PRELIMINARY DRAFT

# How useful are ESG ratings to mitigate climate change?*

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**Abstract**

**Abstract** This paper calls into question the usefulness of ESG ratings to contribute to climate change mitigation. While in a net-zero transition period, such ratings should help in driving capital towards less-emitting firms, this paper shows the opposite. Using a sample of almost 3,000 companies over the 2013-2020 period representing 77% of world market capitalization, we provide evidence that the relationship between ESG rating and carbon emissions is positive or, at the very least, insignificant in some cases. Even more surprising, our results remain true when focusing on the E (environmental) part of the ESG rating. In other words, firms with high total carbon emissions (Scope 1, 2 or both) exhibit higher (ESG/E) scores for the three main data providers we examine (Refinitiv, S&P Global and MSCI). Our results are robust across different industries, sub-periods and regions, with a stronger effect in Asia. Despite the fact that ESG ratings include firm performance criteria well beyond GHG emissions, we show here that, as far as curbing climate change is concerned, relying on ESG ratings is unequivocally misleading.

*JEL classification*: G11, G14, M14, Q54
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## 1. Introduction

"Prior to the Industrial Revolution and all the subsequent detrimental human activities, the global average amount of carbon dioxide was about 280 parts per million (ppm). Today, that level is close to 420 ppm; and every ton of CO2 emissions adds to global warming. The Intergovernmental Panel on Climate Change (IPCC) has identified several so-called 'tipping points of climate change', critical thresholds in a system that, if exceeded, can lead to irreversible consequences. Every ton of CO2 emissions adds to global warming. This tight correlation is highly suggestive of the fact that increasing anthropogenic greenhouse gas emissions is going to cause drastic changes in

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weather patterns, habitation, and biodiversity." Earth.Org (2022) Hence, there is an urgency to react against the rise of carbon emissions and its effect on growing temperatures, destruction of ecosystems, and consequently, climate change.

In response to climate change and global warming, at the heart of current policy debates, financial markets are also faced with the pressure of taking the right actions representing their willingness to contribute to the mitigation of climate change. There has been a wave of "green initiatives" such as Amazon announcing The Climate Pledge Fund to support the development of sustainable technologies and services that will enable Amazon and other companies to meet The Climate Pledge—a commitment to be net zero carbon(2020); Apple announcing a first-of-its-kind carbon removal initiative, called the Restore Fund (2021). Initiatives and frameworks like the Task Force on Climate-related Financial Disclosures (TCFD), the Carbon Disclosure Project (CDP), the Net-Zero Asset Owner Alliance, the UNFCCC COP-affiliated "Race to Net Zero" are a few examples of the importance climate-related risk disclosures have been gaining recently.

Various products and tools have been made available to financial market participants to aid this transitional process of taking the necessary steps to address climate change and align investments with climate-change strategies.Among them, ESG integration has been one of the most used forms of sustainable investment, and has known a remarkable growth when compared to its early stages in the beginning of the decade. In recent years, ESG integration has become an important investment criteria, and it is projected to hit $53 trillion by 2025, a third of global AUM according to Bloomberg (2021). As a widely used tool that provides a synthesized picture of the sustainable profile and efforts of companies, these ratings are being considered by market actors to facilitate the transition towards a net-zero economy by mid-century. Additionally, given that a number of central banks cite ESG integration in their low-carbon investments within the broader context of environmentally sustainable development, the extent to which environmental rating and reporting reflects the true impact of the carbon footprint and resource use of businesses today is critical to helping market participants make informed decisions that can contribute to these goals. Hence, we are motivated to further investigate the utility of these ratings to tackle climate change, particularly the *environmental score*, as an effective proxy for the "low carbon" emitting profile of companies, that can respond to the net-zero commitments.This becomes particularly important for retail investors, where the misperception of these sustainability scores plays a crucial role. As they may not have the necessary background on financial topics or not have access to more specific environmental indicators, a high ESG score, and more particularly an E score, can confuse investors.

ESG rating companies and investment funds are increasingly incorporating metrics aligned with environmental impact, climate risk mitigation, and strategies toward greater use of renewable energy, innovations, and products in their business activities. This is happening as a response to market participants who are demonstrating a greater awareness over the physical and climate transition risks that may affect financial stability and market efficiency. Due to the rising usage of the environmental "E" pillar as a proxy for asset selection in line with a low-carbon transition, the environmental "E" pillar score of the ESG rating has grown to be a significant part of ESG investing.

While ESG scores assess a company's ability to withstand long-term, industry-relevant environmental, social, and governance risks and can be equally influenced by social and governance risks, in addition to environmental ones, it wouldn't be surprising to find a correlation between carbon emissions and ESG ratings. On the other hand, the "E" factor of ESG considers a company's use of natural resources as well as the impact of its operations on the environment, both directly and through its supply chains. In other words, the environmental pillar investigates a company's environmental disclosure, impact, and efforts to reduce carbon emissions — issues that pose both tangible risks and opportunities for stakeholders and stockholders. Depending on the methodology used by rating providers, among the metrics used to calculate the E score, GHG emissions are only a part of it; companies' long-term policies, climate risk management, innovation practices also play an important role. This suggests that the E score may not be suitable tool for investors to mitigate climate change.

Following this logic, dependent on the methodology of each provider and which metrics each rating agency decides to take into account to calculate this score, some providers are more focused on environmental assessment, giving greater weight to environmental issues, others prioritize financial materiality or focus on disclosure and company reporting. This can have an impact on how sustainability is reflected in the final rating, raising questions about how methodologies should be standardised. Boffo et al. (2020)

So far, there is a lack of research that mainly focuses on the importance of the environmental pillar (E score), and whether this pillar is in line with GHG emissions of companies. As previously mentioned, rating providers adopt different methodologies to assess each parameter of the ESG score, which can strongly influence the final sustainability score. The report of OECD by Boffo et al. (2020) has looked at the correlation of carbon emissions and E scores for different quantiles of companies and has found that on average, higher ESG rated firms pollute more in terms of gross output of carbon dioxide.

Hence, the aim of this study is to depict how reliable ESG, and more particularly E scores, are for investors looking to better align their portfolios with low carbon emissions. Our hypothesis is that E scores are not clear signals of carbon footprint and cannot be used as a proxy for the emitting profile of companies. In our analysis, we paid more attention to the E score as it is a more restrictive proxy, therefore more prone to give us pertinent results when trying to understand the utility of such scores for investors trying to help mitigate climate change. We performed a fixed-effect panel data analysis, with ESG and E score as the dependent variable, GHG emissions as the independent variable, as well as control variables and industry/firm-year fixed effects. To perform our analysis we are using ESG and GHG data from three data providers, Refinitiv, S&P Global and MSCI, that we have merged in a final dataset of 2,955 companies from 62 countries, among 58 sub-industries over the period 2013-2020. As suspected, we find that the E scores are not clear signals of carbon footprint. A higher score on the overall E pillar does not always correlate to low environmental or carbon impact as measured by the metrics (Scope 1, 2, 3, Total). Regarding the E scores we find mostly positive correlation with carbon emissions. We further see how this relationship varies when considering different determinants such as regions, industries and sub-periods. There are differences noticed between the three main regions considered (Europe, Asia, and US). Asia shows the highest positive correlation between E scores and carbon emissions, especially for total scope of emissions across the three data providers. Whereas, US shows negative correlations for scope 2 (Refinitiv) and scope total (MSCI), with the rest mostly insignificant results. Europe shows mostly insignificant correlation, with the exception of scope 2 (MSCI) and scope total (1+2) where we notice a positive correlation between E score and GHG emissions. We notice that carbon intensive industries do not manifest significant negative correlations with the E score, which is what would be expected, leading to believe that the E scores is not as pertinent for carbon intensive industries as an investor would believe. Finally, we believe that since in the recent few years ESG integration has gained a key role in financial markets and investment decisions, we should have noticed a significant negative correlation between E scores and carbon emissions after 2018, which we saw is not the case. We can conclude that out of the three data providers, MSCI shows the most coherent and intuitive results with either insignificant or negative correlation results in most regressions.

So far, this is the first paper that investigates the relationship between E scores and carbon emissions, and how well E scores represent the carbon footprint of companies. Our contribution to the literature lies in the analysis we performed between emissions variables and E-scores *within* each data provider, in addition to across data providers. We also took the idea of the OECD report of Boffo et al. (2020) a step further, proving statistically that a higher score on the overall E pillar is not always correlated with a lower environmental impact, and is an insufficient tool to to mitigate climate change. More than a proxy for "low-carbon transition", it shows to send to an incorrect signal.

The remainder of the paper is structured as follows: In Section 2 we present a brief overview of the literature related to ESG investing and carbon emissions, Section 3 describes the data used for our study. Section 4 discusses the empirical approach, section 5 provides the results of our analysis and Section 6 concludes.

## 2. Literature Review

GHG emissions have an unparalleled effect on climate change in a manner that has radically altered the environment we live in and have become the center of the alarming policy debate on how to tackle climate change. Some organizations make voluntary disclosures about their carbon emissions status, while others have to comply with prescribed norms.

The terminology of Environment Social and Governance (ESG) was first highlighted in 2005 and demonstrated the direct or indirect impact it can have on a range of financial issues that can come under the ESG standards of reporting and resource management, with the sole objective of building trust through transparency. Among the important fields of operations that can be included in this domain are organizational health, supply chain management, and essential safety policies. Several research studies have been initiated worldwide on ESG and its whirlwind effect and value on financial markets, investment decision making and their value as a tool to integrate sustainablitity in investments. Essentially, this paper has highlighted and contributes to three distinctive areas of ESG and carbon emission research studies.

### ESG rating confusion

Six different rating agencies were analyzed by Berg et al. (2022b), a notable research on the divergence of ESG ratings. These included: *Kinder, Lydenberg, and Domini (KLD), Sustainalytics, Moody's ESG (Vigeo-Eiris), S&P Global (RobecoSAM), Refinitiv (Asset4), and MSCI.* A taxonomy method of scope, weight, and measurement was employed to assess the divergences. The study concluded that measurement contributed the largest amount 56%, scope accounted for 36%, and weight had a smaller impact of 6%.

As illustrated, ESG ratings can be biased and noisy at times and may suffer from errors in variable reporting deficiencies. Berg et al. (2022a) tried to disentangle signal from noise in ESG ratings and to uncover the true impact of ESG performance on expected stock returns, by proposing two noise-correction methods that compare instrument ESG ratings with the ones that rating agencies delivered, and noticed that on average the coefficients increase by 2.6 times, implying that the noise-to-signal ratio is 61.7%. However, by employing their simulated strategies it was possible to outperform the routine methods that many practitioners use, namely, the averages or principal component analysis.

This disagreement among data providers can have important effects, more specifically on stock returns Gibson Brandon et al. (2021). They confirm a correlation of only 0.46 among six different ESG data providers, which is significantly lower compared to 0.99 correlation among credit rating agencies. Three main variables explain this prevailing disagreement among ESG ratings, mainly the profitability of firms which contributes to a lower rating disagreement. Also, firms without a credit rating and larger firms exhibit a higher disagreement, and finally there is a significant industry heterogeneity, where the disagreement among sub-scores (E,S,G) manifest differently according to the industries.

Besides considerable divergence that is visible between the categories chosen to make the ESG evaluations, Christensen et al. (2022) put forward the idea that higher ESG disclosure can lead to a greater ESG disagreement. The precise reasons for the disagreement between the rating agencies are unclear, but the presumption was that the ESG disclosures made by some organizations led to further confusion. Additionally, many raters also differ on the evaluating metrics. Also, the study extended to note that whenever the ESG differences were higher, there was a greater return volatility in a stock's price fluctuations.

**Benefits of ESG; Financial Performance**

The resiliency of sustainable investing has been a subject of research of many academics as the predominant view of it is maximising shareholder's welfare by engaging in responsible and socially-cautious investments, integrating Environmental, Social and Governance (ESG) criteria. This kind of investment is often summarized as "doing well by doing good" McWilliams and Siegel (2001). The unprecedented stock market crash during the Covid-19 pandemic presented an opportunity for some researchers to analyze some environmental and social policies [ES] and their resiliency in times of a declining market. A research study by Albuquerque et al. (2020); Christensen et al. (2022) observed that despite the difficult times, the companies with a higher ES rating displayed better returns and maintained a higher operating profit.

