is HSP, Policy Employee Health Safety is PEHS, Policy Child Labor is PCL, Bribery Corruption and Fraud Controversies is BCFC and Product Quality Controversies is PQC.*

Table E: The HAC and SCC estimates for the governance model.

	Dependent Variable: log(PD)																	
	(1)		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**(8)**		**(9)**	
	Basic Materials		**Consumer Cyclicals**		**Consumer Non-Cyclicals**		**Energy**		**Healthcare**		**Industrials**		**Technology**		**Utilities**		**All Sectors**	
	HAC	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**	**HAC**	**SCC**
CGBC	-0.32	-0.32	-0.08	-0.08	-0.18	-0.18	0.36	0.36	0.25	0.25	-0.33	-0.33	-0.20	-0.20	-0.36	-0.36	-0.20 *	-0.20 *
	(0.26)	(0.25)	(0.18)	(0.18)	(0.29)	(0.28)	(0.26)	(0.25)	(0.24)	(0.24)	(0.17)	(0.17)	(0.29)	(0.26)	(0.31)	(0.29)	(0.09)	(0.09)
PBI	-0.15	-0.15	-0.15	-0.15	-0.35	-0.35 *	-0.23	-0.23	0.09	0.09	-0.14	-0.14	-0.02	-0.02	-0.63 **	-0.63 **	-0.14 **	-0.14 **
	(0.16)	(0.16)	(0.10)	(0.10)	(0.19)	(0.17)	(0.23)	(0.25)	(0.21)	(0.20)	(0.08)	(0.09)	(0.12)	(0.11)	(0.23)	(0.20)	(0.05)	(0.05)
SRP	0.38	0.38	0.27	0.27	0.62	0.62	-0.26	-0.26	-0.27	-0.27	0.30	0.30	0.19	0.19	Dropped	Dropped	0.29 *	0.29 *
	(0.50)	(0.50)	(0.27)	(0.26)	(0.43)	(0.41)	(0.27)	(0.26)	(0.21)	(0.21)	(0.18)	(0.20)	(0.22)	(0.21)			(0.11)	(0.12)
CSRSR	-1.00 *	-1.00 *	0.29	0.29	-1.24 **	-1.24 **	0.11	0.11	-0.03	-0.03	-0.11	-0.11	-0.16	-0.16	0.35	0.35	-0.05	-0.05
	(0.43)	(0.43)	(0.32)	(0.33)	(0.42)	(0.40)	(0.37)	(0.36)	(0.23)	(0.24)	(0.12)	(0.12)	(0.13)	(0.14)	(0.38)	(0.39)	(0.09)	(0.09)
ROA	-7.65 ***	-7.65 ***	-8.97 ***	-8.97 ***	-9.46 ***	-9.46 ***	-6.07 ***	-6.07 ***	-3.92 **	-3.92 **	-9.60 ***	-9.60 ***	-7.08 ***	-7.08 ***	-11.37 ***	-11.37 ***	-7.81 ***	-7.81 ***
	(1.88)	(1.80)	(1.06)	(1.00)	(1.75)	(1.79)	(1.32)	(1.35)	(1.24)	(1.27)	(0.91)	(0.89)	(0.88)	(0.90)	(3.03)	(3.05)	(0.48)	(0.48)
ART	0.11 ***	0.11 ***	0.02 ***	0.02 ***	0.04 *	0.04 *	-0.00	-0.00	0.05	0.05	0.06 ***	0.06 ***	-0.00	-0.00	0.12 *	0.12 *	0.04 ***	0.04 ***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.02)	(0.01)	(0.02)	(0.02)	(0.06)	(0.06)	(0.00)	(0.00)
LEV	3.78 ***	3.78 ***	1.77 ***	1.77 ***	3.71 ***	3.71 ***	0.91	0.91	4.06 ***	4.06 ***	2.66 ***	2.66 ***	1.51 ***	1.51 ***	0.73	0.73	2.37 ***	2.37 ***
	(0.62)	(0.62)	(0.38)	(0.37)	(0.78)	(0.79)	(0.64)	(0.61)	(0.78)	(0.74)	(0.31)	(0.31)	(0.30)	(0.32)	(1.05)	(0.98)	(0.21)	(0.21)
WC/TA	-0.58	-0.58	-0.32	-0.32	-0.40	-0.40	-1.71 *	-1.71 *	-0.06	-0.06	-0.01	-0.01	-0.54	-0.54	0.10	0.10	-0.46 *	-0.46 *
	(0.81)	(0.85)	(0.33)	(0.32)	(0.68)	(0.67)	(0.83)	(0.85)	(0.64)	(0.58)	(0.33)	(0.34)	(0.32)	(0.33)	(1.01)	(1.05)	(0.19)	(0.19)
SIZE	-0.15 **	-0.15 **	-0.07 *	-0.07 *	-0.31 ***	-0.31 ***	-0.13	-0.13	-0.22 **	-0.22 **	-0.10 **	-0.10 **	-0.11 **	-0.11 **	0.02	0.02	-0.12 ***	-0.12 ***
	(0.05)	(0.05)	(0.03)	(0.04)	(0.08)	(0.08)	(0.07)	(0.07)	(0.07)	(0.07)	(0.03)	(0.03)	(0.04)	(0.04)	(0.08)	(0.06)	(0.02)	(0.02)

