An Empirical Analysis of Companies in the S&P 500: Testing the Efficacy of ESG Scores and the Existence of Greenwashing in the Wider Market

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This study conducts an analysis on the relationship between a firm's Environmental, Social, and Governance Score (ESG Score), and each firm's corresponding greenhouse gas emissions cost, investigating the existence of greenwashing in the American stock market at large and the efficacy of ESG Scores as a tool to assess a firm. Critics hold that the criteria used to create a firm's ESG score varies significantly across providers, raising concerns over the reliability of ESG metrics. For future investors, stakeholders, and firms, there lies uncertainty in the effectiveness of ESG metrics and ESG investing as a practice. Using S&P Global ESG Scores and Trucost Environmental data between 2013-2020, linear univariate, multivariate, and fixed effect regression models were employed to derive the relationship between a company's average annual ESG score and the natural log of a company's annual greenhouse gas emissions cost. Prior to analysis, the datasets were filtered and cleaned to ensure that only companies in the S&P 500 were represented. It was hypothesized that there would exist a strong positive correlation between a firm's ESG score and greenhouse gas emissions cost. However, there existed a small positive correlation between a firm's ESG score and greenhouse gas emissions, signaling that a firm's greenhouse gas output and financial cost is not at the forefront of score calculations.This raises the concern that ESG scores do not account for the negative effects of greenhouse gas emissions, misleading investors and stakeholders and potentially leading to greenwashing in the wider market

Introduction

In recent years, global concern has underscored the detrimental effects of climate change, specifically in regards to rising temperatures, negative environmental impacts, health risks, and socio-economic disruptions. The growth of sustainable finance has summoned the attention of investors, policy-makers, and civil servants to deliver financial objectives, alleviate societal concerns, and promote sustainability. In accordance with public sector initiatives to oblige with the climate goals of the Paris Agreement of 2015 and the Sustainable Development Goals (SDGs), there has been a sharp incline in Environmental, Social, and Governance (ESG) investing, sustainability reports, and emissions targets to promote long-term value and alignment with societal values[1].

The beginning of the practice of sustainable investing, or ESG investing, over the last 20 years can be attributed to rising global temperatures, climate disasters, and environmental activism, making the way a company is perceived to become an increasingly important factor for investors and stakeholders. The rise of socially responsible investing can be traced back to the Socially Responsible Investing Movement of the 1960s and 1970s, where investors had arguably just begun to consider social and environmental factors in their investments. More recently, the UN Principles for Responsible Investment (PRI) of 2006 launched a framework for responsible investing that encourages investors and institutions to factor ESG principles into the process of decision-making. Most importantly in 2015, the adoption of the COP21 Paris Agreement and the introduction of the Sustainable Development Goals by the UN marked a steep incline in the acknowledgement of environmental issues and climate change in investment-strategies, increasing global commitment to address climate change. Presently, ESG reporting standards such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB) has provided firms and investors with standardized methods of evaluating their ESG initiative.

In practice, these global standards are translated into organizational strategies that jointly consider corporate governance, corporate social responsibility, and ESG. The fact that ESG reporting is adding value to a firm and the practice of ESG investing is increasingly becoming commonplace also comes with shortcomings. The main hindrance on ESG reporting lies is the lack of transparency in the discretion on the release of ESG-based metrics by companies. There is a lack of consistent information and data to create meaningful, verified, and standard ESG metrics to evaluate companies[2]. To increase transparency and credibility, it is vital to understand the possibility of credibility-enhancing mechanisms of ESG disclosures using either internal or external mechanisms[3]. Industry failure to respond to evolving disclosure requirements threatens divestment in the practice of investing in environmental and socially responsible firms[4].

The economic importance of ESG considerations, specifically environmental sustainability, has become increasingly important to investors, companies, and policymakers. Climate change poses a long-term risk to various industries, and firms that embrace ESG principles can lead themselves to effective long-term valuations. Globally, companies that adhere to ESG standards are more globally competitive, innovative, and more likely to manage risk effectively, overall increasing the valuation of companies long-term. Social and environmental performance had a significant positive relationship with business sustainability, indicating that profitability and creating societal and environmental value are mutually dependent[4]. It was also found that ESG disclosures strengthen business sustainability and performance[4].

As ESG standards become increasingly important to investors, researchers Aydoğmuş, Gülay, and Ergun suggest that the overall ESG combined score, including the Environmental, Social, and Governance indicators, is positively and significantly associated with firm value[5]. In addition, the individual Social and Governance scores have a positive correlation with firm value and profitability, but individual Environmental componentes do not[5]. Karim, Albitar, and Elmarzouky indicate a positive relationship between internal governance, capital expenditure and carbon emission disclosure in their analysis, displaying the need for more governmental regulations on the environmental practices of firms[6].

