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Impact of ESG Ratings on Brown Sector Firms' Financial Performance

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Abstract. *As we are witnessing a shift of paradigm from traditional economic growth towards sustainable development, backed by United Nation's Sustainable Development Goals call to action, the concept of Environmental, Social and Governance (ESG) has been integrated in almost all aspects of the economy. Firms are probably the category of stakeholders towards the most expectations have been made for them to do better in terms of ESG. Significant scrutiny is being put on firms activating in traditionally emission-intensive sectors however, one cannot deny the aspect that the polluting sectors of economy have been the main pillar of economic growth since the industrial revolution. The current research aims at studying in what way the ESG performance of polluting firms is backed by improved financial performance and whether greening these firms leads to a trade-off or a win-win situation. By doing so, the paper aims at filling a gap in the existing literature as there is significant evidence concerning the relationship between ESG and financial performance in general, while a limited number of studies focus on firms activating in emission-intensive sectors. We perform the analysis using panel data regression models for a set of 138 firms registered across the European Union and over a period of 14 years. We look at financial performance from both a profitability and as well as market value perspective and the findings indicate that improvements in governance and social performance positively influence return on assets (ROA) and return on equity (ROE), while environmental performance, as well as the aggregated ESG score, has a limited impact, particularly in the case of Tobin's Q. The study brings valuable insights to both business actors and policymakers by highlighting that the social and governance goals can be attained without sacrificing financial performance, while greening polluting firms may be perceived as burdensome and could imply financial trade-offs.*

Keywords: ESG, Sustainability, Emissions, Profitability, Market Value.

Introduction

In the aftermath of the 2015 Paris Agreement the concept of ESG rooted itself in the business environment, particularly in Europe. The concept itself is much older than that, being officially introduced in 2004 in the UN report *Who Cares Wins*. Since then, the Corporate Sustainability Standard was set up and the International Financial Institutions, such as the International Financial Corporation or the European Bank for Reconstruction and Development, introduced ESG criteria for the counterparties they finance. With the latest ESG reporting requirements, such as the Corporate Sustainability Reporting Directive, the topic of ESG has become a mainstream subject on the agenda of all corporate entities.

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Stakeholders ranging from investors and regulators to consumers and employees increasingly demand that firms go beyond financial performance and address broader societal and environmental concerns. Improving a firm's ESG performance often means investments. A highly relevant question being asked by management board members is whether the required investments do make financial sense. At the end of the day, the main point of interest for a firm's shareholders is value creation. This is the question that our research is trying to answer.

The novelty of this study lies in on studying the impact of ESG performance on the profitability and market value of firms activating exclusively in emission-intensive, or *brown*, economic sectors. Sectors such as oil & gas, mining, industry or transportation have been the backbone of economic development in the 20th century – however they are responsible for most of the greenhouse gas emissions across the planet. As decarbonisation – the reduction of CO2 emissions – is the main pillar of climate mitigation, emission-intensive economic sectors are under scrutiny to transform their activity towards being more environmentally friendly. Such a transition, however, could be very costly and might imply a compromise in terms of profitability, at a micro level, and in terms of economic output, from a macro perspective. In this context, our analysis serves as bridge between microeconomic and macroeconomic perspectives and aims to bring added value to both corporate decisionmakers and macroeconomic policymakers on the complex topic of ESG.

Further on, the paper is structured as follows: in section 2 we present the most relevant findings of the current literature, in section 3 we describe the data and the methodology used, section 4 is reserved for discussing the results, and in section 5 we outline the main conclusions of our research while indication potential future research directions.

Literature review

Before presenting the past findings directly corelated to our study there is an important aspect needed to be addressed. When discussing about ESG performance, academics and professionals often refer to ESG scores as the most relevant metric. Such scores are provided by various rating agencies and bodies however, the consensus points towards a misalignment in the scoring methodologies across different providers. The existing literature documents such aspects, and the study of Berg et al. (2022) highlights the discrepancy between ESG scores while calling for better methodological transparency. Chatteji et al. (2016) go as far as suggesting that this aspect can lead to different results when analysing the impact of ESG scores on firms' performance.

The study of ESG and its impact on firms' financial performance can be traced back to the 1970s, as mentioned by Friede et al. (2015) in the bibliometric analysis. By considering approximately 2200 studies, the authors conclude that over 90% of the papers included in their sample point towards a positive relationship between ESG and financial performance. Such insights have also been provided by Alshehhi et al. (2018) as their literature analysis points towards the fact that 78% of papers indicate a positive relationship between ESG and firms' performance.

More recently, Whelan et al. (2021) perform a similar bibliometric analysis for a sample of approximately 1000 papers published during the 2015-2020 period. Similarly to the previous studies, the authors conclude that most of the research papers indicate a positive financial result correlated with improved ESG performance, while less than 10% of the papers point towards a negative relationship. Approximately 21% of the studies in their sample showcase mixed effects while almost 13% indicate no interconnection between ESG and financial performance.