A report by Delevingne et al. (2020) at McKinsey, observed that sustainable investments have increased over the preceding years. Several academicians have been interested in further investigating sustainable investment behavior, manifested in the relationship between sustainable scores and investment decisions. Investors consider sustainability as a positive fund attribute Hartzmark and Sussman (2019), but investors mostly react to the ratings of the mutual funds, less than the underlying data Ceccarelli et al. (2019). This preference for sustainable investments can be also affected by social signaling as a major, determining factor for the likelihood of investing sustainably Riedl and Smeets (2017). Shareholder value implications of positive and negative CSR events in the short-run reveals that investors react strongly negatively to negative news about CSR, and this reaction is particularly pronounced for information regarding communities and the environment Krüger (2015). One of their key findings was that for investors corporates that adopt a responsible stance towards ESG stand to benefit more in the long term. Another prominent observation was that pension funds hold more than $51 trillion under management and most beneficiaries showed a leaning toward ESG preferences.

Time and again, several researchers/academics have tried to establish a correlation between ESG and stock returns. Literature has mixed conclusions regarding the relationship that exists between the two, but Chava et al. (2021) based on SRMF (Socially Responsible Mutual Funds) a strategy of employing the Fama-French 5-factor to assess the risks associated with mutual funds over 12 years (2005-2016). The study found that despite underperforming the SRMF in this period, there was no significant difference observed during the Great Recession (Leite and Cortez (2015); Nofsinger and Varma (2014); Szepesi (2020)). Importantly, the corresponding effect on portfolio managers and planners has been identified.

By adopting the standards and classification laid down by the Sustainability Accounting Standards Board (SASB), Consolandi et al. (2022) evaluated the financial relevance and the intensity of ESG materiality to analyze the precise impact they had on equity returns. The samples collected for this study were large organizations listed in the Russel 3000 index and related to the period between January 2008 to 2019. The outcome of this research established that due to variations in the ESG rating changes (ESG momentum), a direct relative impact could be observed in the performance of equities. Interestingly, the companies that had a higher concentration of ESG material issues displayed better equity premiums or had higher intrinsic stock values.

A detailed research study by Henriksson et al. (2019); Ioannou and Serafeim (2019), uncovered the direct impact of integrating ESG in portfolio construction. The research was based on two essential premises. First, segregating good and bad ESG organizations by the number of ESG material items used in their respective industry. Secondly, possibility to negate the inadequate voluntary ESG data disclosed by companies by integrating an ESG Good v/s an ESG Bad factor to demonstrate a direct positive relation in the stock value of companies that employed the Good ESG conditions. In the face of imitation pressures by industry peers, this study explores the conditions under which firms maintain competitive advantage through sustainability-based differentiation helps them maintain their competitive advantage. Henriksson et al. (2019);Ioannou and Serafeim (2019) observed that almost all industries in their collected samples show a growing Intra industry convergence on sustainability actions over time. Interindustry heterogeneity in Intra industry convergence is related to (a) the importance of environmental and social issues relative to governance issues, and (b) stakeholders' tone and volume of feedback. In addition, actions characterized by low regulatory uncertainty are more likely to be imitated while those characterized by high novelty are less likely. Consequently, sustainability can be used as a long-term strategy. Ioannou and Serafeim (2019) used data on 1312 active US mutual funds amounting to a combined corpus of $3.9 trillion and noted that there was a direct link between ESG-based funds and their returns by analyzing their factors loadings and alphas. They concluded that there was a significant divergence between the funds with higher ESG scores than those with lower scores. This depicts a strong positive relationship between the alphas and the factor-based ESG scores.

To collaborate on a link between funds with a bottom-up approach on holdings based on ESG scores to assess the returns by incorporating style factor loadings and alphas analyzed 1312 active US equity-based mutual funds that held a $3.9 trillion corpus under their management. The study concluded that funds with higher ESG ratings loading factors performed differently from the ones with low-scoring ESG funds. Consequently, the funds with better environmental scores had an inherent higher quality and increased momentum. This demonstrated that a strong proportional impact existed between fund alphas and momentum scores.

Pedersen et al. (2020) exhibited that the individual scores have two roles to play. Firstly, they offer useful information about a company's fundamentals and secondly, how it affects investor sentiment. The strategy involved integrating an ESG-efficient frontier to display the highest possible Sharpe ratio for every ESG level. The portfolios examined satisfied the four-fund separation technique. By combining large data sets, the ESG-efficient frontier can be calculated to establish the benefits of profitable investing. This theory was authenticated against proxies for carbon emissions and ESG overall.

A landmark research study by Baker et al. (2022), categorically states that for corporate executives and their corresponding boards, ESG was at the top of their agenda, as they understood that shareholders had a strong leaning towards ESG values. The study adopted revealed that shareholders were willing to pay 20 basis points more for fund-management charges for ESG-oriented funds as against funds that were more profitable and ensured better returns annually. Moreover, this appeared to be the common consensus among mutual fund investors. This path-breaking study added that the management charges had risen from 9 basis points in 2019 to 28 basis points in 2022.

**ESG & Carbon**

Bolton and Kacperczyk (2021a) revealed that after controlling the risk factors by allowing for suitable changes in reducing CO2 emissions, they delivered higher returns in terms of the book-to-market, overall momentum, and other risk factors that could affect returns. The study found that most institutional investors relied heavily on a screening process that involved testing their direct emissions. The screening results indicate some investors demand compensation for being exposed to higher carbon mission risks. The study examined a cross-sectional stock returns analysis and established a direct link between changes in climate that occurred due to carbon emissions and its corresponding effect after observing a reduction in them.

With the prevailing environmental status and the dynamically changing climate worldwide, Bingler et al. (2021), found it necessary for corporates to make climate-related financial risk disclosures mandatory for investors to make a fair assessment. This study questioned the validity of the procedures suggested by the Task Force for Climate-related Financial Disclosures (TCFD). The research argues whether this requirement was justified or not, although it was supposed to be an effective procedure. The authors trained a Climate BERT that is based on a deep neural language model and modified it to match the precise language model needed to analyze the impact of the disclosures made by firms. In the final analysis, the study concluded that the TCFD format is mostly cheap talk and cherry-picking and makes no difference to the climate risk information revealed.

Faced with rapid climate change effects, some investors are altering their investment allocations from carbon-intense firms to ones with effective decarbonization plans. A research study by Cheema-Fox et al. (2019) analyzed investor behavior toward decarbonization. The studies established that low-carbon-intense firms performed better than their counterparts. Additionally applying decarbonizing factor returns affected institutional flows into factors. The investment strategy recommended was to buy decarbonizing factors when the coincident flows were positive while simultaneously selling negative coincident flows to earn superior returns and by maintaining continuous exposure to low-carbon emitting firms in a portfolio.

So far, the question to how the ESG ratings, particularly E score, reflect the real carbon footprint of companies has so far not been clearly addressed in the literature, besides the report of OECD, that is also one of the study works this paper draws inspiration from. The report assesses the extent of alignment between the E score and carbon dioxide (CO2) emissions;and tries to understand how such E scores influence the emissions composition of high-ESG portfolios. They draw their data from three key providers: Bloomberg, MSCI and Thomson Reuters (known as Refinitiv). We also have access to two of these three data providers, which allows us to compare our results and interpretations to theirs. Their findings suggest that E scoring may not necessarily be suitable for investors seeking to better align their portfolios with low carbon economies, because of the high correlation between E scores and high carbon emissions. This suggests the E score in its current form may not be an effective tool to differentiate between companies' activities related to outputs that affect the environment or support decarbonisation of portfolios.

## 3. Data

We have three categories of data in this paper: i) carbon emissions data, ii) ESG ratings data, and iii) firm-specific control variables data. The ESG and carbon emissions data is sourced from three different data providers: Refinitv (previously known as Thomson Reuters), S&P Global (including Trucost) and MSCI. These three data providers have been used in notable research studies in the literature (Berg et al. (2022b), Gibson Brandon et al. (2021), Boffo et al. (2020), Bolton and Kacperczyk (2021b)).

*i) Carbon emissions variables*

- GHG Scope 1: Direct of CO2 and CO2 equivalents emission in tonnes. They represent direct emissions from sources that are owned or controlled by the company.
- GHG Scope 2: Indirect of CO2 and CO2 equivalents emission in tonnes. They represent indirect emissions from consumption of purchased electricity, heat or steam which occur at the facility where electricity, steam or heat is generated.
- GHG Scope 3: Total CO2 and CO2 Scope Three equivalent emission in tonnes. These emissions include emissions from contractor-owned vehicles, employee business travel (by rail or air), waste disposal, outsourced activities. They also include emissions from product use by customers, emission from the production of purchased materials, emissions from electricity purchased for resale. There are considerable challenges in measuring Scope 3 emissions due to the lack of accurate data and a standardised methodology, making it a very noisy metric.
- GHG Scope Total: Total Carbon dioxide (CO2) and CO2 equivalents emission in tonnes. They are the sum of direct (scope 1) + indirect (scope 2), excluding scope 3 in order to reduce the noise in this metric.
- GHG Intensity: GHG Scope Emissions (tonnes/$M)

*ii) ESG ratings*

- ESG/E Score: Environmental, Social, and Governance (ESG) Score/ Environmental Score

*ii) Control variables (Sourced from Datastream)*

- Market Capitalization: Total value of a company's outstanding shares of stock.
- Return on Assets(ROA): A measure of a company's profitability that indicates how well a company is using its assets to generate profits.
- Return on Equities (ROE): A measure of a company's profitability that indicates how well a company is using its shareholders' investments to generate profits.
- Leverage ratio: Leverage ratio, is a measure of a company's financial leverage (the amount of debt it has relative to its equity).
- Current ratio: Current ratio, is a measure of a company's short-term liquidity (its ability to pay its short-term debts with its current assets).

Table 1 provides an overview of the main characteristics of the three datasets. We have initially obtained firm-specific carbon emissions and ESG ratings for each of the data providers from 2010 to 2020, as the data for 2021 was quite sparse. We had access to ESG sub-scores for all three data providers, which is essential for our analysis regarding the E scores. In column (1) we show the ratings scales initially used by each provider. The ESG ratings scale varies from 0-100 (Refinitiv, S&P Global) and 0-10 (MSCI), where the highest score signifies that the company is managing well its environmental, social and governance risks compared to its peers in the industry. Column (2) shows the ESG active universe for each provider, meaning the number of companies for which we have at least one year of ESG data. We have initially considered data from 2010-2020 as shown in column (3). Unlike the two other data providers, S&P Global has a time series of ESG ratings starting from 2013. As per column (4), for each of the data providers we have had access to the total ESG scores, and the sub-scores E, S and G scores (we have been interested only on the E sub-score for this study). Lastly, column (5) shows the GHG emissions to which we have access through the data providers. All these providers follow Green Gas Protocol that sets the standards for measuring corporate emissions. GHG Protocol distinguishes between direct emissions (scope 1), indirect emissions (scope 2) and other indirect emissions (scope 3). Scope 1 emissions signify emissions that originate from sources owned or controlled by the company. Scope 2 emissions are not directly related to a company's activities, but they mostly result from the production of electricity, steam, heating and cooling purchased and consumed by the reporting company. Scope 3 emissions come from sources that are not owned or directly controlled by the company. This includes emissions from both upstream activities (e.g., within a company's supply chain) and downstream activities (e.g., through the use of an organization's products or services). In total, there are 15 scope 3 emission categories – the materiality of which varies from industry to industry.