Environmental, Social, and Governance Scores (ESG) Scores are crucial tools for investors to analyze a company's sustainability and have been applied to companies representing around 80% of market capitalization in 2020[7]. The scores range from 0-100, with 50 representing a relatively poor score and 70 representing a relatively good score. In order to align capital flow with sustainability, a number of indexes, instruments, ratings, and principles have emerged to guide the risks and opportunities of a climate-focused firm. The environmental "E" pillar of ESG scores is increasingly employed as a tool to align investors with climate-focused firms with goals of long-term sustainability, with a main objective being driving down greenhouse gas emissions.

Greenhouse gas (GHG) emissions include carbon dioxide, methane, nitrous oxide, and various industrial gasses, with their emissions contributing to a phenomenon known as the greenhouse gas effect, a driver of global warming and climate change. The dependent variable of the external cost of direct and indirect greenhouse gas emissions estimates the value of a service based on the cost of damage that results from its loss. It is based on the assumption that the cost of maintaining an environmental benefit is a reasonable estimate of its value.

As of 2021, two-thirds of S&P 500 companies have set targets to reduce greenhouse gas emissions, but only 9% of S&P 500 companies have implemented or plan on implementing science-based targets, which create a clearer pathway to decarbonization[6]. Although 354 of the S&P 500 companies have emissions policies, only 245 have specific reduction targets[6]. An increase in ESG-based investing has led firms to generally pursue a more favorable score, but the gap between the implementation of proposed and effective climate objectives, as well as proof supporting an actual decrease in negative emissions after implementing policies, remains wide.

The transition to a low-carbon economy is reliant upon the assumption that companies adapt their business operations and practices accordingly to deliver climate-related objectives. Corporate transparency of environmental disclosure plays an important role in achieving a low-carbon economy. However, there is an absence of an effective market-based mechanism to help prevent greenwashing behavior[8]. Corporate transparency in regards to environmental standards is also linked to better stock market performance[9]. Khalil and Nimmanunta assert that investing in green innovation has a positive correlation with a reduction in carbon emissions and an improvement in financial performance[10]. In a recent meta-analysis, the researchers found that 58% of the papers had a positive relationship between ESG and financial performance, 8% negative relationship, 13% no relationship, and 21% mixed results[10]. This indicates that there still exists considerable disagreement about the accuracy and validity of ESG data.

However, the existence of greenwashing in the large-scale market threatens the validity of ESG scores and ESG reporting. Pei-yi Yu, Van Luu, and Chen suggest that greenwashing behavior in ESG dimensions is present globally, but can be deterred by scrutiny from independent directors, institutional investors, influential public interests, and by being cross-listed[11]. Furthermore, Boffo, Marshall, and Patalano's findings suggest that the environmental pillar of ESG scoring may not necessarily be effective for investors seeking to better align their portfolios with low carbon economies[7]. It was found that environmental scores often do not align with carbon emissions exposures and can be difficult to interpret due to the multitude of diverse metrics on environmental factors. For some ESG rating providers, high E scores positively correlate with high carbon emissions and for other ESG rating providers, the opposite is true. Furthermore, it is asserted that the E score does not prioritize carbon emissions in its range of environmental metrics[7]. Therefore, the E score in its current form could potentially be an ineffective tool for analyzing a firm's carbon emissions and footprint. This calls for firms to report different ranges of metrics of data, as opposed to standardized values to further affirm a company's 'green' practices and agenda. Greater transparency and compliance of firms can lead to more effective and honest ESG reporting.

There lies a gap in the analysis of greenhouse gas emissions in relation to societally accepted standards of evaluating a firm's climate intentions. Focus has been placed on carbon emissions in various studies, and methods of ESG reporting are generally accepted, not challenged for the sake of improving such record-keeping and industry standards. The individual Environmental score is not properly evaluated. The impact of a firm's negative environmental outputs on a firm's ESG score is not well-known. Without perpetually challenging the validity of industry standards, there lies the risk of outdated standards incorrectly evaluating contemporary firms, frameworks, and practices. The risk of greenwashing, the act of misleading consumers of a firm's environmental benefits, in the large-scale market stands as a threat to investors who use ESG scores as their primary tool for evaluating the sustainability of a company.

The identified research gap underscores the importance of testing the correlation between a company's score and their climate impacts. There lies a lack of credibility and reliability in ESG standards and metrics, which could potentially lead to the existence of greenwashing in the wider market and a devaluation of environmentally sustainable practices. Furthermore, a net-zero carbon economy and low greenhouse gas emissions is at the forefront of environmental activism, and a leading goal of the study was to analyze whether or not ESG scores truly accounted for low greenhouse gas emissions cost or not. Although there remains a plethora of additional environmental and social practices encompassed in ESG scores, focusing on greenhouse gas emissions cost, which is one of investors' main focuses, can help pave the way for analyzing and understanding whether or not ESG scores correctly portray environmental and social priorities in their scores. There still lies a gap in whether ESG scores account for inputs or outcomes, how the score accounts for different ESG dimensions and categories, and how a company's score reflects the firm's policy goals and reporting bias. The primary objective of this study was to empirically assess the relationship between a company's ESG score and their GHG emissions cost in order to investigate the presence or absence of greenwashing, as well as test the efficacy of ESG scores in regards to evaluating greenhouse gas emissions cost, in the stock market at large. The independent variable/regressor was the ESG scores of companies in the S&P 500, and the dependent variable/regressand was the direct and indirect cost of greenhouse gas emissions. The direct and indirect cost of greenhouse gas emissions is calculated by assessing the financial damage (in dollars) caused by the loss of an environmental benefit. By doing so, the value can be estimated by assessing how much it would cost to fix the problems incurred by losing the environmental benefit.