While our study does not focus on bibliometric analysis, figure 1 below presents the output of the analysis performed by us best on the most relevant 500 articles in the literature matching the

research theme 'Impact of ESG on financial performance'. ESG performance seems to be the driving topic, being closely interconnected to ESG ratings and disclosure, financial returns, enterprises and the banking sector.

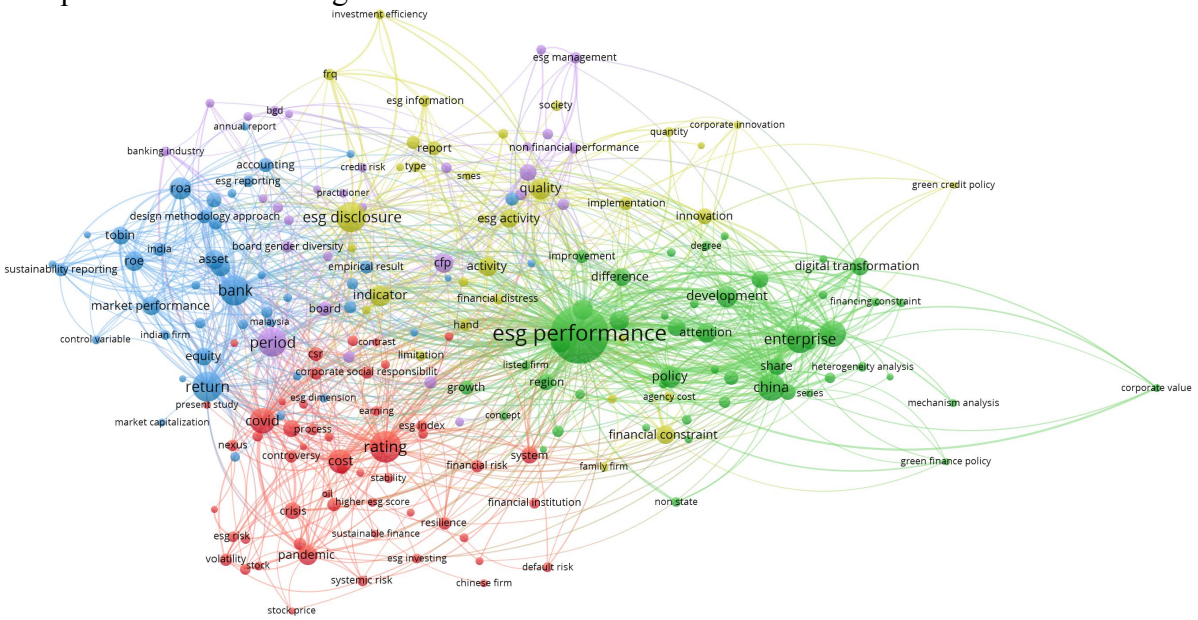

Figure 1: Bibliometric map of ESG impact on firms' financial performance

Source: VOSviewer representation.

We now continue with presenting the current state of relevant literature where we classified the research papers into three main categories, based on the type of relationship between ESG and financial performance: positive, negative, and mixed. Most of the papers fall into the positive category, supporting the bibliometric results of previous authors such as Whelan et al. (2021).

Papers with findings of positive relationship between ESG performance and firm profitability

Aydoğmuş et al. (2022) investigate the impact of ESG performance on firm value and profitability using a large dataset of 1,720 firms worldwide from 2013 to 2021. By applying fixed effects panel data regression models the authors indicate that the ESG combined score has a positive and significant effect on both firm value and profitability. Their results indicate that the social and governance components have a positive influence over firm value however, the environmental score does not mark a significant impact over firms' financial performance.

As noticeable in our bibliometric analysis map presented in Figure 1, there are many studies performed on data for the Chinese market. One such study is the one of Zhou et al. (2021) who found that higher ESG scores are associated with improved operating capacity, thus driving the market value of firms. Another valuable contribution on this line is the one of Xu and Zhu (2024) who deploy a two-way fixed effects model. The authors argue that an improvement in ESG score leads to a direct, less substantial, increase in ROA while the mediating effect via firms' innovation capability is stronger. Similarly to our study, Dou and Yin (2024) examine the relationship between ESG performance and financial performance in heavily polluting industries, with a focus on China. Using a two-way fixed-effects regression model the findings indicate a positive and significant relationship between ESG scores and financial performance, measured by Tobin's Q. The environmental dimension contributes the most, while the social and governance dimensions show no statistical significance.

While the available data for China facilitates the study of this paradigm, the literature focuses on other geographies as well. By analysing the impact of ESG scores on ROA in a multiple regression equations setup Chen et al. (2023) conclude that ESG score has a positive impact on firms' financial performance at the 1% significance level. Further on, their analysis has been performed at a granular level and the findings indicate a stronger correlation between ESG score and ROA in the case of large and high-risk firms, versus in the case of small and low-risk firms. In a study focusing on the 50 firms that are in the composition of the STOXX Europe ESG Leaders 50 index, Koundouri et al. (2022) argue that higher ESG scores are associated with improved ROA and ROE values across all economic sectors. Moreover, top ESG performing firms exhibit less equity volatility as they have lower Beta values, particularly in the automotive industry where the green transition can be perceived as disruptive. Kalia and Aggrawal (2022) focus their study on healthcare firms across 33 countries and come up with similar results to the previously presented study. Namely, they find that improving ESG score by 1 point is responsible for a 0.4% increase in ROA and ROE. Individual dimensions show, however, variations as environmental activities have the most significant impact on financial performance, while social scores impact ROE in a non-significant manner.

