REICE
Revista Electrónica de Investigación en Ciencias Económicas
Abriendo Camino al Conocimiento
Área de Conocimiento de Ciencias Económicas y Administrativas
Universidad Nacional Autónoma de Nicaragua, Managua (UNAN-Managua)

Vol. 12, No. 24, julio – diciembre 2024 **REICE ISSN: 2308-782X**
https://revistas.unan.edu.ni/index.php/reice
revista.reice@unan.edu.ni

Exploring the Impact of Environmental Factors on Performance: Empirical Evidence for FTSE100 Companies

Exploración del impacto de los factores ambientales en el desempeño: evidencia empírica para las empresas del índice FTSE100

Fecha de recepción: septiembre 29 de 2024
Fecha de aceptación: octubre 25 de 2024
DOI: https://doi.org/10.5377/reice.v12i24.20111

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Abstract

The purpose of this article is to investigate if certain environmental factors affect performance, with a focus on asset and equity profitability. The issue being addressed is extensively topical, given the current circumstances surrounding environmental concerns and sustainability. Studies that analyze how environmental factors such as pollutant emissions or natural resource use are essential for understanding the long-term impact of economic activities on the environment and society. This provides , providing valuable information for developing more sustainable and environmentally responsible practices and , but also helps to increase the company's performance and image. A sample of companies from the United Kingdom belonging to the FTSE100 stock index is used across a 10-year period10 years, from 2015 to 2024. The quantitative framework incorporates a variety of variables, including performance, indebtedness, liquidity, resource usage factors, and variables related to emissions. The econometric methodology uses the ordinary least squares method to investigate existing interactions, implementing regression models without effects and models with fixed and random effects. Environmental factors have a significant influence on ROA and ROE, according to estimates from several multiple regression modelsAccording to estimates from several multiple regression models, environmental factors have a significant influence on ROA and ROE. Thus, total CO2 emissions, NOx emissions, and expenditures for environmental protection are statistically significant and negatively impact ROA and ROE, while the total renewable energy has a positive influence.

***Keywords*:** Return on Assets; Return on Equity; Environment; Emissions.

Resumen

El objetivo de este artículo es investigar si ciertos factores ambientales afectan el desempeño, con un enfoque en la rentabilidad de activos y patrimonio. El tema que se aborda es de amplia actualidad, dadas las circunstancias actuales en torno a las preocupaciones ambientales y la sostenibilidad. Los estudios que analizan cómo factores ambientales como las emisiones contaminantes o el uso de recursos naturales son esenciales para comprender el impacto a largo plazo de las actividades económicas sobre el medio ambiente y la sociedad, lo que proporciona información valiosa para desarrollar prácticas más sostenibles y responsables con el medio ambiente y, además, ayuda a aumentar el desempeño y la imagen de la empresa. Se utiliza una muestra de empresas del Reino Unido pertenecientes al índice bursátil FTSE100 a lo largo de un período de 10 años, de 2015 a 2024. El marco cuantitativo incorpora una variedad de variables, incluyendo desempeño, endeudamiento, liquidez, factores de uso de recursos y variables relacionadas con las emisiones. La metodología econométrica utiliza el método de mínimos cuadrados ordinarios para investigar las interacciones existentes, implementando modelos de regresión sin efectos y modelos con efectos fijos y aleatorios. Los factores ambientales tienen una influencia significativa en el ROA y el ROE, según estimaciones de varios modelos de regresión múltipleSegún estimaciones de varios modelos de regresión múltiple, los factores ambientales tienen una influencia significativa en el ROA y el ROE. Así, las emisiones totales de CO2, las emisiones de NOx y los gastos para la protección del medio ambiente son estadísticamente significativos e inciden negativamente en el ROA y el ROE, mientras que la energía renovable total tiene una influencia positiva.

Palabras claves: Rentabilidad de los activos; Rentabilidad del capital; Medio ambiente; Emisiones.

Introduction

Environmental factors and their impact on performance are a current topic because these environmental elements have a significant impact and directly influence a company's performance. Eco-friendly practices draw the attention of businesses aiming for a positive image, as companies that generate large amounts of pollution and have a negative impact on the environment are being scrutinized more closely. The focus is on environmental regulations aimed at reducing pollution levels and lowering emission thresholds.

The increasing environmental concern helps quicker implementation of environmental practices, which constitutes a competitive advantage for sustainable development. Wu and Tham (2023) explore the impact of environmental factors such as environmental regulations, environmental performance, and technological innovation on adaptability and capacity for environmental changes, as well as how they support innovation and sustainable development in companies, which is a prime example. The difference between environmental performance and financial performance lies in the fact that environmental performance focuses on the organization's impact on the environment and how it manages these aspects, while financial performance refers to the organization's financial results, such as revenues and expenses, but both aim at targeting maximum profit. With regard to technological innovation and its relationship to financial performance, the focus is on using new technologies to improve processes, reduce environmental impact, and become more competitive in the market. These aspects are also supported by Thompson and Rust (2023), who highlighted that environmental factors such as sustainability, energy efficiency, and social responsibility have a significant impact on financial performance.

In terms of empirical study regarding the impact of environmental factors on performance, it is essential to analyze the impact of environmental factors on performance, especially for companies listed on the FTSE100, as London companies have a major influence on the economy, being an important market. By understanding how environmental factors influence the performance of these

companies, efficient strategies can be developed to enhance performance, which helps investors.

The research issue is current and relevant, with humanity becoming increasingly concerned about the environment. For example, Hristov et al. (2021) observed a rise in environmental issues, facing difficulties in developing practical solutions due to challenging implementation. By efficiently managing environmental issues, companies can improve their reputation and attract more customers interested in sustainability. Implementing responsible environmental practices can help a business reduce long-term operational costs and adapt better to changes.