It is posited that higher ESG scores of companies in the dataset positively correlates with a higher greenhouse gas cost, as a firms' cost of maintaining an environmental benefit should be directly correlated with their acquired ESG rating.

All data was obtained from S&P Global Market Intelligence using Wharton Research Data Services. ESG data was garnered specifically through S&P Global ESG Scores, and greenhouse gas emissions data was obtained from Trucost Environmental engines by inputting the 500 tickers of the S&P 500 Index for each year from 2013 to 2020. Due to the fact that S&P Global Market Intelligence outputs global data, not just data from the US, the data was prepped manually, ensuring that each ticker was a part of the US's S&P 500 Index in each year's dataset. Using Stata BE Version 2018, 5 regressions were run to analyze the data. This includes a univariate regression with GHG cost as the y-variable and ESG score as the x-variable, a multivariate regression of GHG cost on ESG score with additional control variables including a company's age, whether the company is evaluating an "arm" of a company or not, which is represented through the variable "public," and its industry type, the same multivariate regression adjusted for heteroscedasticity, a two-way fixed effect model using a company's ID and year, and the same fixed effect models with clustered standard errors at the company level.

Results

It was hypothesized that a company's ESG score is positively related to its greenhouse gas emissions cost, demonstrating that the cost associated with greenhouse gas emissions correlates to a lower ESG score. Upon conducting a univariate regression with the natural log of the average annual GHG cost as the y-variable and the average annual ESG score as the x-variable, the coefficient of the regression was 0.02094 with a p-value of 0.000. Holding all else constant, a one-point increase of a company's ESG score is associated with a $0.02094 increase in a company's GHG cost, being statistically significant at the 5% level ($p < 0.05$).

$$\ln(\text{GHG\_cost}) = b_0 + b_1 \cdot \text{average\_annual\_score}$$

The multivariate regression analyzed the relationship between the natural log of the average annual GHG cost as the y-variable and the average annual ESG score as the x-variable, while holding a company's age, whether it is an "arm" of a company, and its Simple Industry Type as additional variables. The coefficient comparing a company's average annual ESG score and the natural log of its average annual GHG cost is 0.0034943, meaning that a one-point increase in a company's ESG score leads to a $0.0034943 increase in their GHG cost. This result is statistically significant at the 5% level ($p < 0.05$). While the result is statistically significant, a $0.0034943 corresponding increase in GHG cost indicates the average annual ESG score having a modest impact on the GHG cost.

$$\ln(\text{GHG\_cost}) = b_0 + b_1 \cdot \text{average\_annual\_score} + b_2$$

$$\cdot \text{company\_age} + b_3 \cdot \text{public} + \sum_i b_i \cdot \text{industry\_type}_i$$

With the multivariate regression, a company's age, which is the number of years since the company was founded, was correlated with the natural log of a company's average annual GHG cost. The coefficient was 0.0000403, indicating a one year increase in a company's age is associated with a $0.0000403 increase in a company's GHG cost, but this result is not statistically significant as the p-value is not less than 0.05.

The same multivariate regression regression, adjusted for heteroscedasticity errors, was run, similarly comparing the natural log of a company's average annual GHG cost with the same company's average annual ESG score, the company's age, whether it is an "arm" of a company or not, and its Simple Industry. A one-point increase in a company's average annual ESG Score leads to a $0.0034943 increase in a company's GHG cost, indicating a minor positive relationship between a company's GHG cost and its ESG score. This result is statistically significant at the 5% level ($p < 0.05$). A one-point increase in a company's age leads to a $0.0000403 increase in a company's GHG cost, indicating that a company's age does little to impact its GHG cost. This result is not statistically significant at the 5% level, as p is not less than 0.05.

$$\ln(\text{GHG\_cost}) = b_0 + b_1 \cdot \text{average\_annual\_score} +$$
$$b_2 \cdot \text{company\_age} + b_3 \cdot \text{public} + \sum_i b_i \cdot \text{industry\_type}_i$$

A two-way fixed effect model with the dependent variable as the natural log of a company's average annual GHG cost and the independent variable as a company's average annual ESG score, with a company's unique ID and the year of the data as fixed effects. A one-point increase in a company's average annual ESG score is associated with a $0.0019942 increase in the same company's GHG cost at a statistically significant level of 5% ($p < 0.05$). This indicates a small positive association between a company's ESG score and GHG cost.