Ahmad et al. (2021) focus their research on firms that are constituent of the FTSE350 index. By deploying both static and dynamic panel data analysis, the authors identify a positive relationship between ESG score and firms' market value and earnings per share. In a similar manner to our research, Naeem et al. (2022) selected a sample of firms form emission-intensive sectors and studied the impact of ESG score on ROA, ROE and Tobin's Q. In developed markets, ESG score is associated with a positive variation in ROE and Tobin's Q, without having a significant effect on ROA. In the case of emerging markets, however, the authors found that there is no association between improved ESG performance and the financials of firms.

Papers with findings of negative relationship between ESG performance and firm profitability

Whilst many studies indicate a positive relationship, some researchers argue that ESG has a negative impact on firms' profitability, particularly in developing economies. One such study is the one of Gargia and Orsato (2020) who argue that ESG score is associated with a negative evolution of financial performance among firms in emerging markets. Duque-Grisales and Aguilera-Caracue (2021) examined over 100 international corporation in Latin America and concluded that there is a negative relationship between ESG scores and firms' financial performance. In the same line of emerging market studies, Włodarczyk et al. (2024) analysed the effect of CO2 emission intensity on return on sales and return on assets of carbon intensive firms listed on the Warsaw Stock Exchange for the 2009-2021 timeframe. Using a combination of GLS regressions, that in the short-run renewable energy production had a negative impact on firms' profitability due to higher incurred costs.

Papers with findings of mixed relationship between ESG performance and firm profitability

Lastly, in this sub-section we will present the results of a third group of researchers, that found mixed relationships between ESG and firms' financial performance. In a study focusing on listed companies in Germany, Velte (2017) argues that improvements in ESG scores positively influence ROA but have no measurable impact on Tobin's Q. The author also performs the analysis on a more granular level and find out that the governance component has the most significant influence.

By measuring financial performance via a composite score, Bruna et al. (2022) identified a non-linear relationship between ESG score and financial performance, with medium-sized firms boasting a stronger positive relationship compared to small-sized firms. In a sectoral analysis

focused on energy and power generation firms, Naeem and Cankaya (2022) bring evidence towards the fact that ESG performance of energy sector firms positively influences their return on equity, while having a detrimental impact on their return on assets and market value.

Sinha Ray and Goel (2023) also analysed the relationship between ESG score and various financial performance metrics by deploying both static and dynamic panel regression models. Whilst ESG scores do positive influence some financial metrics such as ROA, share price and profitability, they showcase a negative influence on ROE, market capitalisation, while no influence has been identified in the case of Tobin's Q. We conclude the literature review section a study form Giannopoulos et al. (2022) who investigate how ESG score impacted the financial performance of 20 Norwegian listed firms over the 2010-2019 period. The authors indicate that ESG negatively impacts return on assets while noticing an improvement in the market performance, measured through Tobin's Q. These results can be based on the specificities of Scandinavian countries, where one can generally expect investors to be more ESG oriented than in other geographies.

Methodology

The aim of this section is to provide information on the data used in our analysis, while supporting the reasons for firms and variable selection methodology. Leveraging on the results found in the literature, we will describe the econometric framework, with a focus on data testing, modelling techniques and estimations.

Data sample

As this paper is aimed at providing an answer to the research question of whether ESG performance impacts the financial performance of listed companies activating in brown (polluting) sectors, the first step in setting up the data sample was selecting the most relevant polluting industries and sub-industries. Based on data sourced from the European Environment Agency (EEA) the economic sectors emitting the largest amounts of CO2 are presented in Figure 2.