The aim of the study is to discover whether certain environmental factors influence performance, with the primary goal of a company being to maximize profit, hold a larger market share, satisfy customers, and address management and environmental issues. Empirical evidence is crucial to understanding how these factors impact company performance, reducing risks that could affect profitability and firm value, and making informed decisions for investors.

The objectives that need to be achieved are to demonstrate that a series of environmental variables can lead to performance changes and to try to discover and evaluate how environmental factors influence the performance of companies listed on the London Stock Exchange. Research examining environmental factors such as pollutant emissions or natural resource use is essential for understanding the long-term impact of economic activities on the environment and society. It also provides valuable information for promoting sustainable and responsible environmental practices, thereby enhancing company performance and image.

Empirical findings on the impact of environmental factors on performance and their impact on various stakeholders aim to show that there is a positive relationship between environmental practices and performance. Therefore, according to estimates from multiple regression models, environmental factors have a significant impact on ROA and ROE. Thus, total CO2 emissions, total NOx emissions, and

environmental expenses are statistically significant and have a negative impact on ROA and ROE, while total renewable energy has a positive impact.

Regarding the study, there are still research gaps regarding the effectiveness of environmental implementations to achieve significant performance increases, primarily due to the diversity of environmental factors, secondly because of the limitations of available data that restrict studies, and last but not least, due to the difficulties in measuring the impact on performance, with some findings not being practical in everyday life.

Regarding the "paper contribution" in the research field, the study uses a sample of companies from the United Kingdom belonging to the FTSE100 stock index over 10 years, from 2015 to 2024. The quantitative framework incorporates a multitude of variables, including performance, indebtedness, liquidity, resource utilization factors, and emission variables. The econometric methodology uses the method of ordinary least squares to investigate interactions in this way, implementing regression models without effects and models with fixed and random effects. Additionally, another element considered a "research gap" is the lack of research specifically focusing on this subject in the context of companies listed on the London Stock Exchange. The FTS100 database was chosen because it is an important stock index with relevant financial data found on official websites. Their study provides a broad perspective on how environmental factors influence performance, with the London market being fundamental.

On the other hand, the "paper novelty" of the article is the exploration of the impact of environmental factors on performance, especially the impact of variables related to resource utilization and emissions, such as energy consumption, CO2 emissions, sulfur dioxide, nitrogen, renewable energy, pollutant emissions, and so on, which are current variables of interest. The aim is for the variables used to provide empirical evidence and a detailed analysis of companies in London, with the issue of environmental responsibility being a sensitive subject.

The implications of the study are important for stakeholders as it is necessary to integrate environmental elements into the profit growth process and decision-making, helping to promote social and sustainable responsibility. By understanding the impact of environmental factors on performance, important elements that become risks or obstacles in profit creation can be identified and managed. However, it is concluded that, statistically, these emissions and environmental protection expenditures negatively impact ROA and ROE, while renewable energy has a positive influence.

This paper is divided into six main sections: a brief introduction, the theoretical part summarizing existing studies, the research methodology, a complex case study, and conclusions, followed by references. The first section is the introduction; the second examines existing knowledge and relevant articles related to the discussed subject; the next focuses on how numerical research will be conducted, including detailing the dataset and variables used in the econometric study, as well as presenting the numerical techniques used. The fourth section includes a practical example that combines theory with practice, carried out through a personal econometric study involving multiple regressions and tests to confirm hypotheses, both models without effects and with fixed and random effects. It includes statistical and economic interpretations and comparisons between the obtained results and the analyzed studies. The final section focuses on conclusions and final results.

Review of empirical literature and hypothesis development

Environmental factors are important for a company as they impact production, its image, and its relationships with stakeholders. According to Hristov et al. (2021), environmental factors are essential for the performance management of a business and the efficient management of environmental issues. Studies by Wu and Tham (2023) analyze how environmental regulations and innovation influence a company, focusing on sustainable development and environmental responsibility, as well as the additional financial expenses and effort to implement these regulations.

H1: Expenses for environmental protection have significant negative influences on performance.

Environmental factors can be multiple, but this time, the focus is on factors related to resource utilization such as energy and gas emissions. The studies by Eng et al. (2021) and Mahmoudian et al. (2023) highlight the importance of proper management of toxic substances in companies and their impact on financial performance. In companies that adopt practices for managing toxic substances and reducing emissions, financial performance is better, according to research conducted on firms in the United States and North America.

Gas emissions have implications for environmental responsibility through their effect on air quality. Greenhouse gases, such as carbon dioxide, nitrogen oxide, chemical and organic substances, and emissions from volatile organic compounds (CO2, NOX, SOC, and VOC), are released into the atmosphere, having a negative impact on the environment by contributing to global warming and climate change. This reduction in emissions can contribute to increased profits, especially through well-implemented management practices involving the CEO's involvement. Therefore, emission reduction goes hand in hand with the board of directors in a company, with corporate governance being an important element.

H2: Nitrogen oxide emissions have a significant negative influence on performance.

The decisions made by CEOs can also be influenced by the gender of the CEO. Through his results, Homroy (2023) presents the influence of the CEO's gender on environmental decisions and their impact on profitability. It is concluded that female CEOs are more willing to adopt sustainable strategies, and by reducing emissions, significant increases in profitability can be achieved. Additionally, Kuwornu et al. (2023) discuss the impact of sustainable management practices on company performance and gas emissions, especially carbon dioxide. The implementation of such sustainable practices, like emission reduction and responsible resource management, can lead to significant improvements in

performance and product quality but may also entail additional expenses for environmental protection.