$$\ln(\text{GHG\_cost}) = b_0 + b_1 \cdot \text{average\_annual\_score} +$$
$$\sum_i b_i \cdot \text{Institution\_ID}_i + \sum_j b_j \cdot \text{year}_j$$

The same initial two-way fixed effect model with clustered standard errors at the company level indicated that a one-point increase in a company's average annual ESG cost is associated with a $0.0019942 increase in a company's GHG cost, indicating that while controlling for company-specific effects, the association between the two variables is small in magnitude. This result is not statistically significant at the 5% level, as the p-level is not less than 0.05.

$$\ln(\text{GHG\_cost}) = b_0 + b_1 \cdot \text{average\_annual\_score} +$$
$$\sum_i b_i \cdot \text{Institution\_ID}_i + \sum_j b_j \cdot \text{year}_j$$

Discussions

The objective of this study was to investigate the relationship between a company's ESG score and greenhouse gas emissions cost, testing the credibility of ESG scores for environmentally conscious and oriented investors and understanding the scope of greenwashing in the wider market. This study aimed to primarily explore the relationship between S&P 500 companies' ESG score and their greenhouse gas emissions cost, demonstrating an empirical analysis of the impact of an important environmental indicator on the company's overall Environmental, Social, and Governance score, as an analysis of the wider US market. It was found that a company's GHG cost was positively associated with its ESG score in a small magnitude, showing that although the two are positively correlated, affirming the hypothesis, the economic impact of greenhouse gas emissions may not be at the forefront of ESG score calculations. The small size of the coefficient also indicates the lack of significant correlation between a firm's greenhouse gas emissions cost and their ESG score as a whole. It is also acknowledged that there may exist a bi-directional relationship between ESG scores and greenhouse gas cost values. This highlights the need for additional indicators and methods of measuring the environmental impact of companies.

In order to be useful, E (Environment) scores should align with both a company's financial and environmental materiality in a transparent manner, allowing investors to be clear on what factors go into determining an ESG score. There exists no universal, standardized formula for calculating ESG scores, and discrepancies on score calculations due to the factors of determining ESG scores can serve as barriers to investors receiving accurate data. For instance, a company that excels in risk management and renewable transition plans, despite poor performance on emissions metrics, could receive a high ESG, and E, score[7]. In order to reduce the risk of greenwashing and to help investors distinguish the meaning behind an E score, the disparities in underlying metrics should be made clear, specifically to better address the reporting on low-carbon efforts and climate-based transitions of various companies.

To determine the relationship between carbon emissions in association with a company's E score, Boffo, Marshall, and Patalano analyzed the correlation of total CO2 and CO2 equivalent emissions, a common sustainability measure taken into account whilst determining the E pillar score7. Without accounting for the size of the company, results display a positive correlation with the E scores for two out of three providers, meaning that higher rated ESG companies on average pollute more in terms of a gross output of carbon dioxide, and an inverse relationship for one out of three providers, holding the opposite to be true. However, after accounting for the size of the company through company revenues, CO2 emissions are not correlated to E pillar scores[7]. Moreover, although there existed little correlation between the E pillar score and CO2 emissions, researchers showed a positive correlation between transition policies adopted and the E pillar score for all three ESG score providers, illustrating how long-term policies are better reflected in ESG score ratings, and specifically E pillar scores, as opposed to specific negative outputs, such as greenhouse gas emissions like carbon[7]. In accordance with the findings of this study, there exists little correlation between a firm's greenhouse gas emissions cost, an important economic driver, and ESG scores as a whole. These findings suggest that long-term policies, as opposed to company outputs, are the primary drivers of high E pillar scores.

Analyzing data from 2013-2021, Aydoğmuş, Gülay, and Ergun found that a firm's ESG combined score has a positive and highly significant relationship with the firm value[5]. In addition, both the individual Social score and individual Governance score have highly significant positive relationships between a firm's combined ESG score and firm value. However, the individual Environment score has no significant relationship with firm value. Simply looking at the combined score can potentially mislead investors.

This analysis raises scrutiny on the effectiveness and practicality of the application of ESG scores, specifically in relation to the E pillar, and its usefulness of ESG score metrics on the investment process in order to create investment portfolios aligned with low-greenhouse gas strategies. Due to the low correlation between E pillar scores and greenhouse gas emissions, the E pillar of ESG scores on its own is not an appropriate tool for indicating low emission companies for investors. Instead, E pillar scores are better markers of long-term transition strategies, despite debate still remaining on the effectiveness of such strategies and the adoption of such policies. Furthermore, as with green bonds, there are no extant principles or formal standards to construct the E pillar; rather, the E pillar is subject to various different underlying metrics, oftentimes not made transparent to an investor, for determining the score[9]. With confounding variables such as the score provider and the underlying metrics that determine an E pillar score, there is potential for greenwashing in the market at large, where companies that do not pursue low greenhouse gas emissions policies receive high E scores contingent upon the provider and underlying metrics. This leads to companies who have received high E pillar scores to benefit from investor trust and greater capital but not to face scrutiny over their lack of policies addressing negative outputs.