Note: *Where *p<0.05, **p<0.01 and ***p<0.001. For Corporate Governance Board Committee is CGBC, Policy Board Independence is PBI, Shareholder Rights Policy is SRP and CSR Sustainability Reporting is CSRSR.*

Table F: The HAC and SCC estimates for the ESG model.

	Dependent Variable: log(PD)																	
	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Basic Materials		Consumer Cyclicals		Consumer Non-Cyclicals		Energy		Healthcare		Industrials		Technology		Utilities		All Sectors	
	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC
RRT	-0.21	-0.21	-0.07	-0.07	-0.28	-0.28	-0.54	-0.54	-0.21	-0.21	-0.05	-0.05	-0.13	-0.13	0.10	0.10	-0.16 **	-0.16 **
	(0.14)	(0.14)	(0.10)	(0.11)	(0.17)	(0.17)	(0.29)	(0.30)	(0.23)	(0.24)	(0.09)	(0.09)	(0.14)	(0.13)	(0.22)	(0.23)	(0.06)	(0.06)
REU	-0.66 ***	-0.66 ***	-0.29 **	-0.29 **	-0.25	-0.25	-0.07	-0.07	-0.42	-0.42	-0.30 ***	-0.30 ***	-0.20	-0.20	0.05	0.05	-0.31 ***	-0.31 ***
	(0.18)	(0.18)	(0.10)	(0.10)	(0.21)	(0.20)	(0.23)	(0.24)	(0.24)	(0.23)	(0.09)	(0.09)	(0.13)	(0.13)	(0.35)	(0.38)	(0.05)	(0.05)
EC	-0.03	-0.03	0.39	0.39	-0.79 *	-0.79 *	0.03	0.03	0.87	0.87	0.21	0.21	-0.88 ***	-0.88 ***	0.41	0.41	0.41 **	0.41 **
	(0.28)	(0.28)	(0.32)	(0.33)	(0.35)	(0.35)	(0.33)	(0.33)	(0.96)	(1.02)	(0.43)	(0.43)	(0.24)	(0.24)	(0.30)	(0.33)	(0.14)	(0.14)
EP	-0.11	-0.11	0.02	0.02	-0.28	-0.28	-0.19	-0.19	-0.35	-0.35	-0.03	-0.03	-0.08	-0.08	-0.05	-0.05	0.01	0.01
	(0.24)	(0.23)	(0.11)	(0.11)	(0.19)	(0.18)	(0.23)	(0.24)	(0.27)	(0.29)	(0.09)	(0.09)	(0.12)	(0.13)	(0.32)	(0.30)	(0.06)	(0.06)