H3: Carbon dioxide consumption negatively impacts performance.

To demonstrate the impact of environmental factors on performance, a good example is represented by reused products and renewable energy, which have a significant sustainability impact, reducing resource consumption and carbon emissions associated with the production of new goods. The adoption of renewable energy is essential, with solar or wind energy being increasingly useful alternatives that reduce the carbon footprint. Claudio Comoglio et al. (2022) underline the importance of reporting environmental sustainability regarding waste-to-energy conversion and its benefits in evaluating the company's environmental impact.

Approaching the topic of renewable energy, Sha (2022) analyzes the impact of natural and energy resources alongside fuel and oil prices, establishing a connection between these elements and sustainable economic performance. Wu et al. (2022) explore the link between natural resources, renewable energy, carbon emissions, and economic performance in various countries, while Sun et al. (2023) focus on the energy sector in China, evaluating the climate impact of renewable energy on performance. Taking a different approach, Wang et al. (2024) emphasize the importance of atmospheric water harvesting technology for energy and energy resource savings, addressing the water-energy connection. Atmospheric water harvesting helps obtain drinking water or water for various purposes without the need for electricity consumption for pumping, treatment, and distribution, positively impacting the environment and resource efficiency. Therefore, adopting renewable energy can have a positive impact on a company's financial performance by improving asset profitability (ROA) through reducing operating costs and dependence on non-renewable resources, thus enhancing asset efficiency and revenue generation.

H4: The total amount of renewable energy has a positive influence on performance.

Methodologies and Data

Description of the database and variables

Companies listed on the London Stock Exchange are evaluated based on their performances, which are determined by variables such as ROA and ROE.

According to Table 1, environmental-related variables include aspects such as the amount of renewable energy, carbon emissions, sulfur emissions, nitrogen emissions, pollutant emissions, as well as environmental protection expenses. As control variables, factors such as tax rate, cash flow, reinvestment rate, dividend policy, and factors like age since establishment and COVID are considered. Some variables are calculated as follows: ROA is calculated as net profit divided by total assets, ROE is the net profit on equity, and so on.

Table 1. Description of the variables

Variables	Acronym	Definition	Formula
PERFORMANCE VARIABLES			
return on assets	ROA	Asset efficiency	net profit/ total assets
return on equity	ROE	Shareholders' investment return	net profit/ equity
INDEBTEDNESS AND LIQUIDITY VARIABLES			
total debt to total assets	DA	Assets financed from other sources	total debt/ total assets
leverage	LEV	Debt influence on capital profitability	total debt/equity
current ratio	CR	Paying short-term debts from current assets	current assets/current liabilities
RESOURCE USE AND EMISSION VARIABLES			
total renewable energy to energy use in million	TRE	Total renewable energy quantity compared to total energy use in million	
total CO2 equivalent emissions	TCO2	Total CO2 emissions compared to revenues in million	

NOx emissions	NOxE	Nitrogen oxide emissions from fossil fuel combustion	
SOx emissions	SOxE	Sulfur dioxide emissions	
VOC emissions	VOCE	Industrial chemical emissions	
water pollutant emissions	WPE	Pollutant emissions in the aquatic environment	
environmental expenditures	EE	Expenses for environmental protection	
CONTROL VARIABLES			
effective tax rate	ETR	tax liability	
free cash flow	FCF	Cash flow	
total assets	SIZE	Total number of assets	
reinvestment rate	RR	expected return invests cash flow	
politica de dividend	DY	profit distribution as dividends to shareholders	
years since founding	vechime	years since establishment	
COVID-19	dummycovid	Coronavirus infection	

Source: Own estimates.

Methods quantitative

From the point of view of how research is conducted, the method of least squares is used to show how certain influences affect the performance of companies present in the FTSE100. We randomly selected 78 firms listed in the FTSE100 to avoid selecting only the best or the weakest companies so as not to influence the results. We included companies with high and low profits to obtain a comprehensive perspective on how environmental factors influence performance.

Different regression models have been created for research, including linear and nonlinear models with fixed and random effects. The appropriate model is chosen using the Hausman test, which is based on data from the Stata program. Correlations between variables presented in the correlation matrix were also

considered when estimating regression models. Variables with correlation coefficients above +/- 0.7 were included in separate regression models.

The data comes from official sources, and articles from ScienceDirect, and the hypotheses are based on them. Information from the case study is extracted from Thomson Reuters. The variables used are found in the companies' official reports and on the Thomson Reuters website. The analysis focuses on key variables in the field of environment and performance. Regression analysis is used to evaluate the relationship between factors, which helps identify and quantify the link between the environment and performance using linear regression models. In this analysis, data limitations like availability and quality may alter or impact the results. Interpretations can also be influenced as the criteria vary.

Therefore, to study the impact of environmental factors on performance, a panel data study is conducted using data from companies in the FTSE100 index over 10 years. Statistical analysis is employed to assess the relationship, considering other control factors. Variables are grouped to ensure the validity and correct interpretation of results by creating variable categories. The general regression form is:

$$DEP_{it} = a_0 + a_1 \times DAT\text{-}LICH_{it} + a_2 \times RESP\text{-}EMIS_{it} + a_3 \times CNTRL_{it}$$

Where:

$a\ 0 = constant;$

$a_1 \ldots a_3 = = coefficients\ corresponding\ to\ variable\ categories;$

$i = [1,78];$

$t = [2015;2024];$

$\varepsilon it = error\ term;$

$DEP = dependent\ variable;$

$DAT\text{-}LICH = variables\ related\ to\ indebtedness\ and\ liquidity$

$RESP\text{-}EMIS = variables\ related\ to\ resource\ usage\ and\ emissions$

$CNTRL = control\ variables.$

Results and discussion

Descriptive statistics and correlation matrix

An empirical study will be conducted to analyze the environmental factors influencing the performance of the 78 companies listed on the London Stock Exchange, included in the FTSE100 stock index. The data will be collected from Thomson Reuters, covering the period 2015-2024.