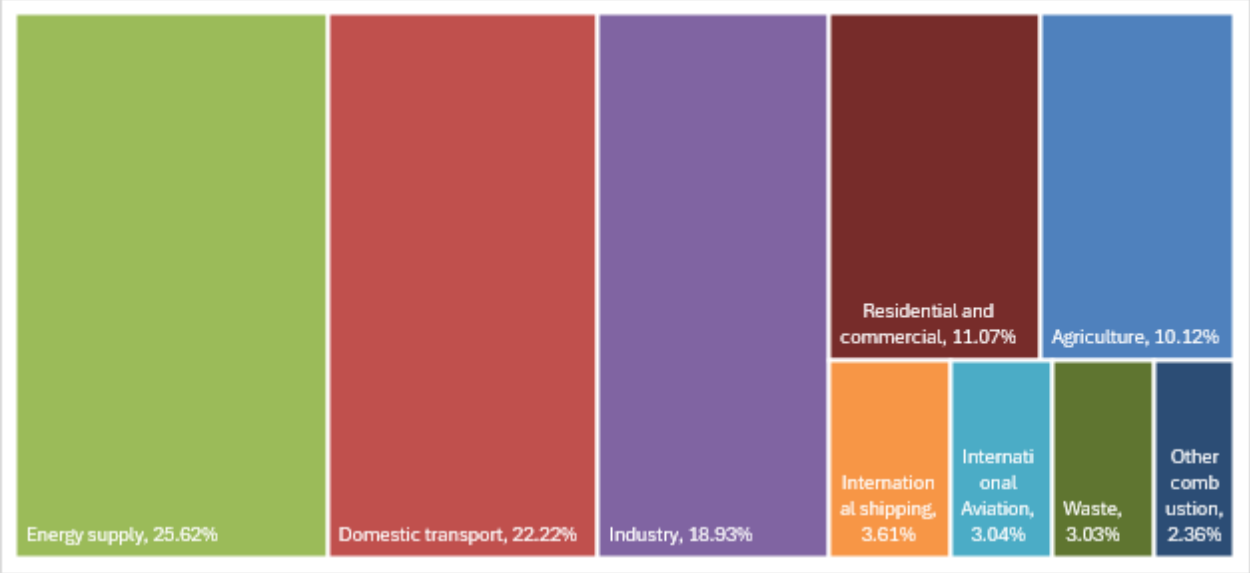

Figure 2: Sectoral GHG emissions in CO2 equivalents in 2022 (% of total GHG emissions)
Source: authors' representation based on EEA data.

Based on this broad classification of polluting economic sectors further granularity has been added when shaping the pool of selected companies at an industry and sub-industry level. Using

the Refinitiv database, the following industries and sub-industries have been selected, as presented in Table 1. The European Union's 27 member states have been considered as the geographical focus area.

Table 1. Selected industries based on The Refinitiv Business Classification (TRBC)

Industry name		
Aerospace & Defense	Electrical Components & Equipment	Natural Gas Utilities
Agricultural Chemicals	Fishing & Farming	Non-Gold Precious Metals & Minerals
Airlines	Gold	Oil & Gas Drilling
Aluminum	Ground Freight & Logistics	Oil & Gas Exploration and Production
Auto & Truck Manufacturers	Heavy Electrical Equipment	Oil & Gas Refining and Marketing
Auto, Truck & Motorcycle Parts	Heavy Machinery & Vehicles	Oil & Gas Transportation Services
Coal	Independent Power Producers	Oil Related Services and Equipment
Commodity Chemicals	Industrial Machinery & Equipment	Passenger Transportation, Ground & Sea
Construction Materials	Integrated Oil & Gas	Real Estate Rental, Development & Operations
Courier, Postal, Air Freight & Land-based Logistics	Iron & Steel	Shipbuilding
Diversified Chemicals	Marine Freight & Logistics	Specialty Chemicals
Diversified Mining	Mining Support Services & Equipment	Specialty Mining & Metals
Electric Utilities	Multiline Utilities	Tires & Rubber Products

Source: Authors' computations.

The sampling process resulted in a total number of 1714 EU-based listed companies initially selected. As many companies received an ESG score only in recent years further filtering has been applied, selecting only those companies evaluated with an ESG score starting with 2010 and continuing at least until 2022. The final data sample consists of 153 listed companies, covering the 2010-2023 timeframe.

After carefully analysing the existing literature, we chose to measure firms' financial performance via three separate indicators: The financial performance was measured using three different indicators: ROA (as selected by Velte (2017) and Chen et al. (2023)), ROE (similarly to Naeem et al. (2022) and Kalia and Aggrawal (2022)), and Tobin's Q (such as Giannopoulos et al. (2022) and Sinha Ray and Goel (2023)). For the ESG performance the aggregated ESG score has been considered along with the Environmental, Social, and Governance individual scores. Control variables have been included in order to capture the effect of various financial metrics in relation to a firm's profitability in the existence of an ESG score as it follows: leverage reflects a firm's capital structure and financial risk, influencing both accounting-based performance metrics (ROA, ROE) and market-based valuation (Tobin's Q), price-to-book ratio captures market perceptions of growth potential and over- or undervaluation, directly affecting Tobin's Q, productivity growth signals operational efficiency, which directly contributes to improved profitability, CapEx represents investments in growth opportunities, which can impact future profitability and market expectations of the firm's value, and EBITDA margin captures profitability and operational performance, serving as a key determinant of accounting returns and influencing market perceptions of financial health. A description of the variables included in the analysis is provided

in Table 2 below. All variables, including the underlying data needed for authors' calculations, are extracted from the Refinitiv database.

Table 2. Description of the variables

Variables	Description	Winsorization
ROA	Return-on-assets (%): Net profit/Average total assets	Winsorized at the 1st and 99th percentiles
ROE	Return-on-equity (%): Net profit/Average total equity	Winsorized at 5th and 95th percentiles
TQ	Tobin's Q: calculated by authors by dividing a firm's market capitalization by its total assets	-
ESG	ESG Score: overall company score based on the self-reported information in the environmental, social and corporate governance pillars	-
ENV	Environmental pillar score	-
SOC	Social pillar score	-
GOV	Governance pillar score	
LEV	Financial leverage (%): Total debt/Total equity	Winsorized at 5th and 95th percentiles
PBV	Price-to-book value: Market capitalization/Total equity	Winsorized at 95th percentile
Δ%PROD	Labour productivity (annual % change): calculated by authors by dividing the total revenue of a company by its full-time employees figures	Winsorized at 5th and 95th percentiles
CAPEX	Calculated by authors by dividing a firm's capital expenditures to its total assets (%)	Winsorized at 95th percentile
EBITDA	EBITDA margin (%): Earnings Before Interest, Taxes and Depreciation expressed as a percent of Total Revenue	Winsorized at 5th and 95th percentiles

Source: Authors' computations.