**Table 1.** Description of used data

| Data Provider | Rating Scale | Active Universe | Time Period | Scores | GHG Metrics |
|---|---|---|---|---|---|
| **Refinitiv** | 0 - 100 | 9921 | 2010 - 2020 | ESG, E,S,G | Scope 1, 2, 3 |
| **MSCI** | 0 - 10 | 13791 | 2010 - 2020 | ESG, E,S,G | Scope 1,2,3 |
| **S&P Global (Trucost)** | 0 - 100 | 19271 | 2013 - 2020 | ESG, E,S,G | Scope 1,2,3 |

We matched the three dataset on the ISIN of each companies, which was the common indicator between them. Initially we had a sample of 9960 companies and 109 560 observations, as shown in Table 2. We applied some conditions to further precise and have a unified dataset to use for our analysis. We only took into account the companies for which we had complete data across data providers for the period of 2013 − 2020 (as the data for S&P Global starts in 2013), for the following variables: ESG scores, E scores, Scope 1 emissions, Scope 2 emissions, Scope Total (Scope 1+2) and the market capitalization, as the main variables for our regressions. Our final database consists of a panel data of 2 955 firms from 62 countries, 58 sub-industries over the 2013-2020 period. As shown in graph 5 in Appendices, Banking, Machinery, Equipment and Components, Residential and Commercial REITs, Metals and Mining, Chemicals, Food and Tobacco, Real Estate Operations, Computer Software and Services, and Petroleum and Gas are the most represented industries in our data set (in terms of number of companies). The largest market capitalization are found in the following industries: computer software and services, banking services, oil gas and pharmaceuticals (graph 4) in Appendices.

**Table 2.** Description of used data

| **Characteristics** | **Initial Merged Panel Data** | **Final database (77% of Market Cap)** |
|---|---|---|
| **Period** | 2010 - 2020 | 2013 - 2020 |
| **Observations** | 109 560 obs. | 12 394 obs. |
| **Companies** | 9 960 | 2 955 comp. |
| **Full data for:** | | ESG/E scores |
| | | GHG (metric tons): scope 1, 2, (1+2) |
| | | GHG Intensities (1+2) |
| | | Market Capitalization |

## 4. Empirical approach

This study uses panel data consisting of 2955 firms which are observed over the period 2013 to 2015. Panel data estimation techniques are used to model the relationships between ESG scores and carbon emissions while controlling for the financial characteristics of firms. ESG/E score, carbon emissions, and carbon intensity data have been collected from three sources including MSCI, Refinitiv, and S&P Global. Panel data modelling technique is used as it accommodates variations in both cross-section and time in a time-series dimension. Another advantage of panel data is it mitigates the likelihood of temporal errors in the data in generalizing the results Breusch and Pagan (1980). The two popular approaches for panel data include fixed effect and random effect models. The former estimates the time-invariant underlying fixed effects for each cross-sectional unit whereas the random effects model assumes that underlying cross-sectional specific impacts are randomly distributed. The random-effect model gains efficiency and does not need to estimate each parameter for each cross-sectional unit. In the case of a correlation between fixed effect and independent variables, the random effects estimator however becomes inconsistent Baltagi and Baltagi (2008).

Model specification tests are first used to identify relevant panel data modeling approaches based on a given data structure among Panel Ordinary Least Square (POLS), Fixed Effects Model (FEM), and Random Effects Models (REM) estimation techniques. The basic regression model takes the following form:

$$ESG_{i,t} = a_0 + a_1 Emissions_{i,t} + a_2 Controls_{i,t} + \mu_t + \epsilon_{i,t} \quad (1)$$

$$E_{i,t} = a_0 + a_1 Emissions_{i,t} + a_2 Controls_{i,t} + \mu_t + \epsilon_{i,t} \quad (2)$$

*ESG/E* score is the dependent variable. *Emissions* is the primary variable of interest whereas control variables include market capitalization, return on assets, return on equities, current ratio, and leverage ratio. Industry, country and year fixed-effect are also included. All proxies of carbon emissions, carbon intensity and market capitalization are used after applying the 'log' transformation. This section first discusses model specification tests which are followed by model diagnostics.

# 5. Results

## 5.1. Preliminary Analysis

As Table 3 shows, the mean ESG/E scores for the three rating agencies are all relatively high, with a range of 62.767 to 42.962. This suggests that, on average, the companies in the sample have relatively high ESG/E scores.
The standard deviations for the ESG/E scores are relatively high, indicating a wide range of scores among the companies in the sample. This suggests that there is a significant variation in the ESG/E scores among the companies in the sample.
The mean GHG emissions (Scope 1+2) expressed in (tonnes CO2e) for the companies in the sample are quite high, with a range of 3,664,654 to 3,844,239. This suggests that the companies in the sample have relatively high levels of carbon emissions. The intensity of carbon emissions (emissions per unit of revenue) is also relatively high, with a range of 385.659 to 353.122. This suggests that the companies in the sample have relatively high carbon intensities.
The mean values for the control variables are relatively varied. For example, the mean ROE is 18.365, while the mean current ratio is 1.684. The mean market capitalization is also quite high, with a range of 22,469,546 to 8,165,503.
Overall, these statistics suggest that the companies in the sample have relatively high ESG/E scores and carbon emissions, but there is significant variation among the companies in terms of the control variables.

**Table 3.** Descriptive statistics of the variables used

| Variables | Mean | Standard Deviation | Median |
|---|---|---|---|
| ESG Score - Refinitiv | 62.767 | 15.216 | 63.950 |
| E Score - Refinitiv | 62.160 | 20.855 | 64.580 |
| ESG Score - MSCI | 54.827 | 22.544 | 56 |
| E Score - MSCI | 54.510 | 22.365 | 53 |
| ESG Score - S&P Global | 42.962 | 23.680 | 37 |
| E Score - S&P Global | 44.851 | 27.628 | 41 |
| Scope 1 - Refinitiv | 3,053,802.000 | 12,444,469.000 | 57,056 |
| Scope 2 - Refinitiv | 600,791.000 | 1,892,110.000 | 112,962 |
| Scope 3 - Refinitiv | 14,187,779.000 | 80,009,746.000 | 105,352 |
| Scope Total (1+2) - Refinitiv | 3,664,654.000 | 13,347,001.000 | 246,663.500 |
| Scope Total (1+2) Intensity - Refinitiv | 385.659 | 1,804.060 | 40.570 |
| Scope 1 - Trucost | 3,253,642.000 | 13,716,420.000 | 74,514.410 |
| Scope 2 - Trucost | 590,596.800 | 1,717,136.000 | 123,575.900 |
| Scope 3 - Trucost | 2,841,881.000 | 7,673,488.000 | 683,033.700 |
| Scope Total (1+2) - Trucost | 3,844,239.000 | 14,442,041.000 | 278,681.300 |
| Scope Total (1+2) Intensity - Trucost | 353.122 | 1,073.625 | 45.824 |
| Scope 1 - MSCI | 3,171,319.000 | 13,689,330.000 | 59,940 |
| Scope 2 - MSCI | 594,251.700 | 1,818,336.000 | 119,725 |
| Scope 3 - MSCI | 16,785,652.000 | 89,115,266.000 | 259,130 |
| Scope Total (1+2) - MSCI | 3,765,565.000 | 14,609,172.000 | 254,238 |
| Scope Total (1+2) Intensity - MSCI | 349.076 | 1,087.749 | 41.100 |
| ROE | 18.365 | 405.095 | 10.990 |
| Current Ratio | 1.684 | 1.275 | 1.390 |
| ROA | 5.525 | 7.920 | 4.630 |
| Leverage Ratio | 110.218 | 2,914.539 | 71.135 |
| Market Capitalisation | 22,469,546.000 | 60,579,209.000 | 8,165,503.000 |

Graph 1, 2, 3 show a simple linear relationship between our two variables of interest. We want to first see the linear relationship between these two variables which gives a very simplified image of the correlation between the E score and GHG Emissions level. An upward-sloping line for Refinitiv and S&P and a slightly downward-sloping line for MSCI suggests that, for these three rating agencies, there is a positive relationship between ESG/E scores and carbon emissions. Specifically, as carbon emissions increase, ESG/E scores tend to increase for Refinitiv and S&P Global, while they tend to decrease slightly for MSCI.

This relationship may be due to a variety of factors. For example, companies with higher carbon emissions may also have less favorable environmental practices, which could lead to lower ESG/E scores. On the other hand, companies with higher carbon emissions may also be investing more in renewable energy or other measures to reduce their environmental impact, which could lead to higher ESG/E scores.

**Figure 1.** GHG level of emissions (Refinitiv): APAC, Europe, US

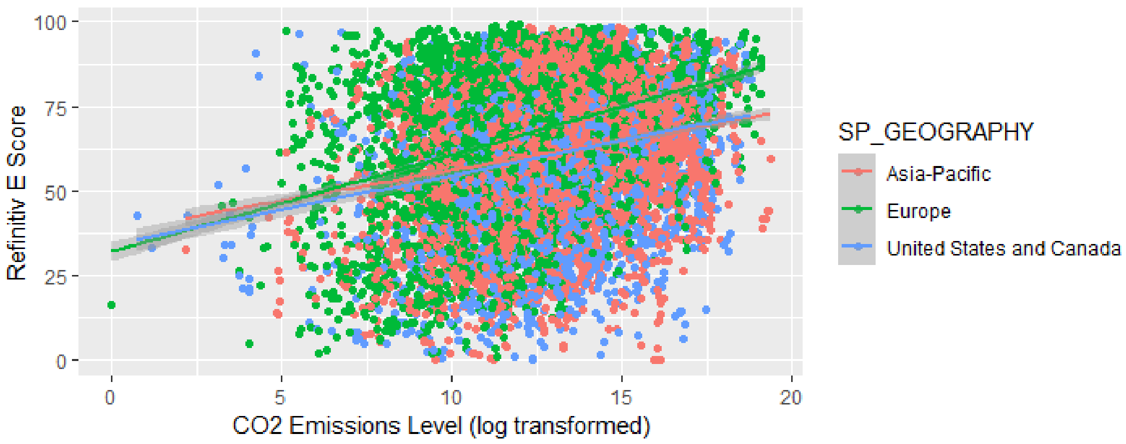



**Figure 2.** GHG level of emissions (S&P Global): APAC, Europe, US

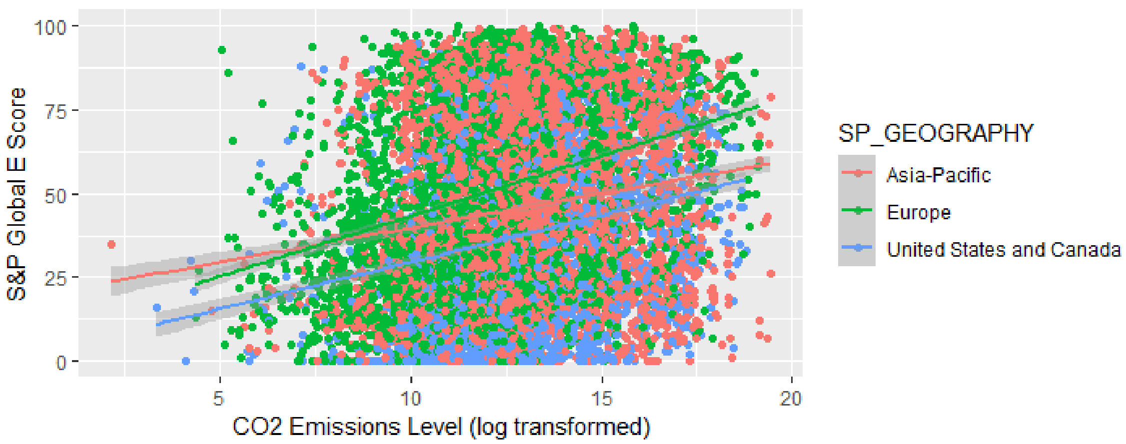
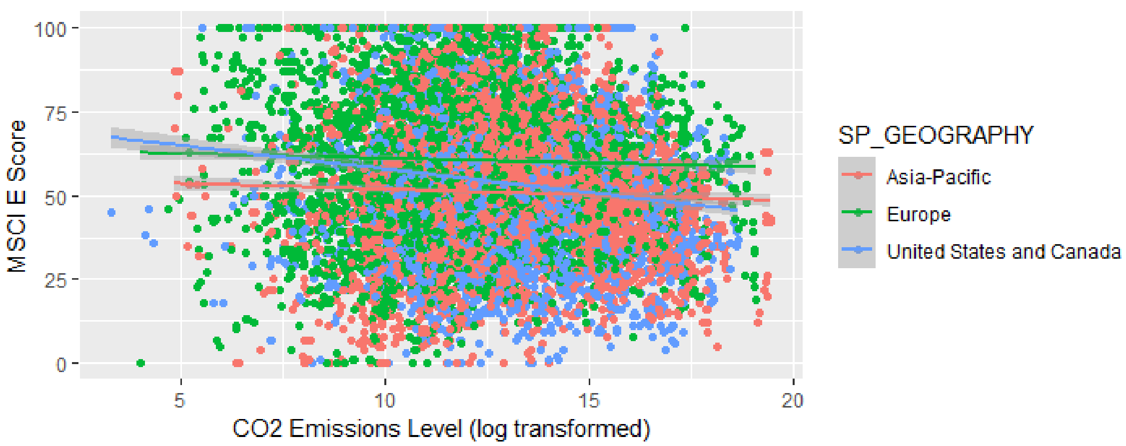



**Figure 3.** GHG level of emissions (MSCI): APAC, Europe, US



**Graphs and Descriptive Statistics Comparison:** Comparing the lines in the plot to the previous descriptive statistics, we can see some potential relationships between the ESG/E scores and carbon emissions. For example, the mean ESG/E scores for Refinitiv and S&P Global are relatively high, while the mean ESG/E score for MSCI is lower. This is consistent with the upward-sloping line for Refinitiv and S&P and the downward-sloping line for MSCI, as higher ESG/E scores would be expected to be associated with higher carbon emissions.