Table 2 shows descriptive information about the variables used in the empirical analysis of the study. The firm size recorded the maximum value, indicating that the firms are significant and have a considerable history. The minimum average value, 0.03, belongs to the dividend policy. The number of observations varies between a minimum of 87 and a maximum of 780.

Table 2. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
ROA	775	0.086	0.204	-0.139	1.87
ROE	751	0.3	0.774	-1.064	6.641
DA	767	0.248	0.149	0	0.83
LEV	750	1.114	1.406	0	9.714
CR	767	1.59	1.163	0.4	8.11
LOGTRE	298	11.588	2.124	0.788	17.073
LOGTCO2	751	3.568	1.701	-2.996	7.166
LOGNOxE	196	7.815	2.565	0.867	11.768
LOGSOxE	184	6.752	3.595	-4.605	11.765
LOGVOCE	145	6.232	2.553	-1.022	11.533
LOGWPE	87	7.959	1.97	5.037	11.387
LOGEE	210	17.466	2.493	11.035	22.805
ETR	692	0.236	0.193	-0.267	1.318
LOGFCF	570	19.637	1.403	14.179	24.218
LOGSIZE	767	21.775	1.536	17.709	25.835
RR	748	0.129	0.614	-0.692	5.505
DY	740	0.033	0.021	0	0.112
Vechime	780	78.59	62.305	3	327
Dummycovid	780	0.4	0.49	0	1

Source: Own estimates.

Table 3 highlights the correlations between variables. To have strong correlations, correlation coefficients must be above 0.5. If they are below this

threshold, the relationships between variables are weaker. Most coefficients are below 0.5, indicating weak correlations and reducing the probability of multicollinearity. However, we also have strong correlations between ROE - ROA, RR - ROA, RE - ROE, LEV - DA, WPE - CR, SOXE - NOXE, VOCE - NOXE, EE - NOXE, VOCE - SOXE, WPE - VOCE, EE - VOCE, SIZE - FCF, and DY - SIZE.

Table 3. Correlation matrix

Variables	(1) ROA	(2) ROE	(3) DA	(4) LEV	(5) CR	(6) LOGTRE	(7) LOGTCO2	(8) LOGNOxE	(9) LOGSOxE	(10) LOGVOCE
(1) ROA	1									
(2) ROE	0.788	1								
(3) DA	-0.177	-0.094	1							
(4) LEV	-0.095	0.034	0.659	1						
(5) CR	0.06	-0.052	-0.284	-0.268	1					
(6) LOGTRE	0.149	0.018	-0.016	-0.085	0.093	1				
(7) LOGTCO2	-0.269	-0.209	0.231	0.122	-0.13	-0.315	1			
(8) LOGNOxE	0.242	0.247	-0.339	-0.036	-0.062	-0.164	0.321	1		
(9) LOGSOxE	0.289	0.26	-0.462	-0.305	0.291	-0.246	0.151	0.902	1	
(10) LOGVOCE	-0.031	-0.291	-0.226	-0.337	0.221	0.047	0.384	0.565	0.626	1
(11) LOGWPE	0.256	0.097	-0.007	-0.161	0.709	0.06	-0.065	0.289	0.441	0.816
(12) LOGEE	0.177	0.188	-0.385	-0.131	0.012	-0.388	0.076	0.619	0.427	0.557
(13) ETR	-0.096	-0.046	0.04	0.022	-0.011	-0.064	0.113	0.022	-0.007	0.219
(14) LOGFCF	-0.067	-0.072	0.088	0.139	-0.136	0.129	0.058	-0.072	-0.093	0.119
(15) LOGSIZE	-0.356	-0.214	-0.076	0.107	-0.121	-0.121	0.254	0.177	0.087	0.279
(16) RR	0.865	0.852	-0.092	0.026	-0.015	0.126	-0.231	0.23	0.259	-0.001
(17) DY	-0.148	-0.096	0.013	0.035	-0.101	0.16	0.13	0.002	-0.004	0.36
(18) vechime	-0.098	-0.097	-0.066	-0.007	0.042	0.174	-0.062	0.183	0.264	0.483
(19) dummycovid	-0.045	-0.03	0.102	0.034	0.036	0.02	-0.063	-0.137	-0.163	-0.144

Variables	(11) LOGWPE	(12) LOGEE	(13) ETR	(14) LOGFCF	(15) LOGSIZE	(16) RR	(17) DY	(18) vechime	(19) dummycovid	
(11) LOGWPE	1									
(12) LOGEE	0.268	1								

(13) ETR	0.198	0.059	1							
(14) LOGFCF	0.37	0.201	-0.054	1						
(15) LOGSIZE	0.035	0.099	0.096	0.629	1					
(16) RR	0.276	0.169	-0.075	-0.031	-0.288	1				
(17) DY	-0.161	-0.217	0.069	0.447	0.534	-0.109	1			
(18) vechime	0.453	0.089	0.097	0.143	0.11	-0.055	0.106	1		
(19) dummycovid	-0.042	-0.002	0.066	0.14	0.083	-0.02	0.003	0.026	1	

Source: Own estimates.