As the initial data cleansing and data analysis revealed outliers were present in the data set mostly due to anomalies resulting from the Great Financial Crisis (GFC) and the COVID-19 crisis, thus requiring the use of the winsorization techniques outlined in Table 2. The ROA exhibited less significant outliers, potentially correlated to the extreme losses during the GFC and the COVID-19 crisis, which in terms proved that winsorizing the data series at the 1st and 99th was sufficient. For the rest of the winsorized variables more severe outliers imposed choosing the 5th and 95th percentiles. A summary of statistics for the variables described so far is presented in Table 3.

Table 3. Descriptive statistics (winsorized data)

Variables	No. of obs.	Mean	Std. Dev.	Min	Max
ROA	1932	3.7298	4.8776	-12.5234	17.5166
ROE	1932	9.7370	11.1162	-17.2726	28.5404
TQ	1932	0.7067	0.6713	0.0124	6.0105
ESG	1894	63.9784	17.3144	5.8737	95.9626
ENV	1894	65.8828	22.1631	0.0000	99.0622
SOC	1894	67.7658	20.9612	0.2635	97.9947
GOV	1894	56.6391	20.5319	1.6972	97.9221
LEV	1929	84.3030	60.5409	9.9270	230.4032
PBV	1932	1.8439	1.2328	0.0000	4.9989
Δ%PROD	1929	3.1504	16.0605	-24.1695	40.7570
CAPEX	1932	4.6976	2.6559	0.0011	10.5373
EBITDA	1932	17.4927	11.1954	4.1819	50.6162

Source: Authors' computations.

Empirical framework

To determine the components of our regression equations, we then test the correlation between the independent variables. Table 4 presents the correlation matrix of our sample of variables and its output allows us to identify high correlation between the aggregate ESG score and its component sub-scores as well as between some of the sub-scores themselves. To avoid multicollinearity issues, we have decided to use each of the scores in separate regression equations for all three dependent variables.

Table 4. Correlation matrix

Variables	ROA	ROE	TQ	ESG	ENV	SOC	GOV	LEV	PBV	Δ%PROD	CAPEX	EBITDA
ROA	1											
ROE	0.88	1										
TQ	0.57	0.43	1									
ESG	0.08	0.13	-0.01	1								
ENV	0.03	0.09	-0.02	0.87	1							
SOC	0.13	0.18	0.08	0.89	0.69	1						
GOV	0.03	0.07	-0.06	0.63	0.30	0.42	1					
LEV	-0.29	-0.11	-0.36	0.18	0.14	0.18	0.11	1				
PBV	0.42	0.46	0.76	0.07	0.05	0.16	0.00	-0.03	1			
Δ%PROD	0.17	0.17	-0.01	0.01	0.01	0.00	0.00	-0.04	-0.04	1		
CAPEX	0.10	0.06	-0.01	-0.11	-0.13	-0.13	-0.04	-0.05	-0.11	-0.02	1	
EBITDA	0.26	0.23	0.15	0.03	-0.02	0.07	0.00	0.16	0.06	0.01	0.27	1

Source: Authors' computations.

The next step in our analysis is to assess the stationarity of the variables, for which we chose to perform the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The results of the unit root tests presented in Table 5 indicate that all variables are stationary at the 90% confidence interval. Intuitively, one would expect for the ESG score and its components to improve over time which led us to perform the stationarity test including the individual intercept and trend. Fo the rest of the financial variables the stationarity has been tested in the presence of an individual intercept only.

Table 5. Panel unit root tests results

Level					
Variables	**Individual Intercept**		**Variables**	**Individual Intercept and Trend**	
	ADF	PP		ADF	PP
ROA	480.132 ***	613.693 ***	**ESG**	362.005 ***	580.018 ***
ROE	472.949 ***	617.740 ***	**ENV**	315.032 *	459.693 ***
TQ	390.311 ***	608.549 ***	**SOC**	331.050 **	536.914 ***
LEV	363.696 ***	348.919 ***	**GOV**	350.469 ***	332.886 **
PBV	379.275 ***	599.297 ***			
Δ%PROD	688.234 ***	1288.58 ***			
CAPEX	476.905 ***	480.869 ***			
EBITDA	371.370 ***	467.514 ***			

Source: Authors' computations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01

The econometric techniques deployed in our analysis consists of panel data regression equations. After refining, we were left with an unbalanced panel consisting of 153 companies spread of the period of 14 years (2010-2023). After running the relevant covariance tests, the conclusion was that the aggregated ESG score and each of the E, S, and G pillars scores should be

specified in different regression equations. Below, a generic representation of the twelve resulting equations can be found.