## 5.2. Results

### 5.2.1. Differences between providers

The relationship between E Scores and various measures of carbon emissions for companies varies across the datasets provided by three global providers including REFINITIV, S&P Global, and MSCI for which the estimates are provided in Table 4, Table 5 and Table 6 respectively. The difference between results provided in columns (1) to (5) and columns (6) to (10) is that the former controls for industry-wise fixed effects whereas the later controls for firm fixed effects. The models with firm fixed effects outperformed as R2 is significantly higher than the other models. Specifically, R2 is more than 87 percent for model results in columns (6) to (10) whereas it is in the range of 20-45 percent for results in columns (1) to (5) considering all three global data providers.

The dependent variable, E Score, is a measure of a company's environmental performance as rated by each data provider. The independent variable is one of five different measures of carbon emissions for each regression: Scope 1 emissions, Scope 2 emissions, Scope 3 emissions, Total emissions (Scope 1+2), or intensity of emissions (emissions per unit of revenue). The control variables include measures of financial performance (return on equity (ROE), return on assets (ROA), current ratio), leverage ratio, market capitalization which can provide further explanation of the relationship between our variables.

We suppose that emissions can tend to cluster within specific industries, hence we examine this possibility in columns (1) to (5).When controlling for industry and year-fixed effects for which results are provided in columns (1) - (5), it is observed that the carbon emissions when measured by scope 1, scope 2, scope 3, and scope total are all positively and significantly impacting the E scores when these relationships are estimated using REFINITV and S&P Global datasets. However, the magnitude of impact is higher in most cases for estimates corresponding to S&P Global. Carbon scope total intensity turned out statistically insignificant in explaining E scores for both of these data providers. This means that, on average, companies with higher E Scores tend to have higher levels of carbon emissions, industry fixed effects considered (Table 4).

The relationship between the E Score and carbon emissions is statistically significant at the 1% level for all measures of emissions, as indicated by the asterisks next to the coefficient estimates, when reasoning within industries (industry/year fixed effects). On the other hand, an absolute contradiction can be observed for the relationship between carbon emission and E scores when estimated over data sourced from MSCI (Table 6). Specifically, carbon emission proxies including scope 1, scope 2, scope 3, and scope total have a significantly negative impact on E scores. In addition, scope total intensity also turned out to be negatively related to E scores. Among control variables, current ratio and return on assets are negatively related to the E score whereas market capitalization is positively related to the E score for both REFINITIV and S&P Global.

The strength of the relationship between E Score and carbon emissions varies depending on the measure of emissions used, as all as the fixed effects considered. Columns (6) to (10) show the results within firms (as we assume that firms can have different characteristics that can impact their environmental and emitting profile, despite belonging in the same industry) and we notice that the positive correlation between the two variables prevails, but this relationship weakens and remains significant only for Scope 1 and Scope Total (1+2). In the subsequent columns that are, (6) - (10), estimates for the impact of carbon emission on E score while controlling for firm and year-fixed effects are provided. Scope 1 and Scope total turned out positively and statistically significant for explaining the E score for both REFINITIV and S&P Global whereas Scope 3 additionally appears significant for S&P Global. For MSCI, carbon emission is only positively and statistically significant in explaining the E score when proxied using Scope 2. Among control variables, return on assets is negatively related and leverage ratio is positively related to the E score for REFINITIV and S&P Global respectively whereas market capitalization is positively related to the E score for both of these data providers. However, in the case of MSCI, none of the control variables are statistically meaningful.

The relationship is strongest for total emissions (Scope 1+2), as indicated by the highest coefficient estimate for this measure of emissions.The control variables included in the models generally have the expected signs and are statistically significant at the 1% level. For example, higher levels of ROE and market capitalization are associated with higher E Scores, while higher levels of leverage ratio are associated with lower E Scores. The results suggest that there is a positive relationship between a company's Environmental Score and its carbon emissions. This means that, in general, companies with higher E Scores (i.e., those that score better on environmental metrics) tend to have higher levels of carbon emissions. This could potentially be due to the fact that such companies operate in industries that are more carbon-intensive, or it could indicate that these companies have not made sufficient efforts to reduce their carbon emissions.

**Table 4.** E Scores and Carbon Emissions (REFINITIV)

| | *Dependent variable:* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Scope 1 (LOG) | 1.497*** | | | | | 0.580*** | | | | |
| | (0.095) | | | | | (0.184) | | | | |
| Scope 2 (LOG) | | 1.397*** | | | | | −0.075 | | | |
| | | (0.107) | | | | | (0.167) | | | |
| Scope 3 (LOG) | | | 1.146*** | | | | | 0.123 | | |
| | | | (0.080) | | | | | (0.093) | | |
| Scope Total (1+2) (LOG) | | | | 1.829*** | | | | | 0.992*** | |
| | | | | (0.119) | | | | | (0.277) | |
| Scope Total Intensity (1+2) (LOG) | | | | | 0.193 | | | | | −0.252 |
| | | | | | (0.146) | | | | | (0.287) |
| ROE | 0.0004 | 0.0005 | 0.0004 | 0.0004 | 0.001 | 0.0002 | 0.0002 | 0.0003* | 0.0002 | 0.0002 |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Current Ratio | −1.108*** | −1.223*** | −1.275*** | −1.105*** | −1.564*** | 0.102 | 0.089 | 0.071 | 0.113 | 0.093 |
| | (0.155) | (0.155) | (0.170) | (0.155) | (0.154) | (0.135) | (0.135) | (0.134) | (0.135) | (0.135) |
| ROA | −0.166*** | −0.167*** | −0.097*** | −0.150*** | −0.222*** | −0.069*** | −0.070*** | −0.092*** | −0.068*** | −0.071*** |
| | (0.024) | (0.024) | (0.025) | (0.024) | (0.024) | (0.020) | (0.020) | (0.022) | (0.020) | (0.020) |
| Leverage Ratio | 0.00002 | 0.00005 | 0.0004 | 0.00002 | 0.0001 | −0.00002 | −0.00002 | 0.00002 | −0.00002 | −0.00002 |
| | (0.0001) | (0.0001) | (0.0003) | (0.0001) | (0.0001) | (0.00004) | (0.00004) | (0.0001) | (0.00004) | (0.00004) |
| Market Cap (LOG) | 5.201*** | 5.238*** | 3.654*** | 5.000*** | 6.374*** | 1.089*** | 1.175*** | 1.723*** | 1.051*** | 1.145*** |
| | (0.167) | (0.174) | (0.200) | (0.175) | (0.152) | (0.307) | (0.307) | (0.357) | (0.308) | (0.307) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Industry F.E. | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No |
| Observations | 9,986 | 9,986 | 5,786 | 9,986 | 9,986 | 9,986 | 9,986 | 5,786 | 9,986 | 9,986 |
| $R^2$ | 0.232 | 0.226 | 0.256 | 0.231 | 0.212 | 0.875 | 0.875 | 0.893 | 0.876 | 0.875 |
| Adjusted $R^2$ | 0.226 | 0.220 | 0.247 | 0.225 | 0.207 | 0.836 | 0.836 | 0.855 | 0.836 | 0.836 |
| Residual Std. Error | 17.762 (df = 9917) | 17.832 (df = 9917) | 15.984 (df = 5718) | 17.775 (df = 9917) | 17.983 (df = 9917) | 8.176 (df = 7586) | 8.182 (df = 7586) | 7.005 (df = 4290) | 8.175 (df = 7586) | 8.181 (df = 7586) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Table 5.** E Scores and Carbon Emissions (S&P Global)

| | *Dependent variable:* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | S&P Global - E Score | | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Scope 1 (LOG) | 1.306*** | | | | | 0.509** | | | | |
| | (0.143) | | | | | (0.240) | | | | |
| Scope 2 (LOG) | | 2.187*** | | | | | 0.294 | | | |
| | | (0.167) | | | | | (0.242) | | | |
| Scope 3 (LOG) | | | 3.875*** | | | | | 3.401*** | | |
| | | | (0.248) | | | | | (0.524) | | |
| Scope Total (1+2) (LOG) | | | | 2.148*** | | | | | 1.060*** | |
| | | | | (0.175) | | | | | (0.331) | |
| Scope Total Intensity (1+2) (LOG) | | | | | 0.206 | | | | | −0.478 |
| | | | | | (0.217) | | | | | (0.371) |
| ROE | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0005 | 0.00003 | 0.00004 | 0.00003 | 0.00003 | 0.00004 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0003) |
| Current Ratio | −1.834*** | −1.718*** | −1.375*** | −1.702*** | −2.142*** | 0.096 | 0.095 | 0.199 | 0.116 | 0.086 |
| | (0.211) | (0.209) | (0.212) | (0.210) | (0.209) | (0.185) | (0.185) | (0.185) | (0.185) | (0.185) |
| ROA | −0.213*** | −0.177*** | −0.159*** | −0.178*** | −0.265*** | −0.033 | −0.032 | −0.041 | −0.031 | −0.035 |
| | (0.032) | (0.032) | (0.032) | (0.033) | (0.032) | (0.028) | (0.028) | (0.028) | (0.028) | (0.028) |
| Leverage Ratio | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001** | 0.0001** | 0.0001** | 0.0001** | 0.0001** |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Market Cap (LOG) | 6.718*** | 5.964*** | 4.625*** | 6.094*** | 7.656*** | 1.950*** | 1.958*** | 1.218*** | 1.888*** | 1.937*** |
| | (0.229) | (0.241) | (0.280) | (0.240) | (0.206) | (0.421) | (0.422) | (0.436) | (0.422) | (0.423) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Industry F.E. | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No |
| Observations | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 | 9,986 |
| $R^2$ | 0.214 | 0.221 | 0.226 | 0.219 | 0.207 | 0.871 | 0.871 | 0.872 | 0.871 | 0.871 |
| Adjusted $R^2$ | 0.208 | 0.215 | 0.221 | 0.214 | 0.202 | 0.830 | 0.830 | 0.831 | 0.830 | 0.830 |
| Residual Std. Error | 24.252 (df = 9917) | 24.145 (df = 9917) | 24.058 (df = 9917) | 24.171 (df = 9917) | 24.352 (df = 9917) | 11.236 (df = 7586) | 11.238 (df = 7586) | 11.208 (df = 7586) | 11.231 (df = 7586) | 11.238 (df = 7586) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Table 6.** E Scores and Carbon Emissions (MSCI)