It was found that improving national ESG performance effectively suppressed greenhouse gas emissions in a nation, translating to improved environmental performance. Increased environmental policy stringency has strengthened initiatives of lower greenhouse gas emissions by ESG performance. However, a positive social performance may lead to increased greenhouse gas emissions. Upon a heterogeneity analysis, it is shown that environmental policy stringency reverses the effect of social performance on emissions, and social performance's joint effect with governance performance reduces greenhouse gas emissions in total. With these contrasting results, with one high pillar score (E score) leading to high greenhouse gas emissions and another high pillar score (S score) causing high greenhouse gas emissions, ESG scores are subject to fluctuations and interdependence across a range of categories. The fact that categories encompassed in the Social score is correlated to and can impact greenhouse gas emissions threatens the validity of the ESG score as a whole. Therefore, it is important to provide individual metrics behind each score. Increased transparency amongst ESG providers is the key to re-creating and maintaining value surrounding ESG scores. Not knowing and understanding the calculations, weighting, and determinants hinders the trustworthiness of reliability of ESG score. ESG scores have the potential to revolutionize tools to determine a company's sustainability; they are concise, readily available, and provide a seemingly comprehensive analysis. However, ESG scores risk being too concise and too comprehensive to the point that since such a great number of categories are supposedly being considered, some categories overpower others, subjecting the scores to significant bias. Furthermore, the lack of transparency jeopardizes the authenticity of scores, leading the scores to potentially be manipulated and politicized to a certain extent. For this reason, in August 2022, S&P Global completely stopped including ESG scores in its credit rating methodology due to negative investor feedback. In addition, the SEC has also announced plans to tighten climate disclosure requirements, which can be due to ESG scores' failure to transparently disclose their determinants.

In addition to E pillars not prioritizing carbon or greenhouse gas emissions, there also exists the risk that E scores do not prioritize other negative outputs, such as waste or water. By only prioritizing long-term strategies and not existing negative externalities, E scores fail to account for critical information on companies, misleading ESG investors who use ESG scores as a primary investment tool for long-term sustainability. Therefore, additional, easily accessible methods of tracking negative outputs, especially those related to climate change such as greenhouse gas emissions and carbon emissions, must be made available to the public to progress towards a more environmentally and economically sustainable future. Placing more emphasis on Sustainable Accounting Standards Board (SASB) standards, the Carbon Disclosure Project's Carbon Pricing Pathway, and the Carbon Disclosure Project's other tools can provide investors with the specificity they need to make informed decisions.

A study conducted by PwC reported that around 33% of investors believe that ESG standards are of "good quality"[12]. This poses a threat to the usage and credibility of ESG scores. In order to improve such statistics, instill a sense of trust in the public regarding ESG scores, and prevent a wider presence of greenwashing in the American market, certain robust policy action must be taken. For example, currently, there is no single regulatory framework for ESG scores, and standardization is key to global success. Similarly, there must be standardized auditing to verify reported data, which does not exist in the current state. ESG terminology must be named to be better understood by the wider public; definitions in general, whether they come from the Global Reporting Initiative, Task Force on Climate-Related Financial Disclosures, or the International Sustainability Standards Board, can be difficult to interpret, leading to confusion and misleading interpretations. It is also important to note that reporting agencies and companies like MSCI and Sustainalytics have their methodologies change frequently, with parts of their individual pillar scores diverging significantly, leading to final scores that are unclear to the public. Even internally, reporting can be confusing. For example, Scope 3 emissions can be arduous to gather from external sources and can oftentimes be complicated.

To alleviate these concerns, the most efficient and encompassing solution is to develop globally streamlined and standardized policies, methodologies, and reporting guidelines. Increasing transparency and requiring reporting agencies to disclose their computation strategies, data sources, and weighting is another crucial step towards ESG scores becoming credible sources for investors and stakeholders. Data collection tools that perform modeling such as Nasdaq's Metrio can be resources for independent stakeholders and investors. Focusing on E pillar, emissions tools such as Net0 and Microsoft's Cloud for Sustainability can streamline data processing techniques, analyze, report, and track a firm's environmental progress, identify growth areas, and measure progress against goals. To prevent greenwashing and help society progress towards their environmental goals, increased data transparency, global cooperation, and concerted efforts are crucial values.

For future study, the relationship between ESG scores and other negative outputs, such as waste and water, can also be investigated. Furthermore, each negative output can be compared to each of the three pillars of ESG scores individually to better understand the relationships between the pillars. Moreover, the influence of regulatory environments, technological innovations, and industry-specific characteristics can be correlated with both ESG scores and greenhouse gas emissions cost to better understand the ESG framework.