$$ROA_{it} = \alpha + \beta_1 ESG_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (1)$$

$$ROA_{it} = \alpha + \beta_1 ENV_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (2)$$

$$ROA_{it} = \alpha + \beta_1 SOC_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (3)$$

$$ROA_{it} = \alpha + \beta_1 GOV_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (4)$$

$$ROE_{it} = \alpha + \beta_1 ESG_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (5)$$

$$ROE_{it} = \alpha + \beta_1 ENV_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (6)$$

$$ROE_{it} = \alpha + \beta_1 SOC_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (7)$$

$$ROE_{it} = \alpha + \beta_1 GOV_{it} + \beta_2 LEV_{it}(-2) + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (8)$$

$$TQ_{it} = \alpha + \beta_1 ESG_{it} + \beta_2 LEV_{it} + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (9)$$

$$TQ_{it} = \alpha + \beta_1 ENV_{it} + \beta_2 LEV_{it} + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (10)$$

$$TQ_{it} = \alpha + \beta_1 SOC_{it} + \beta_2 LEV_{it} + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (11)$$

$$TQ_{it} = \alpha + \beta_1 GOV_{it} + \beta_2 LEV_{it} + \beta_3 PBV_{it} + \beta_3 \Delta\%PROD_{it} + \beta_4 CAPEX_{it} + \beta_5 EBITDA_{it} + \beta_6 COVID_{it} + \varepsilon_{it} \quad (12)$$

For an easy understanding of the equations, ROA_{it}, ROE_{it}, and TQ_{it} are our dependent variables for firm i and year t. The independent variable are consisted of ESG_{it}, ENV_{it}, SOC_{it}, and GOV_{it}, while the equations are completed by the inclusion of a set of control variables, namely LEV_{it}, PBV_{it}, $\Delta\%PROD_{it}$, $CAPEX_{it}$, and $EBITDA_{it}$. To capture the effects of the COVID-19 pandemic for the years 2020 and 2021, the $COVID_{it}$ dummy variable has been created. We have specified a two-period lag for LEV_{it}as it is economically sound to assume that when a firm contracts debt, usually for financing investment projects, the positive outcome of the investment will be visible in the financial results, and thus in the ROA and ROE, only in the future periods. When it comes to Tobin's Q, as it is a market-based indicator, the expectation is that the changes in the independent variables will be captured contemporaneously in the market value of a firm – assuming the existence of efficient markets.

Table 6. Hausman test results

Equation	Test summary	Chi-Square Statistic	p-Value
(1)	Fixed effects	183.43	0.0000
(2)	Fixed effects	185.95	0.0000
(3)	Fixed effects	184.19	0.0000
(4)	Fixed effects	179.40	0.0000
(5)	Fixed effects	117.27	0.0000
(6)	Fixed effects	124.90	0.0000
(7)	Fixed effects	112.61	0.0000
(8)	Fixed effects	118.39	0.0000
(9)	Fixed effects	27.307	0.0003
(10)	Fixed effects	26.993	0.0003
(11)	Fixed effects	27.323	0.0003
(12)	Fixed effects	27.161	0.0003

Source: Authors' computations.

Since we have implemented a dummy variable to capture the temporal impact of the COVID-19 crisis on the financial performance of firms no further temporal effects were justified and the Hausman test was only performed for the cross-sectional dimension of our data sample. The results of the Hausman test can be found in Table 6. The test has been performed for each of the twelve regression equation specifications and, based on the output, we can reject the null hypothesis in all cases, meaning that cross-sectional fixed effects are deemed suitable.

Results and discussions

In this section the results of the fixed effects panel regression models are presented, followed by a discussion of these results. The econometric modelling of data as well as the estimation of models was performed using the EViews 10 software.

Table 7 illustrates the results of the regression models (1) – (4), where ROA is the dependent variable. As other studies revealed, such as Aydoğmuș et al. (2022) and Chen et al. (2023), improved ESG performance seems to lead to better financial performance measured thought the ROA. A 1-point increase in the aggregate ESG score is responsible for a modest 0.043 percentage point increase of the ROA. When looking at the component scores, one may notice that only the Social and Governance scores are correlated with an increase in the ROA of approximately 0.033 and 0.024 percentage points respectively. On the other hand, the Environmental score's impact on ROA is not statistically significant. These dynamics can be explained based on the argument that environmental efforts might imply a very high upfront cost for all companies, while in the case of brown sector firms this might imply a loss of business or a downsize of economic activities. Governance related factors may have more a direct positive impact towards a company's financial results when considering improved management practices and cost efficiencies.