Regression results

This study used models without effects and models with fixed and random effects for the case study development. Linear regression models were constructed, and the appropriate model was selected based on the Hausman test, considering the 5% probability values for those with effects. Models with probabilities below 5% are considered to have fixed effects, while those with probabilities above 5% are classified as random effects models. Finally, FE denotes models with fixed effects, while RE represents regressions with random effects.

The results highlight the study's findings, and each table is interpreted separately, focusing on the dominant independent variable in relation to the dependent variables used in the study and emphasizing the significant ones. It is observed that some variables are significant only in certain regression models, with various combinations of dependent variables.

Each table will be analyzed individually, and the results obtained will be compared with previous research, providing explanations for similarities or differences, both from an econometric perspective and an economic perspective of influences.

Starting with Table 4, the results of regression models without effects on the determinants of the ROA variable are presented. In this case, the leverage variable

is statistically significant at a threshold of 0.01 and 0.1. The independent variable LEV has a negative influence on the dependent variable ROA, so a 1% change in LEV statistically leads to a decrease of 0.01 in ROA. This negative influence may arise from the abusive use of debt to finance company operations, involving interest payments and other debt-related costs that can reduce profit and ROA. Moreover, if a company has high debt levels in its portfolio, this can serve as a warning signal for creditors and potential investors.

The effective tax rate variable shows a statistically significant negative impact at a threshold of 0.001, and a 1% change in ETR will lead to a statistically significant decrease of around 0.2 on average. This can occur because high tax costs reduce profit; it can lower profitability as income taxes are paid instead of being invested in other areas, and ultimately, it can impact investments by limiting available funds for investment as the company needs to pay taxes. Additionally, the dividend policy variable also exhibits a negative influence and is statistically significant at a threshold of 0.001. Therefore, the negative impact on ROA could be due to reducing available capital for reinvestment, limiting funding for new projects and expansion, and potentially confusing investors into believing that the company lacks growth opportunities. Another significant negative influence on ROA comes from the total debt to total assets variable, albeit at a statistical significance level of 0.10. This negative impact can be explained by the costs associated with debts and the increased financial risk if the level is high, indicating vulnerability.

COVID-19 is statistically significant and has a positive impact in this case, so a 1% change in this indicator will result in a statistically significant increase of 0.1 in ROA. This is surprising, considering that during the pandemic, revenues decreased, and there were changes in consumer behaviors. The variables CR do not show influences in these regression models and will not be commented on. Additionally, we have an influence value of 0, but we find positive statistical significance for TRE, FCF, SoXe, WPE, and age and negative for TCO2, NOxE, EE, VOCE, and size. In this situation, all four hypotheses found in the knowledge stage are confirmed.

Table 4. Results of regression models without effects on the determinants of the ROA variable.

	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
LEV	-0.01		-0.03†				-0.01**			
	(-1.07)		(-2.11)				(-2.89)			
CR	0	0			0.01					
	(-0.50)	(-0.77)			-0.51					
TRE	0	0.00†	0	0	0.00**	0	0	0		
	-1.64	-1.72	-0.5	-0.35	-3.21	-1.06	-0.82	(-0.90)		
TCO2	0	0	-0.00*	-0.00*	0	0	0	-0.00***	0	0
	(-0.56)	-0.02	(-2.50)	(-2.38)	-0.64	-1.32	-1.23	(-6.44)	-0.89	(-1.21)
NOxE	0	-0.00†							0	
	(-0.71)	(-1.87)							(-1.23)	
ETR	-0.06*	-0.05*	-0.30**	-0.28*	0	-0.01	-0.02	-0.11**	-0.12***	-0.12**
	(-2.37)	(-2.26)	(-3.25)	(-2.82)	(-0.17)	(-0.64)	(-0.99)	(-3.20)	(-3.58)	(-3.31)
FCF	0	0			0.00***			0.00***	0.00**	
	-1.24	-1.35			-4.65			-5.92	-3.31	
DY	-0.71*	-0.71*			-1.60***			1.75**	-0.34	
	(-2.37)	(-2.45)			(-4.86)			-3.21	(-0.85)	
vechime	0.00*	0.00**	0	0	0.00***	0	0	-0.00†	0	0
	-2.56	-2.94	-1.02	-0.92	-4.9	-1.26	-1.04	(-1.92)	-1.33	-0.12
dummycovid	0.01	0.01	0.02	0.02	0	0	0	0.01*	0	0.02
	-0.39	-0.59	-1.76	-1.52	-0.05	-0.13	(-0.05)	-2.33	-0.51	-1.43
DA		-0.08		-0.21†		-0.13*				
		(-1.38)		(-1.84)		(-2.40)				
SOxE			0	0				0.00**		0.00†
			-0.57	-0.55				-4.4		-1.96
WPE			0.00*	0.00†				0	0	0
			-2.38	-2.14				-1.53	(-0.68)	-0.45
EE			-0.00*	-0.00†				-0.00**		-0.00†
			(-2.37)	(-1.84)				(-3.76)		(-1.83)
SIZE			0	0		-0.00†	0			0
			-0.84	-0.44		(-1.67)	(-1.22)			-0.31
VOCE					-0.00*	0	0			
					(-2.43)	(-0.43)	(-0.26)			
_cons	0.10***	0.11***	0.11	0.14†	0.05**	0.10***	0.08***	0.09***	0.09***	0.08***
	-3.51	-3.67	-1.65	-1.93	-3.34	-4.02	-4.27	-5.1	-5.41	-6.26
F statistic	3.22**	3.43**	11.43***	10.50***	7.39***	1.95†	2.33*	36.29***	4.79***	2.32*
R-sq	0.35	0.35	0.92	0.91	0.57	0.22	0.26	0.97	0.45	0.29
Obs	72	75	21	21	61	66	63	21	56	54

Source: Own estimates. *** highlights statistical significance at a threshold of 0.001. ** highlights statistical significance at a threshold of 0.01. * highlights statistical significance at a threshold of 0.05, † highlights statistical significance at a threshold of 0.10. The statistical values are presented in parentheses.