Methodology

For each company in the dataset, the average annual ESG score served as the independent variable, and the dependent variable was the absolute greenhouse gas emissions cost. The data was obtained using the University of Pennsylvania's Wharton Research Data Services (WRDS). Within the database, the values of the ESG scores were obtained from S&P Global Market Intelligence using S&P Global ESG Scores, which is a part of the S&P Global Corporate Sustainability Assessment (CSA). Such environmental, social, and governance scores assess a company based on the S&P Global Corporate Sustainability Assessment (CSA) process and publicly available sources, providing a lens into a company's business value drivers, including growth, profitability, capital efficiency, and risk exposure. The values of the absolute cost of the greenhouse gas emissions was also taken from S&P Global Market Intelligence, using Trucost Environmental data, which measures the environmental impact of over 15,000 companies across key dimensions to assess environmental costs, identify, and manage environmental and climate risk as well as conduct peer and portfolio analysis from a climate and environmental perspective.

The data is representative of companies in the S&P 500, as the index is a widely-accepted indicator of the United States' economic health and stock market performance. The dataset consists of ESG data and greenhouse gas emissions cost values from eight years, from 2013 to 2020. For each year, there are varying numbers of companies with data available from the database; therefore, although indicators for the same 500 companies (503 stocks) were inputted into the database, the database was able to return values for the raw ESG score and greenhouse gas emissions cost for around 60% of the companies in the S&P 500. Since reporting technologies have experienced great improvement between 2013 to 2020, less companies reported scores and greenhouse gas emissions costs in 2013 than 2020. Both datasets, one containing the greenhouse gas cost values and the other containing the ESG score values, saw a sharp increase in reported scores after 2018. Regardless of how many scores were reported, the same data cleaning methodologies were employed. Since the S&P Global Market Database is a global database, not only reporting US-based companies, some tickers represent international companies that share the same ticker as US-based companies. In order to ensure that each ticker represented the US-based company in the S&P 500 and not an international company with an identical ticker, the dataset was analyzed manually to ensure that each company was in fact a part of the S&P 500 database. Regarding manual analysis, any company that did not have a headquarters location in the US was removed, and the remainder of the companies were meticulously searched and verified three times for each dataset to ensure accuracy of filtering. The companies that were removed from the dataset were also individually verified to be companies that were in fact not in the S&P 500. Upon creating a final dataset, the raw data was manipulated to generate the final variables.

The raw ESG scores for a given company each year were averaged, as each company reported scores at varying time

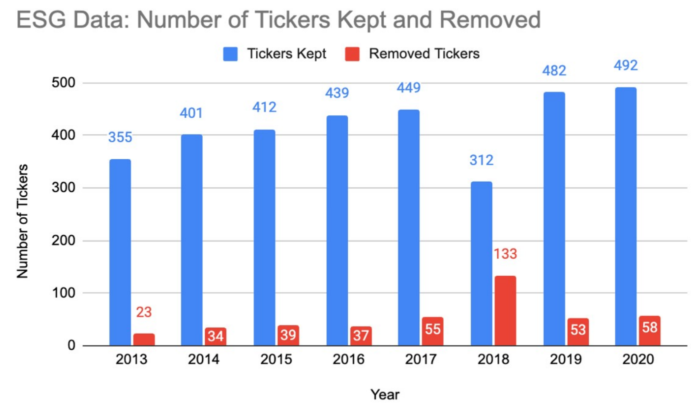

Fig. 1 Number of ESG Data Tickers Kept and Removed.

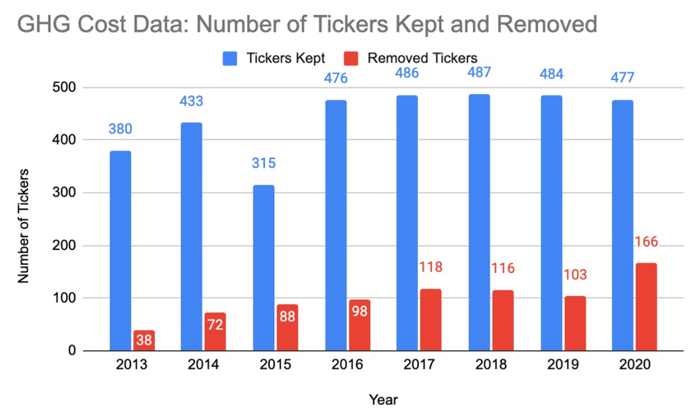

Fig. 2 Number of GHG Cost Data Tickers Kept and Removed.

intervals and frequencies (ranging anywhere from once or three times a year), in order to obtain the final independent variable of the "average_annual_score" of each company.