| | *Dependent variable:* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | MSCI - E Score | | | | | | | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Scope 1 (LOG) | −1.215*** | | | | | −0.088 | | | | |
| | (0.093) | | | | | (0.254) | | | | |
| Scope 2 (LOG) | | −0.380*** | | | | | 0.447* | | | |
| | | (0.104) | | | | | (0.256) | | | |
| Scope 3 (LOG) | | | 0.351*** | | | | | 0.038 | | |
| | | | (0.076) | | | | | (0.094) | | |
| Scope Total (1+2) (LOG) | | | | −1.617*** | | | | | −0.212 | |
| | | | | (0.115) | | | | | (0.360) | |
| Scope Total Intensity (1+2) (LOG) | | | | | −3.042*** | | | | | −0.398 |
| | | | | | (0.137) | | | | | (0.390) |
| ROE | 0.0004 | 0.0003 | 0.0001 | 0.0004 | 0.0004 | −0.0001 | −0.0001 | −0.00004 | −0.0001 | −0.0001 |
| | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Current Ratio | −0.802*** | −0.591*** | −0.363* | −0.844*** | −0.598*** | −0.108 | −0.098 | −0.112 | −0.109 | −0.098 |
| | (0.140) | (0.141) | (0.193) | (0.140) | (0.136) | (0.148) | (0.148) | (0.193) | (0.148) | (0.148) |
| ROA | −0.085*** | −0.053** | 0.020 | −0.103*** | −0.073*** | −0.034 | −0.033 | −0.024 | −0.034 | −0.036 |
| | (0.022) | (0.022) | (0.025) | (0.022) | (0.021) | (0.022) | (0.022) | (0.027) | (0.022) | (0.022) |
| Leverage Ratio | −0.00002 | −0.00004 | −0.0001 | −0.00001 | −0.000 | 0.00004 | 0.00004 | −0.0003 | 0.00004 | 0.00004 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.00005) | (0.00005) | (0.0002) | (0.00005) | (0.00005) |
| Market Cap (LOG) | 4.095*** | 3.466*** | 2.337*** | 4.355*** | 3.042*** | 0.157 | 0.117 | −0.476 | 0.169 | 0.100 |
| | (0.154) | (0.159) | (0.192) | (0.160) | (0.135) | (0.338) | (0.337) | (0.424) | (0.339) | (0.340) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | No | No | No | No | No | Yes | Yes | Yes | Yes | Yes |
| Industry F.E. | Yes | Yes | Yes | Yes | Yes | No | No | No | No | No |
| Observations | 9,986 | 9,986 | 6,516 | 9,986 | 9,986 | 9,986 | 9,986 | 6,516 | 9,986 | 9,986 |
| $R^2$ | 0.458 | 0.450 | 0.455 | 0.460 | 0.475 | 0.872 | 0.872 | 0.870 | 0.872 | 0.872 |
| Adjusted $R^2$ | 0.455 | 0.446 | 0.449 | 0.456 | 0.472 | 0.831 | 0.831 | 0.829 | 0.831 | 0.831 |
| Residual Std. Error | 16.158 (df = 9917) | 16.285 (df = 9917) | 16.040 (df = 6449) | 16.136 (df = 9917) | 15.905 (df = 9917) | 8.997 (df = 7586) | 8.995 (df = 7586) | 8.934 (df = 4950) | 8.997 (df = 7586) | 8.997 (df = 7586) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Carbon Intensity Relevance**

Unlike other GHG metrics, carbon intensity measures in most of our regressions, differ from our other GHG metrics, showing mostly negative or insignificant correlation with E/ESG scores, which is what we would expect. However, the coefficients do not appear to be significant for neither of the data providers. When analysing in regional level, we notice the insignificance of the coefficients persists, except for MSCI which shows a significant negative correlation in all three regions (Europe, Asia-Pacific and US), and Refinitiv in the USA. Carbon intensity coefficients continue to remain insignificant for companies in carbon-intensive industries.

We have decided not to include carbon intensity results in the following tables, as measuring intensity is not compatible with the goal of net neutrality, as also noted in one of the most cited articles concerning the carbon premium Bolton and Kacperczyk (2021b). The reason for this is that reducing the intensity can be a very noisy signal. There are different ways to interpret it: companies can actually reduce the level of emissions, or they can increase their revenues at a much higher rate, moving away from the low carbon goal.

Today, policy makers are pushing to disclose more total level of emissions, rather than relying on measuring carbon intensity. The purpose of this research is to investigate how the E score can be used as a tool to achieve net zero. The accumulation of GHGs in the atmosphere is an absolute problem and will not change by relativizing the metrics, hence the reason why the results won't be discussed in the following sections.

### 5.2.2. Differences by regions

We want to further understand what might explain this anomaly of the correlation between E scores and GHG emissions, but also the difference of results among the data providers. We hypothesize that the regions in which companies operate in might have an important impact on the relationship between the variables. Europe has always shown an early readiness to embrace and incorporate sustainable finance practices, well before the other regions. To become the first continent in the world to be climate neutral by 2050, the European Union made a strong push in December 2019. A bold plan called the European Green Deal was unveiled, promising to "give a roadmap with activities to enhance the effective use of resources by moving to a clean, circular economy and tackle climate change, restore biodiversity loss, and cut pollution." European Commission (2019) When it comes to incorporating ESG considerations into their allocations and decision-making, we notice a slower engagement of Asian investors compared to their developed market counterparts. However, the perspectives of Asian investors on sustainable investing have changed recently. The epidemic particularly highlighted how closely related social and environmental issues are to the expansion of the world economy. As a result, wealthy investors in Asia have become increasingly interested in and aware of sustainable investing, which has increased the appeal of investments that contribute to the reduction of global problems like inequality and climate change. According to a new poll by Robeco, sustainable investing in Asia Pacific has surpassed that in the US and is moving closer to catching up with Europe, the leading global reagion in ESG adoption.

In Table 7 below, we present the results for the three main regions: Europe, Asia-Pacific (denoted APAC) and US and Canada (denoted US). These three regions have also been identified as the three biggest polluters is terms of GHG emissions, and given their distinct characteristics as well as the different evolution of ESG integration for each them, we expect that the E score will represent a different relationship with emissions in each of them. The differences between these regions are clear when looking at GHG Scope Total. Asia shows a strongly positive correlation for Scope Total among the three providers, while the United States shows more intuitive results, with a significant negative correlation for MSCI.

When looking at details of other GHG scopes, Europe shows insignificant correlation between carbon emissions with the E score for Scope 1, 2 for both, Refinitiv and S&P Global, and a slight significantly positive correlation for MSCI, in regards to Scope 2 (Table 10). Whereas, in Table 11, Asia shows a positive correlation for Scope 1 (Refinitiv) and Scope 2 (MSCI). And finally, we see that US shows more intuitive results mostly insignificant results and only negative correlation for Scope 2 (Refinitiv) (Table 12).

**Table 7.** E Scores vs Carbon Emissions (Scope Total) by Regions - Summary Table

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Europe | Europe | Europe | APAC | APAC | APAC | US | US | US |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope Total (1+2) (LOG) - Refintiv | 0.852* | | | 0.807* | | | −0.474 | | |
| | (0.471) | | | (0.437) | | | (0.592) | | |
| Scope Total (1+2) (LOG) - Trucost | | 0.026 | | | 1.410*** | | | 0.327 | |
| | | (0.603) | | | (0.534) | | | (0.676) | |
| Scope Total (1+2) (LOG) - MSCI | | | 0.094 | | | 1.630*** | | | −2.873*** |
| | | | (0.710) | | | (0.547) | | | (0.713) |
| ROE | −0.005 | 0.001 | −0.002 | −0.005 | −0.024* | 0.0003 | 0.0002 | 0.0001 | −0.00004 |
| | (0.003) | (0.004) | (0.004) | (0.010) | (0.014) | (0.010) | (0.0002) | (0.0003) | (0.0002) |
| Current Ratio | −0.121 | 0.121 | 0.206 | 0.212 | 0.301 | −0.607* | 0.062 | 0.096 | −0.050 |
| | (0.399) | (0.609) | (0.534) | (0.326) | (0.438) | (0.315) | (0.167) | (0.217) | (0.186) |
| ROA | −0.058* | −0.009 | −0.043 | −0.004 | −0.038 | −0.060 | −0.068* | −0.014 | 0.015 |
| | (0.030) | (0.046) | (0.040) | (0.057) | (0.077) | (0.056) | (0.035) | (0.045) | (0.039) |
| Leverage Ratio | −0.00003 | 0.0002*** | 0.0001 | 0.002 | 0.005* | −0.005** | −0.0002 | −0.001** | −0.0004** |
| | (0.00004) | (0.0001) | (0.00005) | (0.002) | (0.003) | (0.002) | (0.0002) | (0.0003) | (0.0002) |
| Market Cap (LOG) | 0.694 | 2.716*** | 0.597 | 0.697 | 2.073** | −0.336 | 1.643*** | 2.817*** | 0.638 |
| | (0.479) | (0.726) | (0.642) | (0.611) | (0.822) | (0.591) | (0.588) | (0.761) | (0.655) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,970 | 2,970 | 2,970 | 3,502 | 3,502 | 3,502 | 2,836 | 2,836 | 2,836 |
| $R^2$ | 0.920 | 0.891 | 0.874 | 0.845 | 0.866 | 0.868 | 0.874 | 0.871 | 0.871 |
| Adjusted $R^2$ | 0.893 | 0.854 | 0.832 | 0.799 | 0.825 | 0.828 | 0.831 | 0.827 | 0.826 |
| Residual Std. Error | 6.727 (df = 2220)278 (df = 2290.012 (df = 2280792 (df = 26819)832 (df = 26895)11 (df = 26892)71 (df = 21110)733 (df = 21922)36 (df = 2112) | | | | | | | | |

*Note:* *p<0.1; **p<0.05; ***p<0.01

#### 5.2.3. Differences by industries

We also hypothesize that this correlation between carbon emissions and E ratings may be related to carbon emissions and not to firm characteristics, so we try to see if the magnitude of the association is greater for carbon-intensive firms compared to the rest of the industries (carbon non-intensive counterparts). ESG rating agencies may differently consider the carbon risk of carbon-intensive and carbon non-intensive firms in assessing their environmental and emitting profiles. This may occur because unlike their carbon non-intensive counterparts, carbon- intensive firms are likely to face more environmental issues and responsibility towards net-zero commitments and are maybe more scrutinized by the rating agencies.

We see that carbon-intensive industries make up 22.57% of our dataset, graph 7. Carbon-intensive industries are considered those that are responsible for the biggest part of the total GHG emissions. Specifically, in this study these are the industries that are classified as carbon-intensive in the literature, as well as when compared to our actual data. As expected, the largest market capitalization in these industries is oil and gas, accounting for 7% of the total market capitalization of carbon-intensive companies, as shown in graph 8.Europe and Asia make up 44% of the total market capitalization together: the United States itself accounts for almost half of the market capitalization (49%). The largest market capitalization of carbon-intensive companies is in the United States (35% of the total market for carbon-intensive industries); Europe (23.7%), Asia-Pacific (19.92%) (graph 9).

In Table 8, we compare the results between carbon-intensive industries and the rest of the industries in our dataset. The results show that carbon-intensive industries do not show significant negative correlations with E score, which we would expect, leading to the belief that E scores are not as relevant for carbon-intensive industries as an investor might believe. For the total scope, we do not see any significant coefficients. Even when looking more into the granular GHG emission scopes, (Table 13) in Appendices, we notice that for Refinitiv and S&P Global, the correlation between emissions and their E scores remains insignificant. MSCI is the only one to show significant coefficients. We observe a negative and slightly significant correlation for scope 1. However, we observe a positive and slightly significant correlation for scope 2. In the end, we conclude that we do not see a particularly negative relationship between E scores and GHG emissions for carbon-intensive industries.