Table 7. OLS fixed effects estimations; Dependent variable: ROA

Variables	Equations			
	(1)	(2)	(3)	(4)
ESG	0.0431 ***			
	(4.1084)			
ENV		0.0032		
		(0.3605)		
SOC			0.0325 ***	
			(4.3120)	
GOV				0.0238 ***
				(3.5510)
LEV(-2)	0.0043	0.0047 *	0.0044	0.0045
	(1.5265)	(1.6787)	(1.5825)	(1.6032)
PBV	0.8901 ***	0.8681 ***	0.8630 ***	0.9162 ***
	(6.6141)	(6.4186)	(6.4206)	(6.7699)
Δ%PROD	0.0587 ***	0.0598 ***	0.0584 ***	0.0593 ***
	(11.5746)	(11.7460)	(11.5112)	(11.6842)
CAPEX	0.1452 **	0.1378 **	0.1394 **	0.1349 **
	(2.4910)	(2.3460)	(2.3944)	(2.3127)
EBITDA	0.3547 ***	0.3636 ***	0.3546 ***	0.3574 ***
	(19.5554)	(20.0757)	(19.5718)	(19.7298)
COVID	-1.1919 ***	-0.9921 ***	-1.1952 ***	-1.1443 ***
	(-5.2846)	(-4.4688)	(-5.3105)	(-5.0929)
Adjusted R^2	0.5732	0.5683	0.5737	0.5720
No. of obs.	1612	1612	1612	1612

Source: Authors' computations. Notes: * p < 0.1, ** p < 0.05, *** p < 0.01.
Values in parentheses represent t-statistic.

Firms' financial leverage has a limited impact on ROA, although lagged by two periods, only boasting a small significance when the Environmental score is considered in the model. The Price-to-book variable positively influence ROA across all four estimated models in the range of 0.863 to 0.916. In line with the economic expectations, labour productivity does lead to improved financial performance across all models. The impact can be numerically quantified as an approximately 0.06 percentage point increase in ROA corresponding to a 1 percentage point increase in labour productivity. Capital expenditure, expressed as a % of total assets, also has a positive and significant effect on ROA with a 1 percentage point increase in CAPEX leading to an increase in ROA of as much as 0.145 percentage points. The EBITDA margin is the strongest positive predictor of ROA, as expected, since it directly measures operational profitability. The COVID-19 dummy showcases the strongly negative effect of the pandemic on firms' profitability, in line with the economic reality.

When considering the ROE as a measure of profitability, models (5) – (8) presented in Table 8 produce relatively similar results in terms of the control variables described above. This time leverage has a positive and significant effect on profitability with a 1 percentage point increase corresponding to a an approximately 0.031 percentage points increase in ROE. It is worth noting that when ROE is the dependent variable the price-to-book ratio has a very strong and positive effect on profitability, whilst the COVID-19 pandemic has an effect almost twice as strong than in the case of ROA. These results correlate with the economic intuition as ROE is a shareholder-centric metric influenced by market valuation and equity risks, whereas ROA captures broader operational performance.

Table 8. OLS fixed effects estimations; Dependent variable: ROE

Variables	Equations			
	(5)	(6)	(7)	(8)
ESG	0.0698 ***			
	(2.7238)			
ENV		-0.0011		
		(-0.0494)		
SOC			0.0535 ***	
			(2.9059)	
GOV				0.0519 ***
				(3.1850)
LEV(-2)	0.0304 ***	0.0312 ***	0.0306 ***	0.0305 ***
	(4.4478)	(4.5570)	(4.4864)	(4.4826)
PBV	2.5088 ***	2.4744 ***	2.4648 ***	2.5779 ***
	(7.6426)	(7.5238)	(7.5163)	(7.8275)
Δ%PROD	0.1387 ***	0.1406 ***	0.1381 ***	0.1393 ***
	(11.2147)	(11.3545)	(11.1663)	(11.2859)
CAPEX	0.4356 ***	0.4207 ***	0.4263 ***	0.4182 ***
	(3.0635)	(2.9459)	(3.0010)	(2.9457)
EBITDA	0.6241 ***	0.6389 ***	0.6237 ***	0.6249 ***
	(14.1067)	(14.5073)	(14.1099)	(14.1757)
COVID	-2.4531 ***	-2.1158 ***	-2.4641 ***	-2.4664 ***
	(-4.4591)	(-3.9196)	(-4.4876)	(-4.5108)
Adjusted R^2	0.5081	0.5056	0.5085	0.5090
No. of obs.	1612	1612	1612	1612

Source: Authors' computations. Notes: *** p < 0.01. Values in parentheses represent t-statistic.

In a similar way to Kalia and Aggrawal (2022), the impact of the ESG score on ROE is comparable to the one for ROA, with the difference of having slightly higher coefficients in the case of the aggregated ESG score (approximately 0.07 percentage point increase) as well as for the Social and Governance scores (approximately 0.054 and 0.052 percentage point increase, respectively). The Environmental score is estimated to have a small negative impact on ROE, but without statistical significance.