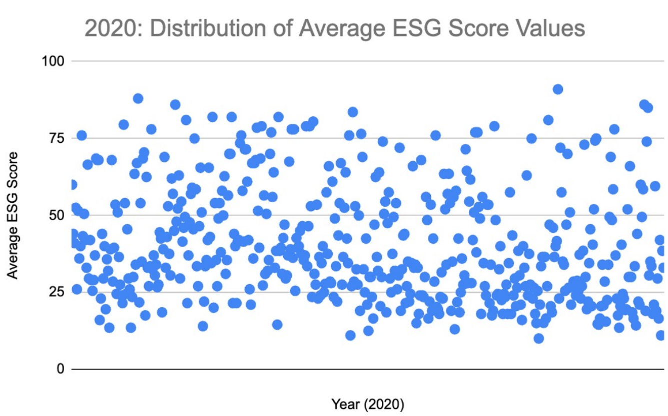

Fig. 3 Distribution of Average Annual ESG Score Values in 2020.

The dependent variable was also curated by averaging all greenhouse gas cost values for a company in a given year. In addition, the average annual value was divided by the employee size of each company, which was obtained from a public S&P data source, in order to control for the size of the company. Lastly, with the dependent variable controlled for the size of the company, the natural log of the company-size controlled variable was taken, establishing the final dependent variable of "lnCost."

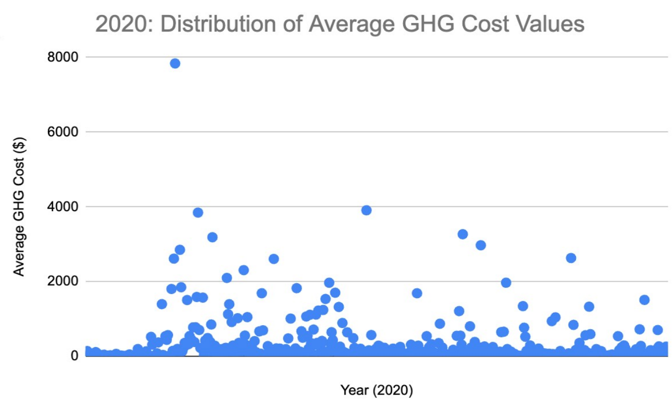

Fig. 4 Distribution of Average GHG Cost Data Values in 2020.

In addition to the independent and dependent variables, the dataset included each reported company's Institution ID, Ticker, Period End Date, Company Name, Company Type, Simple Industry, Incorporation Country, Country, Incorporation State, State, and the Year Founded from the S&P Global Market database accessed through Wharton Research Data Services. In addition, the variable denoting a company's age was curated by subtracting the Year when the data was reported and the Year Founded. The variable Public was also generated, which displays 1 if the company is public and 0 if the ticker represents the investment "arm" of a company, the investment sector, or simply a private company, such as JP Morgan Chase.

In the dataset, the average annual ESG Score, the independent variable, ranged from 10 to 91, and the average was 43.104 with a standard deviation of 17.173. The lnCost, the dependent variable, ranged from -14.560 to 1.972 with a mean of -5.958 and a standard deviation of 2.011. The SimplyIndustry_encoded variable, which took the raw SimpleIndustry data and was encoded for the purpose of analysis, had a minimum of 1 and a maximum of 70. Its mean was 32.801 with a standard deviation of 19.784. As a binary/categorical variable, the variable Public ranged from 0-1.

Data was collected for each year from 2013 to 2020. Using the WRDS database, the tickers for the companies in the S&P 500 were inputted separately into two separate engines: S&P Global ESG Scores and Trucost Environmental to garner the ESG Score values and greenhouse gas emissions costs respec-

Table 1 Summary Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
average_annual_ESG_cost	3,911	43.10382	17.17292	10	91
lnCost	3,312	-5.957957	2.010658	-14.55902	1.971716
SimpleIndustry_encoded	4,465	32.80134	19.78416	1	70
Public	4,549	0.8085293	0.3935018	0	1

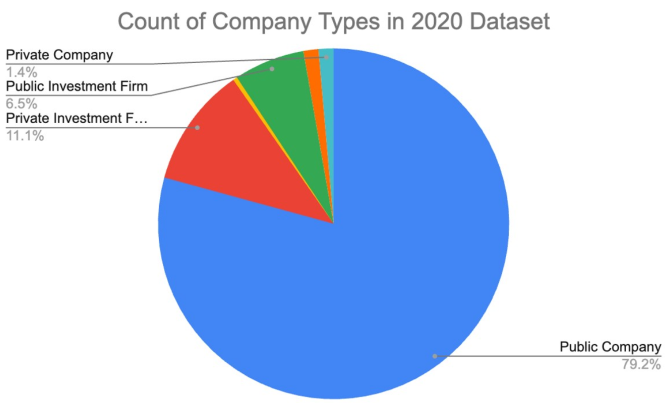

Fig. 5 Split of Company Types in 2020 Dataset.

tively. Scores in any given year range from January 1st of that given year to December 31st. In addition to the specific variable, a company's Institution ID, Ticker, Period End Date, Company Name, Company Type, Simple Industry, Incorporation Country, Country, Incorporation State, State, and the Year Founded was also reported. The data was exported uncompressed onto an Excel spreadsheet, where the data reported for each company was organized in columns.