**Table 8.** E Scores vs Carbon Emissions (Scope Total) by Industries - Summary Table

| | *Dependent variable:* | | | | | |
|---|---|---|---|---|---|---|
| | Carbon-Intensive | Carbon-Intensive | Carbon-Intensive | The Rest | The Rest | The Rest |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Scope Total (1+2) (LOG) - Refintiv | 0.411 | | | 1.375*** | | |
| | (0.441) | | | (0.356) | | |
| Scope Total (1+2) (LOG) - Trucost | | 0.647 | | | 1.334*** | |
| | | (0.571) | | | (0.402) | |
| Scope Total (1+2) (LOG) - MSCI | | | −0.331 | | | −0.162 |
| | | | (0.505) | | | (0.484) |
| ROE | −0.004 | −0.003 | −0.003 | 0.0002 | 0.00002 | −0.00005 |
| | (0.003) | (0.004) | (0.003) | (0.0002) | (0.0003) | (0.0003) |
| Current Ratio | 0.206 | 0.103 | −0.100 | 0.030 | 0.120 | −0.102 |
| | (0.203) | (0.279) | (0.175) | (0.181) | (0.248) | (0.223) |
| ROA | −0.035 | 0.015 | −0.033 | −0.080*** | −0.035 | −0.028 |
| | (0.037) | (0.051) | (0.032) | (0.025) | (0.034) | (0.031) |
| Leverage Ratio | −0.001 | −0.001 | −0.001 | −0.00002 | 0.0001*** | 0.0001 |
| | (0.001) | (0.001) | (0.001) | (0.00004) | (0.0001) | (0.0001) |
| Market Cap (LOG) | 1.353*** | 0.929 | 0.006 | 0.778** | 2.505*** | 0.007 |
| | (0.515) | (0.704) | (0.445) | (0.387) | (0.528) | (0.476) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3,881 | 3,881 | 3,881 | 6,105 | 6,105 | 6,105 |
| $R^2$ | 0.864 | 0.860 | 0.868 | 0.883 | 0.879 | 0.864 |
| Adjusted $R^2$ | 0.821 | 0.816 | 0.826 | 0.845 | 0.840 | 0.821 |
| Residual Std. Error | 8.428 (df = 2954) | 11.566 (df = 2954) | 7.285 (df = 2954) | 8.007 (df = 4619) | 10.954 (df = 4619) | 9.868 (df = 4619) |

*Note:* *p<0.1; **p<0.05; ***p<0.01

### 5.2.4. Differences by sub-periods

Finally, we believe that since in the recent few years ESG criteria has gained a key role in financial markets and investment decisions, data providers have updated their methodologies accordingly to better reflect the environmental profile of companies. Consequently, we could be led to believe that there would be a convergence of the methodologies of our data providers, resulting in a reduction of the heterogeneity of their scores. We expect to notice a significant negative correlation between E scores and carbon emissions after 2018, which we see that is not the case. Coefficients are positive but none significant, for either of the data providers, as seen in Table 9.

**Table 9.** E Scores vs Carbon Emissions (Scope Total) - Summary Table

| | *Dependent variable:* | | | | | |
|---|---|---|---|---|---|---|
| | 2013-2017 | 2013-2017 | 2013-2017 | 2018-2020 | 2018-2020 | 2018-2020 |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Scope Total (1+2) (LOG) - Refintiv | 0.469 | | | 0.689 | | |
| | (0.422) | | | (0.431) | | |
| Scope Total (1+2) (LOG) - Trucost | | 0.239 | | | 0.740 | |
| | | (0.447) | | | (0.509) | |
| Scope Total (1+2) (LOG) - MSCI | | | −0.236 | | | 0.042 |
| | | | (0.712) | | | (0.459) |
| ROE | 0.0001 | 0.0002 | 0.00000 | 0.00000 | 0.0003 | −0.00003 |
| | (0.0003) | (0.0004) | (0.0004) | (0.0003) | (0.0004) | (0.0002) |
| Current Ratio | −0.673** | 0.550 | 0.333 | 0.209 | −0.249 | −0.049 |
| | (0.303) | (0.378) | (0.405) | (0.138) | (0.205) | (0.128) |
| ROA | 0.003 | −0.013 | −0.063 | −0.046** | 0.029 | 0.027 |
| | (0.032) | (0.040) | (0.043) | (0.023) | (0.034) | (0.021) |
| Leverage Ratio | 0.0001 | −0.0001 | −0.0005 | −0.00005 | −0.001*** | −0.00001 |
| | (0.0003) | (0.0003) | (0.0004) | (0.0002) | (0.0002) | (0.0002) |
| Market Cap (LOG) | 0.786 | −0.107 | 1.329* | 1.307*** | 0.865 | 0.012 |
| | (0.532) | (0.661) | (0.711) | (0.400) | (0.595) | (0.374) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4,584 | 4,584 | 4,584 | 5,402 | 5,402 | 5,402 |
| $R^2$ | 0.915 | 0.918 | 0.866 | 0.951 | 0.942 | 0.965 |
| Adjusted $R^2$ | 0.878 | 0.882 | 0.808 | 0.914 | 0.899 | 0.938 |
| Residual Std. Error | 7.065 (df = 3187) | [illegible].778 (df = 3187) | [illegible].437 (df = 3187) | [illegible].919 (df = 3076) | [illegible].840 (df = 3076) | [illegible].521 (df = 3076) |
| *Note:* | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

## 6. Conclusion

With a recent emphasis on reducing carbon emissions globally, there is a growing demand for research in the area of carbon emissions and their impact on sustainable development. So far, there is a lack of research that mainly focuses on the importance of the Environmental pillar (E score), and whether this pillar is in line with the carbon emissions of companies. This is of interest because there are different methodologies adopted by rating providers to assess each parameter of the ESG score, which can strongly influence the final score.

Hence, our research has been redirected to the importance of the environmental pillar of ESG, E score, as there is a rapid growing urgency to react in front of climate change and the new objectives put in place, i.e. net-zero by mid-century and keep 1.5°C within reach, which require a way to reduce emissions of economic activity, in such a way that global emissions fall even as the world economy continues to grow. This boils down to understanding at what extent ESG scores, and more specifically E scores, can be utilized as a tool to promote sustainable development, greening of the financial system and facilitate the transition to a low carbon economy.

Following a quantitative approach, we perform fixed-effect regressions in our panel data, with E score as the dependent variable, carbon emissions (Scope 1, 2, 3 and Total) as the independent variable and will be also including control variables as well as industry/firm and year fixed effects. We have found that E scores are not clear signals of carbon footprint. A higher score on the overall E pillar does not always correlate to low environmental or carbon impact as measured by the GHG metrics. Regarding the E scores, we find mostly positive correlation with carbon emissions. We also find there are differences noticed between the three main regions considered (Europe, Asia, and US). Asia shows the highest positive correlation between E scores and carbon emissions, especially for total scope of emissions (Scope 1 + 2) across the three data providers. Whereas, US shows negative correlations for scope 2 (Refinitiv) and scope total (MSCI), with the rest of metrics showing mostly insignificant results. Also, carbon intensive industries do not manifest significant negative correlations with the E score, which is what would be expected, leading to believe that the E scores are not as pertinent for carbon intensive industries as an investor would believe. Finally, we believe that since in the recent few years ESG has gained a key role in financial markets and investment decisions, we would notice a significant negative correlation between E scores and carbon emissions after 2018, which we see is not the case. Finally, out of the three data providers, we notice that MSCI shows the most intuitive results with either insignificant or negative results in most cases, unlike the rest of data providers.

This study provides a more granular analysis into ESG ratings as we know them, as we believe that ESG scores are not sufficient to understand the accurate environmental profile of companies, as ESG is an umbrella term and score, capturing many potentially contradictory factors. Our results underline the lack of utility of the E scores to send clear messages to investors wanting to mitigate climate change. This pushes towards the need for better transparency of rating criteria, to help the fight against climate change.

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# Appendices

## A. Data characteristics

**Figure 4.** Highest represented sub-industries in the dataset

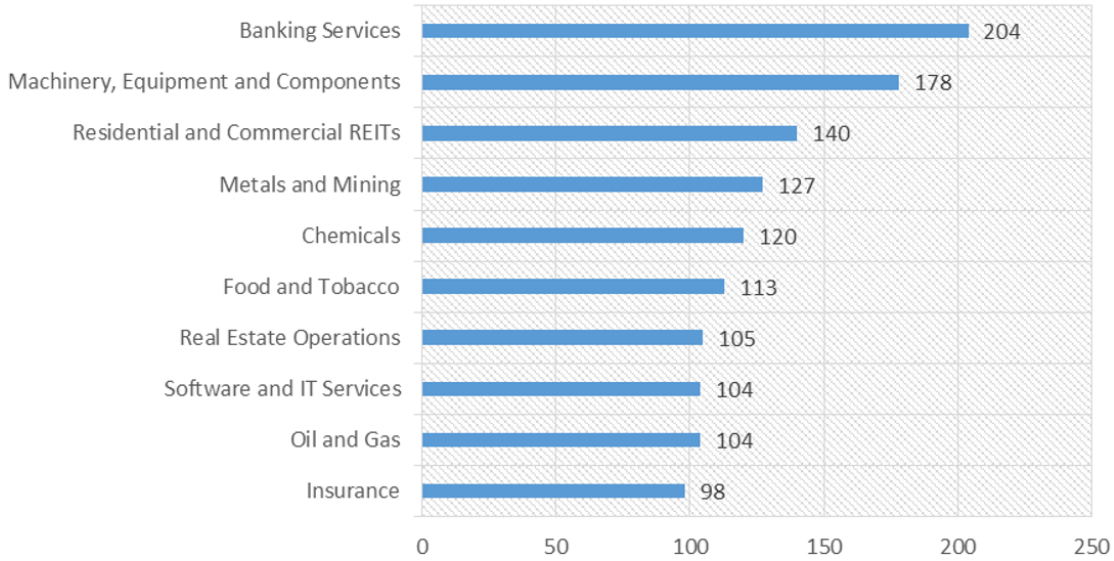
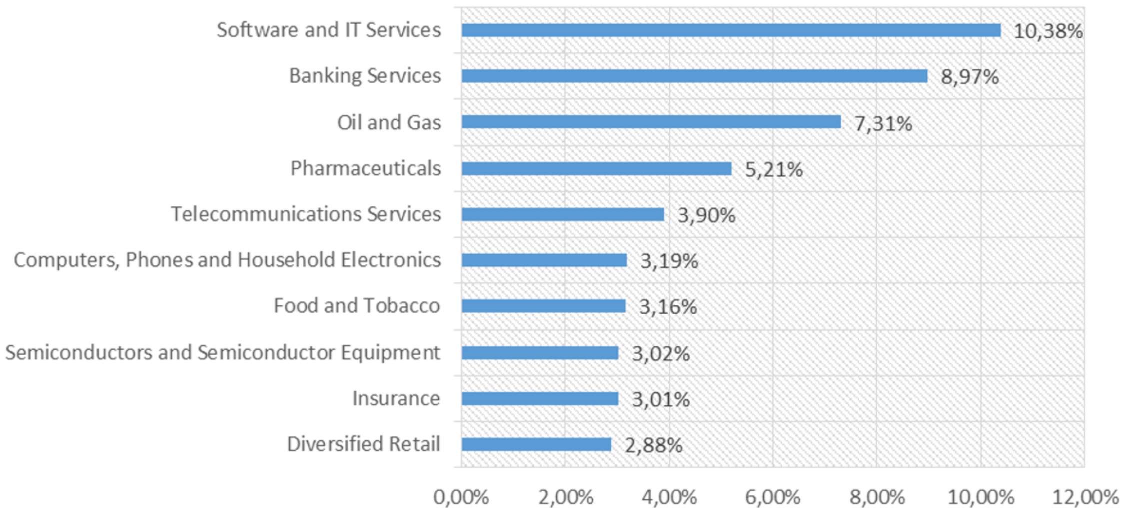