Table 5, containing the results of regression models without effects on the determinants of the ROE variable, shows some important variables and their influence on ROE. The leverage is statistically significant at a threshold of 0.10 and has a positive influence, so a 1% change in LEV will result in a statistically significant increase of 0.04 in ROE. This happens due to high costs and the high level of debt that affects profitability. Another variable with a positive influence is the COVID-19 variable, significant at thresholds of 0.05 and 0.10, positively changing ROE by an average of 0.05. In contrast to many companies, it seems that for the analyzed companies, the COVID pandemic has added value to the business by adapting to new situations due to digitization and online commerce, recording profit increases. Customers prefer to buy online rather than expose themselves to pandemic risks.

The current liquidity ratio is Statistically significant and has a negative impact on ROE. This leads to a 0.2 decrease in ROE with a 1% change. It is possible that when liquidity is too low to cover current obligations, the company is sometimes forced to sell assets at an undervalued price to have funds available to cover debts. The effective VAT rate is also statistically significant and has a negative influence; a high rate reduces profit and available funds for other development purposes. Additionally, the dividend policy, statistically negatively influencing ROE by up to 4.66, should be carefully managed to avoid impacting ROE adversely. It is essential for the company not to employ an aggressive or inappropriate dividend policy that could lead to a significant negative impact on ROE.

The independent variable DA is significant at a threshold of 0.05 and has a negative influence on ROE, statistically changing ROE by 0.59 when DA changes by 1%. Typically, excessive indebtedness is perceived as a risk that impacts profit, value, investors, and ROE.

Variables TCO2, NOxE, EE, age, and FCF, WPE exhibit a statistically significant negative and positive influence on the dependent variable ROE, respectively. Variables TRE, SoxE, SIZE, and VOCE do not show any influence. Hypotheses H2 and H3 are confirmed: Nitrogen oxide emissions have a significant negative impact on performance, and carbon dioxide consumption negatively affects

performance. These are crucial statements supported by Mahmoudian et al. (2023), as both gases contribute to climate change and air pollution, negatively impacting performance from both human health and environmental perspectives.

Table 5. Results of regression models without effects on the determinant factors of the ROE variable.

	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
LEV	0.04†		0.03				0			
	-1.89		-1.31				-0.15			
CR	-0.04*	-0.06**			-0.23**					
	(-2.54)	(-3.00)			(-3.08)					
TRE	0	0	0	0	0	0	0	0		
	-0.11	-0.74	-0.72	-0.78	-1.47	(-0.15)	(-1.03)	-0.15		
TCO2	0	-0.00**	0	0	-0.00*	-0.00*	0	0	0.00†	0
	(-0.36)	(-3.04)	(-0.99)	(-0.99)	(-2.03)	(-2.34)	(-1.40)	(-0.93)	-1.91	(-0.19)
NOxE	-0.00†	0							-0.00*	
	(-1.70)	-0.96							(-2.14)	
ETR	-0.04	-0.1	-0.28	-0.30†	-0.1	-0.03	-0.05	-0.34**	-0.06	-0.16†
	(-0.66)	(-1.27)	(-1.77)	(-1.82)	(-1.04)	(-0.32)	(-0.63)	(-3.33)	(-0.65)	(-1.94)
FCF	0	0			0.00*			0	0.00*	
	-0.86	(-0.20)			-2.02			(-0.53)	-2.45	
DY	-3.37***	-2.83**			-4.66*			0.45	-1.22	
	(-4.32)	(-2.88)			(-2.51)			-0.27	(-1.13)	
vechime	0	0	0	0	0.00*	-0.00†	-0.00*	0	-0.00†	-0.00**
	-1.17	(-0.29)	-1.75	-1.76	-2.67	(-1.75)	(-2.40)	-1.03	(-2.00)	(-2.69)
dummycovid	0.02	0.02	0.04†	0.04*	0.01	0.03	0.02	0.05*	0.04	0.07*
	-0.48	-0.4	-2.18	-2.36	-0.17	-0.55	-0.58	-2.76	-1.38	-2.46
DA		-0.47*		0.21		-0.59*				
		(-2.24)		-1.16		(-2.55)				
SOxE			0	0				0		0
			(-0.43)	(-0.43)				(-0.04)		-1.59
WPE			0.00***	0.00***				0.00***	0.00†	0.00**
			-4.82	-5.05				-8.05	-1.75	-2.85
EE			0	0				0		-0.00*
			(-1.02)	(-1.18)				(-0.93)		(-2.50)
SIZE			0	0		0	0			0
			(-0.42)	(-0.18)		(-1.51)	(-1.41)			-0.78
VOCE					0	0	0			
					(-0.66)	-0.66	-1.15			
_cons	0.39***	0.65***	0.05	0.02	0.55***	0.60***	0.43***	0.11†	0.27***	0.23***
	-5.43	-6.26	-0.46	-0.16	-6.68	-5.63	-6.57	-1.95	-5.8	-7.91
F statistic	4.62***	3.28**	25.69***	24.86***	2.99**	2.14*	1.67	22.35***	3.29**	3.03**
R-sq	0.44	0.35	0.96	0.96	0.35	0.23	0.2	0.96	0.36	0.35

Obs	69	72	21	21	61	66	63	21	56	54

Source: Own estimates. *** highlight statistical significance at a threshold of 0.001. ** highlight statistical significance at a threshold of 0.01. * highlight statistical significance at a threshold of 0.05, † highlight statistical significance at a threshold of 0.10. The values of the statistics are presented in parentheses.