The data was next manually cleaned for each year. Due to the fact that the S&P Global Market Intelligence is a global database, not only reporting the United States' stock exchange, some of the tickers of the S&P 500 reported by the database were duplicates of global stock tickers not representative of the S&P 500. Therefore, each company exported in the data was manually searched and analyzed in order to ensure that every company represented in the dataset was in fact a part of the S&P 500. Since each year's data varied in the number of companies that were initially reported in the raw data, which was contingent on what the database had access to, a different number of companies was manually removed when cleaning the data. In general, the data of anywhere from 23-166 companies was removed for each year due to the fact that they were not companies in the S&P 500. This data cleaning process was conducted for both the ESG score values dataset and the greenhouse gas emissions cost dataset to produce final Excel sheets.

Once the data was collected and cleaned, the datasets were exported from Excel to Stata/BE 18.0, where the data analysis and regression analysis was performed. In order to prepare the ESG data to be merged with the greenhouse gas emissions data, two new variables, average_annual_score (the average annual ESG Score Value) and lnCost (the natural log of the average greenhouse gas emissions cost), were created by first taking the average of all reported scores and values for each company in a given year. After taking the average of all annual values, the independent variable, "average_annual_score" was outputted. However, for the dependent variable, after taking the average of the annual cost values, the natural log of the values was also calculated, producing the final dependent variable "lnCost."

With the independent and dependent variables in respective datasets for each year, the two datasets for each year (from the independent and dependent variable) were merged using each company's Institution ID. Some companies were represented in both the ESG score values dataset and the greenhouse gas emissions cost dataset, others were reported in only one of the two. Only companies with values in both datasets were represented in the final dataset. Once the datasets from each year between 2013 to 2020 were merged, the datasets from all years were appended into one file, producing the final dataset for the regression analysis to be run on.

With the appended file, regression commands were run. This includes a univariate regression analysis with only the average ESG score values and average greenhouse gas emissions cost values. A multivariate regression was run next with additional control variables, including a company's age, whether a company's overall standing or the standing of a company's "arm" is being evaluated, and the industry type. A company's age indicates its founding date, testing the relevance of legacy practices that were implemented before environmental practices were on the rise, regulatory compliance, company culture, innovation, and stakeholder influence. The industry of a company highlights a marked difference between different firms: their purpose. Much of the argument against ESG scores is that the scores elicit undue bias against specific industries, such as oil or energy due to their inclination to pollute more. The "arm" of the company was controlled for because the "arms" do not represent the whole firm, so they may not be accurate representations of the whole firm's actions or policies. These variables were some of the most widely available and had the most potential

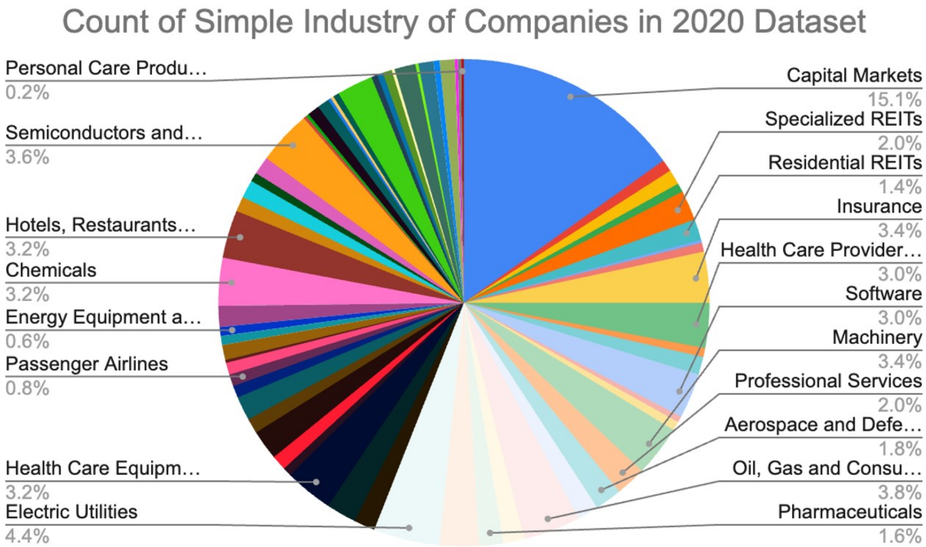

Fig. 6 Split of Industry Types for Companies in the 2020 Dataset.

to impact the data, so they were chosen as control variables. In addition, the same command was re-run with heteroscedasticity controls. A two-way fixed effect model was also run using each company's average ESG score value, greenhouse gas emissions cost, Institution ID, and year. The same two-way fixed model was run again but with clustered standard errors at the company level.

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