HSP	1.21	1.21	0.13	0.13	-1.23 *	-1.23 *	0.22	0.22	0.30	0.30	-0.29	-0.29	-0.12	-0.12	-0.74	-0.74	-0.11	-0.11
	(0.86)	(0.86)	(0.44)	(0.45)	(0.52)	(0.50)	(0.65)	(0.68)	(0.44)	(0.40)	(0.66)	(0.66)	(0.23)	(0.22)	(0.71)	(0.69)	(0.19)	(0.19)
PEHS	**Dropped**	**Dropped**	-0.06	-0.06	1.53 *	1.53 *	**Dropped**	**Dropped**	-0.69 *	-0.69 *	0.04	0.04	-0.12	-0.12	**Dropped**	**Dropped**	0.10	0.10
			(0.26)	(0.26)	(0.71)	(0.73)			(0.30)	(0.31)	(0.63)	(0.63)	(0.16)	(0.16)			(0.16)	(0.15)
PCL	-0.27	-0.27	-0.01	-0.01	-0.24	-0.24	-0.10	-0.10	0.10	0.10	-0.01	-0.01	0.20	0.20	-0.06	-0.06	0.04	0.04
	(0.21)	(0.22)	(0.12)	(0.12)	(0.19)	(0.18)	(0.25)	(0.27)	(0.21)	(0.22)	(0.09)	(0.09)	(0.12)	(0.12)	(0.23)	(0.22)	(0.06)	(0.06)
BCFC	0.37	0.37	0.21	0.21	0.31	0.31	-0.05	-0.05	0.41	0.41	0.28 *	0.28 *	0.41	0.41	0.06	0.06	0.33 ***	0.33 ***
	(0.25)	(0.25)	(0.17)	(0.16)	(0.24)	(0.25)	(0.22)	(0.21)	(0.32)	(0.33)	(0.14)	(0.14)	(0.28)	(0.30)	(0.22)	(0.23)	(0.08)	(0.08)
PQC	-0.17	-0.17	0.20	0.20	-0.55	-0.55	0.35	0.35	-0.00	-0.00	-0.18	-0.18	-0.30	-0.30	-0.43	-0.43	-0.18	-0.18
	(0.29)	(0.28)	(0.17)	(0.17)	(0.31)	(0.30)	(0.28)	(0.28)	(0.52)	(0.52)	(0.20)	(0.20)	(0.33)	(0.31)	(0.70)	(0.70)	(0.14)	(0.13)
CGBC	-0.26	-0.26	-0.06	-0.06	-0.24	-0.24	0.32	0.32	0.07	0.07	-0.33	-0.33 *	-0.18	-0.18	-0.37	-0.37	-0.20 *	-0.20 *
	(0.26)	(0.25)	(0.17)	(0.17)	(0.28)	(0.27)	(0.27)	(0.25)	(0.21)	(0.21)	(0.17)	(0.16)	(0.29)	(0.27)	(0.32)	(0.31)	(0.09)	(0.09)