Table 9. OLS fixed effects estimations; Dependent variable: Tobin's Q

Variables	Equations			
	(9)	(10)	(11)	(12)
ESG	-0.0009 *			
	(-1.6797)			
ENV		-0.0004		
		(-0.8504)		
SOC			-0.0002	
			(-0.5059)	
GOV				-0.0006
				(-1.5678)
LEV	-0.0032 ***	-0.0032 ***	-0.0032 ***	-0.0032 ***
	(-21.7306)	(-21.6852)	(-21.7198)	(-21.7399)
PBV	0.3282 ***	0.3287 ***	0.3286 ***	0.3277 ***
	(45.8832)	(45.9480)	(45.9397)	(45.7013)
Δ%PROD	0.0003	0.0003	0.0003	0.0003
	(1.0464)	(1.0385)	(1.0347)	(1.0150)
CAPEX	0.0036	0.0037	0.0038	0.0038
	(1.2097)	(1.2379)	(1.2753)	(1.2646)

Variables	Equations			
	(9)	(10)	(11)	(12)
EBITDA	0.0064 ***	0.0063 ***	0.0063 ***	0.0064 ***
	(6.3098)	(6.1904)	(6.1920)	(6.2862)
COVID	0.0646 ***	0.0603 ***	0.0608 ***	0.0633 ***
	(4.7729)	(4.5629)	(4.4831)	(4.7208)
Adjusted R^2	0.9162	0.9161	0.9161	0.9162
No. of obs.	1891	1891	1891	1891

Source: Authors' computations. Notes: * p < 0.1, *** p < 0.01. Values in parentheses represent t-statistic.

Table 9 above presents the results of the regression models where Tobin's Q has been used as the dependent variable. In contrast with the ROA and ROE models, in the case of Tobin's Q we identified a negative although not significant impact. One can argue that investors are mostly interested in the financial performance and the fundamental metrics of companies, making ESG less of a priority. Given that a proportion of shareholders might not be interested in ESG performance at all, and given the nature of their economic activity, firms might consider doing the bare minim in terms of ESG efforts and perform only those actions that are compliance driven and imply direct financial or reputational penalties if not complied with. This could be further nuanced when comparing the above results with the ones of Velte (2017), Aydoğmuş et al. (2022) and Sinha Ray and Goel (2023), who obtained similarly weak impacts of ESG score on Tobin's Q, but slightly positive. To the best of our knowledge, we perform one of the first analysis of this kind with a focus solely on brown sector firms.

Concerning the control variables, leverage seems to have a small and constant negative impact across all four models which could be attributed to the fact markets may penalise increased financial risk. Price-to-book ratio captures market confidence and growth expectations, positively influencing Tobin's Q. As expected, operational profitability, measured though the EBITDA margin, has a positive influence towards market valuation, with a 1 percentage point increase in the EBITDA margin being correlated to a 0.0064 increase in Tobin's Q. Lastly, as the COVID-19 pandemic created the premises on extraordinary government and monetary policy support of the economy, the low interest rate environment fuelled stock market investments with most companies seeing a surge in market valuation – thus driving Tobin's Q up by 0.06 – 0.065 across the four models.

Conclusions

The aim of this paper is to analyse the impact of ESG performance on brown sector firms' profitability, being one of the first studies of this kind focusing on firms activating in polluting economic sectors. We use OLS panel fixed effects models for three dependent variables, ROA, ROE, and Tobin's Q, on a sample of 153 EU-listed firms covering the 2010-2023 period.

The obtained results suggest that the ESG score has a positive, amid relatively small, impact on firms' profitability measured though the ROA and ROE. The results are derived from the positive impact of the Social and Governance pillars, whilst the Environmental pillar does not seem to significantly influence financial performance in our sample of firms. One reason for such dynamic is that improving environmental performance in brown sector firms is often very costly and could potentially result in downscaling the economic activity of such firms. From another perspective, reducing a firm's carbon footprint is a long-term process and the results might not be so easily quantifiable as is the case with social or governance initiatives. The sectoral specificities

should be considered as well, as some economic activities are environmentally harming by nature, which in terms could make ESG-oriented investors discount those companies by default.

The results of our study can be considered useful from a two-fold perspective. From a corporate strategy point of view, the results indicate that a quick way of improving a brown sector firm's ESG performance is by focusing on improving its internal governance and minimising its impact and/or add value to the society and affected communities. From regulatory point of view, policymakers can consider these results in weighting future ESG-related legislative initiatives. The current ESG reporting legislation was seen as burdensome by many economic actors, this being one of the reasons for why the European Commission proposed the ESG Omnibus I and Omnibus II packages at the beginning of 2025. Additionally, the shift of policy recently seen in the United States of America adds further pressure on ESG commitments and obligations and academic evidence could be used to justify a perhaps more suitable approach towards improving ESG performance.

One very important topic to be addressed is represented by the heterogeneity between the ESG score calculation methodologies of various external data providers, as discussed by Berg et al. (2022). For availability reasons we use the Refinitiv ESG scores however the impact of the methodological differences can be area of future improvement for our study.

Considering all the above mentioned, our purpose for this study was to contribute to the valuable academic literature in the field of corporate ESG performance while also aiming to add value for both investors and the business environment but also for regulatory authorities. The results are not in favour or against ESG-related corporate efforts but are rather meant to be seen as factual evidence based on the available historical data. Naturally, the research can benefit from potential improvements such as the integration of a GMM (Generalised Method of Moments) for robustness reasons. The modelling can also be enhanced from the perspective of capturing the impact of ESG regulatory changes via the integration of a DiD (Difference-in-Differences) method.

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