Regarding Table 6, the robustness of the results of the models without effects is tested using those with fixed and random effects. The current liquidity ratio variable (CR) becomes significant at a threshold of 0.001 and has a negative influence because this could imply difficulties obtaining cash from asset sales. All other variables maintain the same statistical significance, negatively influencing ROA variables LEV, ETR, DY, and DA, and positively only influencing the COVID variable.

The independent variables TCO2, EE, and VOCE have no influence, but they exhibit the same negative significance. The variable age changes its statistical significance from positive to negative because the older the company, the more likely it is to have inefficient assets, thus decreasing ROA. The variables FCF, SoxE, and WPE do not show influence but are positively significant. In this case, the variables TRE and SIZE do not show significance, although they had statistical significance in the regression models without effects. Only the hypothesis with negative influence is confirmed: H1: Environmental protection expenses have a significant negative impact on performance, H2: Nitrogen oxide emissions have a significant negative impact on performance and H3: Carbon dioxide consumption negatively influences performance. Hypothesis H4 is not confirmed: The total amount of renewable energy has a positive influence on performance. The hypothesis H4 is not confirmed because the study results indicate that there is no significant positive influence of the total amount of renewable energy on performance, as expected and based on previous studies. This outcome may be due to certain variables or external factors that could suggest that the relationship between renewable energy and performance is more complex than anticipated.

Table 6. Results of regression models with fixed and random effects on the determinant factors of the ROA variable.

	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
LEV	-0.01*		-0.03*				-0.01**			
	(-2.08)		(-2.11)				(-3.08)			
CR	-0.02***	-0.02***			0.01					
	(-6.64)	(-4.75)			-0.64					
TRE	0	0	0	0	0	0	0	0		
	(-1.14)	-1.57	-0.5	-0.35	(-0.73)	-0.6	-0.8	(-0.90)		
TCO2	-0.00**	0	-0.00*	-0.00*	0	0	0	-0.00***	0	-0.00***
	(-3.32)	(-0.91)	(-2.50)	(-2.38)	(-1.51)	-0.9	-0.39	(-6.44)	-0.89	(-4.51)
NOxE	0	-0.00*							0	
	(-0.83)	(-2.13)							(-1.23)	
ETR	-0.02	-0.03*	-0.30**	-0.28**	0.01	-0.02	-0.02	-0.11**	-0.12***	-0.15***
	(-1.32)	(-1.96)	(-3.25)	(-2.82)	-0.87	(-1.39)	(-1.52)	(-3.20)	(-3.58)	(-5.52)
FCF	0.00***	0.00**			0.00***			0.00***	0.00***	
	-5.17	-2.7			-6.44			-5.92	-3.31	
DY	-1.92	-1.02*			-0.6			1.75**	-0.34	
	(-0.39)	(-2.31)			(-0.09)			-3.21	(-0.85)	
vechime	0	0.00†	0	0	-0.00**	0	0	-0.00†	0	0
	(-0.00)	-1.84	-1.02	-0.92	(-2.85)	-0.93	-1.08	(-1.92)	-1.33	-0.61
dummycovid	0.01	0.01	0.02†	0.02	0	0	-0.01	0.01*	0	0
	-1.03	-0.82	-1.76	-1.52	(-0.17)	(-0.36)	(-0.88)	-2.33	-0.51	-0.14
DA		-0.11		-0.21†		-0.17**				
		(-1.64)		(-1.84)		(-2.68)				
SOxE			0	0				0.00***		0
			-0.57	-0.55				-4.4		(-0.95)
WPE			0.00*	0.00*				0	0	0
			-2.38	-2.14				-1.53	(-0.68)	-0.46
EE			-0.00*	-0.00†				-0.00***		0
			(-2.37)	(-1.84)				(-3.76)		(-0.70)
SIZE			0	0		0	0			0
			-0.84	-0.44		-0.49	-1.25			-0.2
VOCE					-0.00**	-0.00**	-0.00*			
					(-2.89)	(-2.59)	(-2.55)			
_cons	0.24	0.15***	0.11†	0.14†	0.37	0.10**	0.06†	0.09***	0.09***	0.07

	-1.09	-4.12	-1.65	-1.93	-1.64	-2.61	-1.81	-5.1	-5.41	-0.47
F statistic	12.79***				7.40***					10.09***
R-sq	0.74				0.64					0.69
Obs	72	75	21	21	61	66	63	21	56	54
Prob>chi2	0.0357	0.0852	0.3026	0.0677	0.0332	0.6663	0.4282	0.0875	0.1217	0.0199
FE/RE	FE	RE	RE	RE	FE	RE	RE	RE	RE	FE

Source: Own estimates. *** highlight statistical significance at a threshold of 0.001. ** highlight statistical significance at a threshold of 0.01. * highlight statistical significance at a threshold of 0.05, † highlight statistical significance at a threshold of 0.10. The values of the statistics are presented in parentheses.

Regarding Table 7, the variables CR, ETR, and DY maintain their statistical significance and negative influence, while the pandemic variable remains statistically positive.

Variables with no influence but statistically significant in a positive way are FCF and WPE, and the age-independent variable is added, which was negative in models without effects. In terms of statistically negative influence, only the variable EE remains at this stage, and the VOCE variable is added, which was not significant in models without effects. Additionally, the NOxE variable loses its negative significance and becomes statistically insignificant in models with effects. The remaining variables, LEV, TRE, TCO2, DA, SoxE, and size, are not significant in these models.