Table F continued

	(1)		(2)		(3)		(4)		(5)		(6)		(7)		(8)		(9)	
	Basic Materials		Consumer Cyclicals		Consumer Non-Cyclicals		Energy		Healthcare		Industrials		Technology		Utilities		All Sectors	
	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	HAC	SCC	HAC	SCC	HAC	SCC	HAC	SCC	HAC
PBI	-0.21	-0.21	-0.13	-0.13	-0.38 *	-0.38 *	-0.27	-0.27	0.10	0.10	-0.13	-0.13	0.03	0.03	-0.59 **	-0.59 **	-0.14 **	-0.14 **
	(0.16)	(0.16)	(0.10)	(0.10)	(0.18)	(0.16)	(0.25)	(0.26)	(0.22)	(0.20)	(0.09)	(0.09)	(0.12)	(0.11)	(0.23)	(0.20)	(0.05)	(0.05)
SRP	-0.09	-0.09	0.27	0.27	0.64	0.64	-0.14	-0.14	-0.41	-0.41	0.28	0.28	0.24	0.24	**Dropped**	**Dropped**	0.27 *	0.27 *
	(0.52)	(0.53)	(0.27)	(0.26)	(0.51)	(0.50)	(0.31)	(0.32)	(0.27)	(0.28)	(0.19)	(0.20)	(0.23)	(0.21)			(0.11)	(0.12)
CSRSR	-0.71	-0.71	0.42	0.42	-1.24 *	-1.24 *	0.19	0.19	0.36	0.36	0.03	0.03	-0.02	-0.02	0.60	0.60	0.09	0.09
	(0.46)	(0.48)	(0.27)	(0.28)	(0.56)	(0.54)	(0.49)	(0.50)	(0.23)	(0.24)	(0.12)	(0.12)	(0.16)	(0.16)	(0.64)	(0.60)	(0.09)	(0.09)
ROA	-7.34 ***	-7.34 ***	-8.71 ***	-8.71 ***	-9.05 ***	-9.05 ***	-5.88 ***	-5.88 ***	-3.36 **	-3.36 *	-9.47 ***	-9.47 ***	-6.73 ***	-6.73 ***	-12.21 ***	-12.21 ***	-7.52 ***	-7.52 ***
	(1.73)	(1.67)	(1.05)	(0.98)	(1.64)	(1.70)	(1.23)	(1.27)	(1.28)	(1.30)	(0.90)	(0.88)	(0.88)	(0.90)	(3.41)	(3.48)	(0.48)	(0.48)
ART	0.11 ***	0.11 ***	0.02 ***	0.02 ***	0.03 *	0.03 *	-0.01	-0.01	0.03	0.03	0.06 ***	0.06 ***	-0.00	-0.00	0.12	0.12	0.04 ***	0.04 ***
	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)	(0.03)	(0.03)	(0.01)	(0.01)	(0.02)	(0.02)	(0.07)	(0.07)	(0.00)	(0.00)
LEV	3.61 ***	3.61 ***	1.79 ***	1.79 ***	3.50 ***	3.50 ***	0.83	0.83	4.21 ***	4.21 ***	2.69 ***	2.69 ***	1.61 ***	1.61 ***	0.64	0.64	2.40 ***	2.40 ***
	(0.66)	(0.66)	(0.36)	(0.36)	(0.76)	(0.77)	(0.65)	(0.62)	(0.80)	(0.75)	(0.31)	(0.31)	(0.32)	(0.34)	(1.13)	(1.03)	(0.20)	(0.21)
WC/TA	-0.86	-0.86	-0.29	-0.29	-0.72	-0.72	-1.73 *	-1.73 *	0.16	0.16	0.03	0.03	-0.54	-0.54	0.04	0.04	-0.44 *	-0.44 *
	(0.79)	(0.83)	(0.35)	(0.34)	(0.71)	(0.68)	(0.69)	(0.69)	(0.63)	(0.57)	(0.33)	(0.34)	(0.34)	(0.35)	(0.90)	(0.92)	(0.19)	(0.19)
SIZE	-0.06	-0.06	-0.08	-0.08	-0.18 *	-0.18 *	-0.06	-0.06	-0.16	-0.16	-0.07	-0.07	-0.11 *	-0.11 *	0.05	0.05	-0.10 ***	-0.10 ***
	(0.06)	(0.07)	(0.04)	(0.04)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.04)	(0.04)	(0.05)	(0.05)	(0.10)	(0.08)	(0.02)	(0.02)

***Note**: Where *p<0.05, **p<0.01 and ***p<0.001. For the Environmental Pillar Resource Reduction Targets is RRT, Renewable Energy Use is REU, Environmental Controversies is EC and Environmental Products is EP. For the Social Pillar, Health Safety Policy is HSP, Policy Employee Health Safety is PEHS, Policy Child Labor is PCL, Bribery Corruption and Fraud Controversies is BCFC and Product Quality Controversies is PQC. For the Governance Pillar, Corporate Governance Board Committee is CGBC, Policy Board Independence is PBI, Shareholder Rights Policy is SRP and CSR Sustainability Reporting is CSRSR.*

Table G: Comparison of the time fixed effects and the SCC results for the environmental pillar.