**Figure 5.** Industries with the highest market capitalization



## B. Detailed tables of results

### B.1. Differences by Regions

**Figure 6.** Market capitalization per region

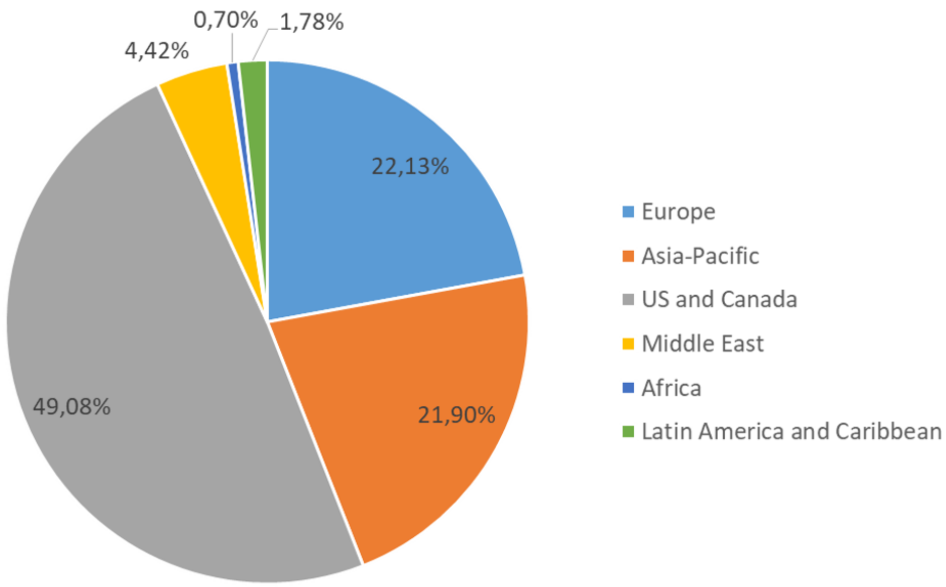


**Table 10.** E Scores vs Carbon Emissions - Europe

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.183 | | | | | | | | |
| | (0.325) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | −0.027 | | | | | | | |
| | | (0.242) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 0.852* | | | | | | |
| | | | (0.471) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | 0.069 | | | | | |
| | | | | (0.457) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | 0.129 | | | | |
| | | | | | (0.496) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 0.026 | | | |
| | | | | | | (0.603) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | −0.302 | | |
| | | | | | | | (0.477) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 1.155** | |
| | | | | | | | | (0.514) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | 0.094 |
| | | | | | | | | | (0.710) |
| ROE | −0.005 | −0.005 | −0.005 | 0.001 | 0.001 | 0.001 | −0.002 | −0.003 | −0.002 |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) | (0.004) |
| Current Ratio | −0.165 | −0.184 | −0.121 | 0.124 | 0.133 | 0.121 | 0.180 | 0.334 | 0.206 |
| | (0.399) | (0.398) | (0.399) | (0.608) | (0.609) | (0.609) | (0.533) | (0.535) | (0.534) |
| ROA | −0.059** | −0.060** | −0.058* | −0.008 | −0.009 | −0.009 | −0.044 | −0.039 | −0.043 |
| | (0.030) | (0.030) | (0.030) | (0.046) | (0.046) | (0.046) | (0.040) | (0.040) | (0.040) |
| Leverage Ratio | −0.00003 | −0.00003 | −0.00003 | 0.0002*** | 0.0002*** | 0.0002*** | 0.0001 | 0.0001 | 0.0001 |
| | (0.00004) | (0.00004) | (0.00004) | (0.0001) | (0.0001) | (0.0001) | (0.00005) | (0.00005) | (0.00005) |
| Market Cap (LOG) | 0.783 | 0.821* | 0.694 | 2.712*** | 2.705*** | 2.716*** | 0.652 | 0.465 | 0.597 |
| | (0.479) | (0.475) | (0.479) | (0.726) | (0.726) | (0.726) | (0.639) | (0.638) | (0.642) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 | 2,970 |
| $R^2$ | 0.920 | 0.920 | 0.920 | 0.891 | 0.891 | 0.891 | 0.874 | 0.875 | 0.874 |
| Adjusted $R^2$ | 0.893 | 0.893 | 0.893 | 0.854 | 0.854 | 0.854 | 0.832 | 0.832 | 0.832 |
| Residual Std. Error (df = 2220) | 6.732 | 6.732 | 6.727 | 10.278 | 10.278 | 10.278 | 9.011 | 9.002 | 9.012 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Table 11.** E Scores vs Carbon Emissions - Asia-Pacific

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.570** | | | | | | | | |
| | (0.271) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | −0.044 | | | | | | | |
| | | (0.298) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 0.807* | | | | | | |
| | | | (0.437) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | 0.439 | | | | | |
| | | | | (0.367) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | −0.049 | | | | |
| | | | | | (0.394) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 1.410*** | | | |
| | | | | | | (0.534) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | 0.363 | | |
| | | | | | | | (0.394) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 1.386*** | |
| | | | | | | | | (0.454) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | 1.630*** |
| | | | | | | | | | (0.547) |
| ROE | −0.005 | −0.006 | −0.005 | −0.024* | −0.024* | −0.024* | −0.0003 | −0.0002 | 0.0003 |
| | (0.010) | (0.010) | (0.010) | (0.014) | (0.014) | (0.014) | (0.010) | (0.010) | (0.010) |
| Current Ratio | 0.204 | 0.205 | 0.212 | 0.274 | 0.268 | 0.301 | −0.638** | −0.592* | −0.607* |
| | (0.326) | (0.326) | (0.326) | (0.439) | (0.440) | (0.438) | (0.316) | (0.316) | (0.315) |
| ROA | −0.007 | −0.009 | −0.004 | −0.046 | −0.047 | −0.038 | −0.067 | −0.063 | −0.060 |
| | (0.057) | (0.057) | (0.057) | (0.077) | (0.077) | (0.077) | (0.056) | (0.055) | (0.056) |
| Leverage Ratio | 0.002 | 0.002 | 0.002 | 0.006* | 0.006* | 0.005* | −0.004* | −0.005** | −0.005** |
| | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) | (0.002) | (0.002) | (0.002) |
| Market Cap (LOG) | 0.724 | 0.801 | 0.697 | 2.206*** | 2.266*** | 2.073** | −0.212 | −0.326 | −0.336 |
| | (0.609) | (0.610) | (0.611) | (0.821) | (0.822) | (0.822) | (0.591) | (0.591) | (0.591) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3,502 | 3,502 | 3,502 | 3,502 | 3,502 | 3,502 | 3,502 | 3,502 | 3,502 |
| $R^2$ | 0.845 | 0.845 | 0.845 | 0.865 | 0.865 | 0.866 | 0.867 | 0.868 | 0.868 |
| Adjusted $R^2$ | 0.799 | 0.798 | 0.799 | 0.825 | 0.825 | 0.825 | 0.827 | 0.828 | 0.828 |
| Residual Std. Error (df = 2689) | 8.791 | 8.798 | 8.792 | 11.845 | 11.848 | 11.832 | 8.524 | 8.511 | 8.511 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Table 12.** E Scores vs Carbon Emissions - United States and Canada

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | −0.323 | | | | | | | | |
| | (0.439) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | −1.116*** | | | | | | | |
| | | (0.338) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | −0.474 | | | | | | |
| | | | (0.592) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | 0.433 | | | | | |
| | | | | (0.487) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | −0.085 | | | | |
| | | | | | (0.434) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 0.327 | | | |
| | | | | | | (0.676) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | −0.524 | | |
| | | | | | | | (0.501) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | −0.379 | |
| | | | | | | | | (0.420) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | −2.873*** |
| | | | | | | | | | (0.713) |
| ROE | 0.0002 | 0.0002 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | −0.00005 | −0.0001 | −0.00004 |
| | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) |
| Current Ratio | 0.065 | 0.052 | 0.062 | 0.097 | 0.087 | 0.096 | −0.062 | −0.070 | −0.050 |
| | (0.167) | (0.167) | (0.167) | (0.217) | (0.217) | (0.217) | (0.187) | (0.187) | (0.186) |
| ROA | −0.067* | −0.068* | −0.068* | −0.015 | −0.014 | −0.014 | 0.017 | 0.016 | 0.015 |
| | (0.035) | (0.035) | (0.035) | (0.045) | (0.045) | (0.045) | (0.039) | (0.039) | (0.039) |
| Leverage Ratio | −0.0002 | −0.0002 | −0.0002 | −0.001** | −0.001** | −0.001** | −0.0004* | −0.0004* | −0.0004** |
| | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0002) | (0.0002) | (0.0002) |
| Market Cap (LOG) | 1.615*** | 1.723*** | 1.643*** | 2.818*** | 2.885*** | 2.817*** | 0.327 | 0.298 | 0.638 |
| | (0.584) | (0.582) | (0.588) | (0.756) | (0.760) | (0.761) | (0.653) | (0.652) | (0.655) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,836 | 2,836 | 2,836 | 2,836 | 2,836 | 2,836 | 2,836 | 2,836 | 2,836 |
| $R^2$ | 0.874 | 0.874 | 0.874 | 0.871 | 0.871 | 0.871 | 0.870 | 0.870 | 0.871 |
| Adjusted $R^2$ | 0.831 | 0.831 | 0.831 | 0.827 | 0.827 | 0.827 | 0.825 | 0.825 | 0.826 |
| Residual Std. Error (df = 2112) | 8.271 | 8.251 | 8.271 | 10.732 | 10.734 | 10.733 | 9.269 | 9.269 | 9.236 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

## B.2. Differences by Industries

**Figure 7.** Market capitalization of carbon-intensive and non-intensive industries

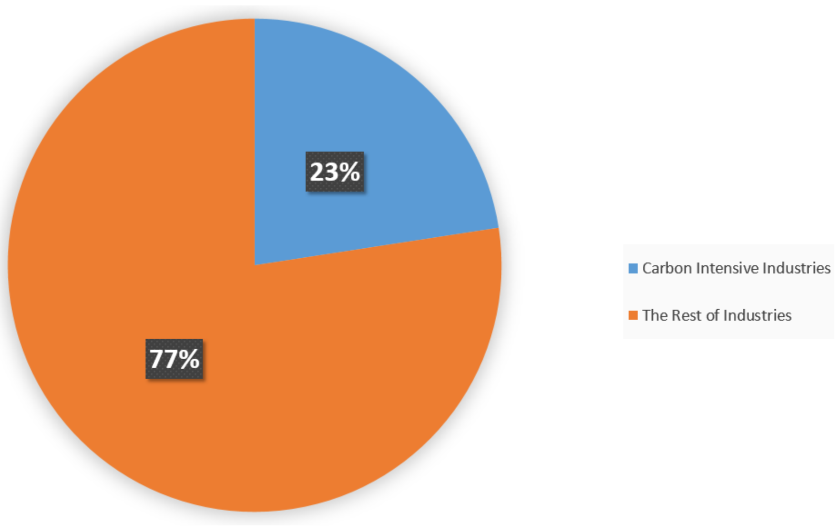



**Figure 8.** Market capitalization of carbon-intensive sub-industries

**Figure 9.** Market capitalization of carbon-intensive sub-industries per region

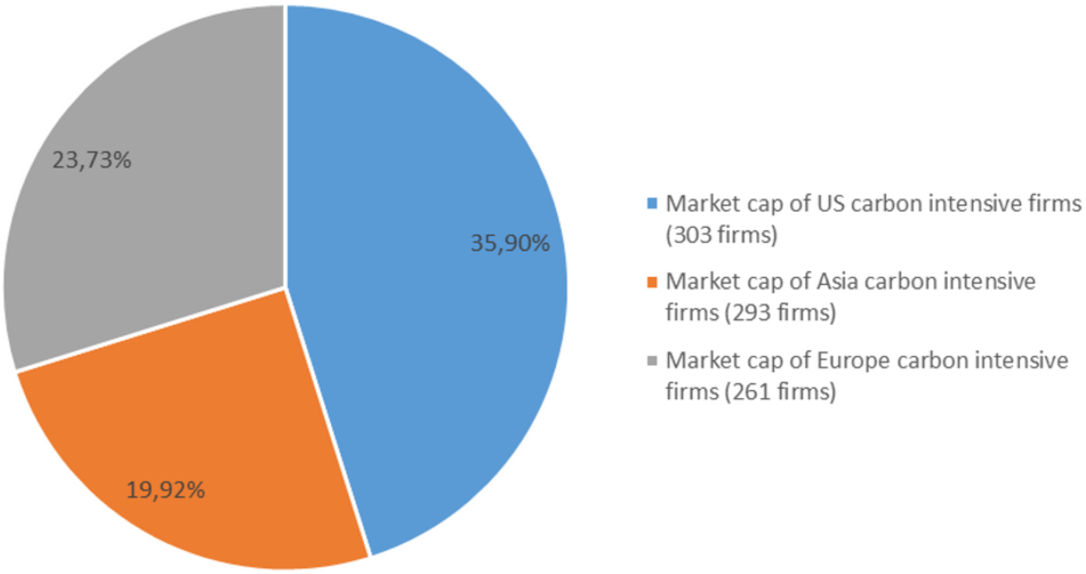


**Table 13.** E Scores vs Carbon Emissions - Carbon Intensive Industries

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.381 | | | | | | | | |
| | (0.335) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | −0.311 | | | | | | | |
| | | (0.236) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 0.411 | | | | | | |
| | | | (0.441) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | −0.172 | | | | | |
| | | | | (0.472) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | −0.022 | | | | |
| | | | | | (0.325) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 0.647 | | | |
| | | | | | | (0.571) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | −0.701* | | |
| | | | | | | | (0.377) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 0.621* | |
| | | | | | | | | (0.339) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | −0.331 |
| | | | | | | | | | (0.505) |
| ROE | −0.004 | −0.004 | −0.004 | −0.003 | −0.003 | −0.003 | −0.003 | −0.003 | −0.003 |
| | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) | (0.004) | (0.003) | (0.003) | (0.003) |
| Current Ratio | 0.207 | 0.198 | 0.206 | 0.089 | 0.090 | 0.103 | −0.084 | −0.086 | −0.100 |
| | (0.203) | (0.203) | (0.203) | (0.279) | (0.279) | (0.279) | (0.176) | (0.176) | (0.175) |
| ROA | −0.034 | −0.035 | −0.035 | 0.012 | 0.013 | 0.015 | −0.032 | −0.032 | −0.033 |
| | (0.037) | (0.037) | (0.037) | (0.051) | (0.051) | (0.051) | (0.032) | (0.032) | (0.032) |
| Leverage Ratio | −0.001 | −0.001 | −0.001 | −0.001 | −0.001 | −0.001 | −0.001 | −0.001 | −0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Market Cap (LOG) | 1.342*** | 1.447*** | 1.353*** | 1.020 | 1.003 | 0.929 | 0.057 | −0.098 | 0.006 |
| | (0.515) | (0.512) | (0.515) | (0.704) | (0.704) | (0.704) | (0.444) | (0.443) | (0.445) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 3,881 | 3,881 | 3,881 | 3,881 | 3,881 | 3,881 | 3,881 | 3,881 | 3,881 |
| $R^2$ | 0.864 | 0.864 | 0.864 | 0.860 | 0.860 | 0.860 | 0.868 | 0.868 | 0.868 |
| Adjusted $R^2$ | 0.821 | 0.821 | 0.821 | 0.815 | 0.815 | 0.816 | 0.827 | 0.827 | 0.826 |
| Residual Std. Error (df = 2954) | 8.427 | 8.427 | 8.428 | 11.569 | 11.569 | 11.566 | 7.282 | 7.282 | 7.285 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

**Table 14.** E Scores vs Carbon Emissions - The Rest of Industries

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.659*** | | | | | | | | |
| | (0.219) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | 0.187 | | | | | | | |
| | | (0.241) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 1.375*** | | | | | | |
| | | | (0.356) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | 0.815*** | | | | | |
| | | | | (0.276) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | 0.802** | | | | |
| | | | | | (0.367) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 1.334*** | | | |
| | | | | | | (0.402) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | 0.164 | | |
| | | | | | | | (0.334) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 0.440 | |
| | | | | | | | | (0.356) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | −0.162 |
| | | | | | | | | | (0.484) |
| ROE | 0.0002 | 0.0002 | 0.0002 | 0.00002 | 0.00002 | 0.00002 | −0.00005 | −0.00005 | −0.00005 |
| | (0.0002) | (0.0002) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0003) |
| Current Ratio | 0.004 | −0.005 | 0.030 | 0.096 | 0.095 | 0.120 | −0.094 | −0.091 | −0.102 |
| | (0.181) | (0.181) | (0.181) | (0.247) | (0.248) | (0.248) | (0.223) | (0.223) | (0.223) |
| ROA | −0.083*** | −0.084*** | −0.080*** | −0.038 | −0.036 | −0.035 | −0.027 | −0.026 | −0.028 |
| | (0.025) | (0.025) | (0.025) | (0.034) | (0.034) | (0.034) | (0.031) | (0.031) | (0.031) |
| Leverage Ratio | −0.00002 | −0.00002 | −0.00002 | 0.0001** | 0.0002*** | 0.0001*** | 0.0001 | 0.0001 | 0.0001 |
| | (0.00004) | (0.00004) | (0.00004) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Market Cap (LOG) | 0.849** | 0.897** | 0.778** | 2.579*** | 2.561*** | 2.505*** | −0.016 | −0.027 | 0.007 |
| | (0.386) | (0.386) | (0.387) | (0.527) | (0.528) | (0.528) | (0.475) | (0.475) | (0.476) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 6,105 | 6,105 | 6,105 | 6,105 | 6,105 | 6,105 | 6,105 | 6,105 | 6,105 |
| $R^2$ | 0.883 | 0.883 | 0.883 | 0.879 | 0.879 | 0.879 | 0.864 | 0.864 | 0.864 |
| Adjusted $R^2$ | 0.845 | 0.845 | 0.845 | 0.840 | 0.840 | 0.840 | 0.821 | 0.821 | 0.821 |
| Residual Std. Error (df = 4619) | 8.012 | 8.020 | 8.007 | 10.956 | 10.961 | 10.954 | 9.868 | 9.866 | 9.868 |

*Note:* *p<0.1; **p<0.05; ***p<0.01

### B.2.1. Differences by Sub-Periods

**Table 15.** E Scores vs Carbon Emissions (Scope Total) - 2013 - 2018

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.103 | | | | | | | | |
| | (0.285) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | 0.008 | | | | | | | |
| | | (0.249) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 0.469 | | | | | | |
| | | | (0.422) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | −0.065 | | | | | |
| | | | | (0.342) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | −0.108 | | | | |
| | | | | | (0.343) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 0.239 | | | |
| | | | | | | (0.447) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | −0.195 | | |
| | | | | | | | (0.502) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 1.043* | |
| | | | | | | | | (0.573) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | −0.236 |
| | | | | | | | | | (0.712) |
| ROE | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0002 | 0.0002 | 0.00001 | −0.00003 | 0.00000 |
| | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) | (0.0004) |
| Current Ratio | −0.678** | −0.681** | −0.673** | 0.528 | 0.522 | 0.550 | 0.333 | 0.377 | 0.333 |
| | (0.303) | (0.303) | (0.303) | (0.377) | (0.378) | (0.378) | (0.405) | (0.405) | (0.405) |
| ROA | 0.001 | 0.001 | 0.003 | −0.015 | −0.015 | −0.013 | −0.062 | −0.057 | −0.063 |
| | (0.032) | (0.032) | (0.032) | (0.040) | (0.040) | (0.040) | (0.043) | (0.043) | (0.043) |
| Leverage Ratio | 0.0001 | 0.0001 | 0.0001 | −0.0001 | −0.0001 | −0.0001 | −0.0005 | −0.0005 | −0.0005 |
| | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0004) |
| Market Cap (LOG) | 0.839 | 0.853 | 0.786 | −0.058 | −0.048 | −0.107 | 1.320* | 1.191* | 1.329* |
| | (0.530) | (0.530) | (0.532) | (0.659) | (0.660) | (0.661) | (0.708) | (0.709) | (0.711) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 4,584 | 4,584 | 4,584 | 4,584 | 4,584 | 4,584 | 4,584 | 4,584 | 4,584 |
| $R^2$ | 0.915 | 0.915 | 0.915 | 0.918 | 0.918 | 0.918 | 0.866 | 0.866 | 0.866 |
| Adjusted $R^2$ | 0.878 | 0.878 | 0.878 | 0.881 | 0.881 | 0.882 | 0.808 | 0.808 | 0.808 |
| Residual Std. Error (df = 3187) | 7.066 | 7.066 | 7.065 | 8.778 | 8.778 | 8.778 | 9.437 | 9.432 | 9.437 |
| *Note:* | | | | | | | | | *p<0.1; **p<0.05; ***p<0.01 |

**Table 16.** E Scores vs Carbon Emissions (Scope Total) - 2018 - 2020

| | *Dependent variable:* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Refinitiv - E Score | | | SP Global - E Score | | | MSCI - E Score | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Scope 1 (LOG) - Refintiv | 0.538** (0.261) | | | | | | | | |
| Scope 2 (LOG) - Refinitiv | | −0.021 (0.250) | | | | | | | |
| Scope Total (1+2) (LOG) - Refinitiv | | | 0.689 (0.431) | | | | | | |
| Scope 1 (LOG) - Trucost | | | | 0.743** (0.330) | | | | | |
| Scope 2 (LOG) - Trucost | | | | | −0.052 (0.332) | | | | |
| Scope Total (1+2) (LOG) - Trucost | | | | | | 0.740 (0.509) | | | |
| Scope 1 (LOG) - MSCI | | | | | | | −0.131 (0.296) | | |
| Scope 2 (LOG) - MSCI | | | | | | | | 0.095 (0.293) | |
| Scope Total (1+2) (LOG) - MSCI | | | | | | | | | 0.042 (0.459) |
| ROE | 0.00001 (0.0003) | 0.00000 (0.0003) | 0.00000 (0.0003) | 0.0004 (0.0004) | 0.0004 (0.0004) | 0.0003 (0.0004) | −0.00003 (0.0002) | −0.00003 (0.0002) | −0.00003 (0.0002) |
| Current Ratio | 0.205 (0.138) | 0.203 (0.138) | 0.209 (0.138) | −0.249 (0.205) | −0.254 (0.206) | −0.249 (0.205) | −0.050 (0.128) | −0.049 (0.128) | −0.049 (0.128) |
| ROA | −0.046** (0.023) | −0.044* (0.023) | −0.046** (0.023) | 0.028 (0.034) | 0.033 (0.034) | 0.029 (0.034) | 0.028 (0.021) | 0.027 (0.021) | 0.027 (0.021) |
| Leverage Ratio | −0.0001 (0.0002) | −0.0001 (0.0002) | −0.00005 (0.0002) | −0.001*** (0.0002) | −0.001*** (0.0002) | −0.001*** (0.0002) | −0.00002 (0.0002) | −0.00001 (0.0002) | −0.00001 (0.0002) |
| Market Cap (LOG) | 1.314*** (0.399) | 1.357*** (0.399) | 1.307*** (0.400) | 0.880 (0.595) | 0.880 (0.596) | 0.865 (0.595) | 0.024 (0.372) | 0.013 (0.372) | 0.012 (0.374) |
| Year F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm F.E. | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 5,402 | 5,402 | 5,402 | 5,402 | 5,402 | 5,402 | 5,402 | 5,402 | 5,402 |
| $R^2$ | 0.951 | 0.951 | 0.951 | 0.942 | 0.942 | 0.942 | 0.965 | 0.965 | 0.965 |
| Adjusted $R^2$ | 0.914 | 0.914 | 0.914 | 0.899 | 0.898 | 0.899 | 0.938 | 0.938 | 0.938 |
| Residual Std. Error (df = 3076) | 5.917 | 5.921 | 5.919 | 8.836 | 8.843 | 8.840 | 5.521 | 5.521 | 5.521 |

*Note:* *p<0.1; **p<0.05; ***p<0.01