	Dependent Variable: log(PD)																	
	(1)		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**(8)**		**(9)**	
	Basic Materials		**Consumer Cyclicals**		**Consumer Non-Cyclicals**		**Energy**		**Healthcare**		**Industrials**		**Technology**		**Utilities**		**All Sectors**	
	FE	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**
RRT	-	0	0	0	-	0	-	0	0	0	0	0	0	0	0	0	-	-
REU	-	-	-	-	-	0	0	0	-	0	-	-	-	0	0	0	-	-
EC	0	0	+	+	0	0	0	0	+	0	0	0	0	-	0	0	+	+
EP	0	0	0	0	-	0	0	0	-	0	0	0	0	0	0	0	0	0
ROA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ART	+	0	+	+	+	+	0	0	0	0	+	+	0	0	+	+	+	+
LEV	+	+	+	+	+	+	+	0	+	+	+	+	+	+	0	0	+	+
WC/TA	-	0	0	0	0	0	-	-	0	0	0	0	-	0	0	0	-	-
SIZE	-	0	-	0	-	-	0	0	-	0	-	-	-	-	0	0	-	-

Note: *All (+) or (-) effects are significant at least at a 95% CI. For the Environmental Pillar Resource Reduction Targets is RRT, Renewable Energy Use is REU, Environmental Controversies is EC and Environmental Products is EP.*

Table H: Comparison of the time fixed effects and the SCC results for the social pillar.

	Dependent Variable: log(PD)																	
	(1)		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**(8)**		**(9)**	
	Basic Materials		**Consumer Cyclicals**		**Consumer Non-Cyclicals**		**Energy**		**Healthcare**		**Industrials**		**Technology**		**Utilities**		**All Sectors**	
	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC	FE	SCC
HSP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PEHS	Dropped	Dropped	0	0	0	0	Dropped	Dropped	0	-	0	0	0	0	Dropped	Dropped	0	0
PCL	-	0	0	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0
BCFC	+	0	+	0	0	0	0	0	+	0	+	0	+	0	0	0	+	+
PQC	0	0	0	0	-	0	0	0	0	0	0	0	-	0	0	0	-	0
ROA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ART	+	+	+	+	+	+	0	0	0	0	+	+	0	0	+	+	+	+
LEV	+	+	+	+	+	+	+	0	+	+	+	+	+	+	0	0	+	+
WC/TA	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	-	-
SIZE	-	-	-	-	-	-	-	0	-	-	-	-	-	-	0	0	-	-

Note: *All (+) or (-) effects are significant at least at a 95% CI. For the Social Pillar, Health Safety Policy is HSP, Policy Employee Health Safety is PEHS, Policy Child Labor is PCL, Bribery Corruption and Fraud Controversies is BCFC and Product Quality Controversies is PQC.*

Table I: Comparison of the time fixed effects and the SCC results for the governance pillar.

	Dependent Variable: log(PD)																	
	(1)		**(2)**		**(3)**		**(4)**		**(5)**		**(6)**		**(7)**		**(8)**		**(9)**	
	Basic Materials		**Consumer Cyclicals**		**Consumer Non-Cyclicals**		**Energy**		**Healthcare**		**Industrials**		**Technology**		**Utilities**		**All Sectors**	
	FE	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**	**FE**	**SCC**
CGBC	-	0	0	0	0	0	+	0	0	0	-	0	0	0	-	0	-	-
PBI	0	0	-	0	-	-	0	0	0	0	-	0	0	0	-	-	-	-
SRP	0	0	+	0	+	0	0	0	0	0	+	0	0	0	Dropped	Dropped	+	+
CSRSR	-	-	+	0	-	-	0	0	0	0	0	0	0	0	0	0	0	0
ROA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ART	+	+	+	+	+	+	0	0	+	0	+	+	0	0	+	+	+	+
LEV	+	+	+	+	+	+	+	0	+	+	+	+	+	+	0	0	+	+
WC/TA	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	-	-
SIZE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-

Note: *All (+) or (-) effects are significant at least at a 95% CI. For the Governance Pillar, Corporate Governance Board Committee is CGBC, Policy Board Independence is PBI, Shareholder Rights Policy is SRP and CSR Sustainability Reporting is CSRSR.*