Only hypothesis H1 is confirmed: Environmental protection expenses have significant negative influences on performance. Statement H1 is difficult to prove because environmental protection expenses do not generally have significant negative influences on performance; on the contrary, environmental protection investments can bring significant benefits both economically and in terms of social and sustainability by reducing pollution.

Table 7. Results of regression models with fixed and random effects regarding the determinants of the ROE variable.

	1	2	3	4	5	6	7	8	9	10
LEV	0.01		0.03				-0.01			
	-0.65		-1.31				(-0.63)			
CR	-0.02**	-0.01			0.02					
	(-2.78)	(-1.55)			-0.23					
TRE	0	0	0	0	0	0	0	0		
	(-0.56)	(-0.70)	-0.72	-0.78	(-0.14)	(-0.59)	(-0.86)	-0.15		
TCO2	0	0	0	0	0	0	0	0	0	0
	(-1.18)	-0.06	(-0.99)	(-0.99)	-0.65	-0.36	(-0.24)	(-0.93)	(-0.67)	(-0.19)
NOxE	0	0							0	
	(-1.26)	(-1.23)							(-1.32)	
ETR	-0.02	-0.06	-0.28†	-0.30†	0.01	-0.04	-0.03	-0.34***	-0.15*	-0.16†
	(-0.71)	(-1.57)	(-1.77)	(-1.82)	-0.16	(-1.07)	(-0.87)	(-3.33)	(-2.10)	(-1.94)
FCF	0.00**	0.00**			0.00*			0	0	
	-3.06	-3.09			-2.58			(-0.53)	-0.75	
DY	-3.27*	34.52**			50.44*			0.45	56.97*	
	(-2.21)	-2.7			-2.13			-0.27	-2.46	
vechime	0	0.01	0.00†	0.00†	-0.01†	0	0	0	0	-0.00**
	(-0.12)	-1.12	-1.75	-1.76	(-2.00)	(-0.42)	(-1.12)	-1.03	-1.02	(-2.69)
dummycovid	0.02	0.03†	0.04*	0.04*	0.01	0.02	0.01	0.05**	0.01	0.07*
	-1.24	-1.83	-2.18	-2.36	-0.82	-0.97	-0.67	-2.76	-0.53	-2.46
DA		0.05		0.21		-0.24				
		-0.22		-1.16		(-1.15)				
SOxE			0	0				0		0
			(-0.43)	(-0.43)				(-0.04)		-1.59
WPE			0.00***	0.00***				0.00***	0	0.00**
			-4.82	-5.05				-8.05	-0.31	-2.85
EE			0	0				0		-0.00*
			(-1.02)	(-1.18)				(-0.93)		(-2.50)
SIZE			0	0		0	0			0
			(-0.42)	(-0.18)		-0.8	-0.76			-0.78
VOCE					-0.00†	0	0			
					(-1.75)	(-0.99)	(-0.77)			
_cons	0.42***	-1.42*	0.05	0.02	-0.73	0.33*	0.39**	0.11†	-2.36**	0.23***
	-4.53	(-2.58)	-0.46	-0.16	(-0.94)	-2.06	-3.09	-1.95	(-2.72)	-7.91
F statistic		4.18***			2.45**				3.95***	
R-sq		0.49			0.37				0.44	

Obs	69	72	21	21	61	66	63	21	56	54
Prob>chi2	0.6618	0.0312	0.129	0.0528	0.0469	0.4036	0.2577	0.0949	0.035	0.936
FE/RE	RE	FE	RE	RE	FE	RE	RE	RE	FE	RE

Source: Own estimates. *** highlight statistical significance at a threshold of 0.001. ** highlight statistical significance at a threshold of 0.01. * highlight statistical significance at a threshold of 0.05, † highlight statistical significance at a threshold of 0.10. The values of the statistics are presented in parentheses.

Conclusion

The research hypotheses are validated and confirmed to synthesize the most essential findings from an econometric perspective. Concerning the concepts and conclusions of the individual case study, the main results of the analysis show that environmental factors have a significant influence on ROA and ROE. Thus, total CO2 emissions, NOx emissions, and environmental protection expenses are statistically significant and have a negative impact on ROA and ROE, while total renewable energy has a positive effect. This is validated in some regression models, while in others, they do not show statistical significance to be commented on.

In the context of the limitations identified within the research regarding the number of words used, to give the study greater complexity and for further research, it would be appropriate to introduce more explanatory variables, including macroeconomic variables. Moreover, expanding the research to a larger sample of companies included in the FTSE100 stock index would bring significant benefits.

To provide guidance and useful recommendations for investors, managers, and decision-makers based on the study's conclusions, it is recommended that investors consider environmental factors in the investment decision-making process, as this aspect can positively influence financial performance, sustainability, and risk management. Companies that integrate environmental factors can identify greater investment opportunities and attract investors interested in ESG aspects and more, leading to business development.

It is important for those interested in the field of financial markets to investigate the correlation between environmental variables and performance, whether we refer to ROA or ROE. This allows us to evaluate more precisely the efficiency,

performance changes, and sustainability of a company in the current context of climate change and stringent environmental requirements. Investors can make more informed decisions, and companies can more easily attract the capital needed to maintain their activities and achieve their goals. Therefore, the inclusion of environmental factors in financial analyses is becoming increasingly relevant in today's business landscape.

In conclusion, the subject is extremely complex, based on a comprehensive analysis of articles and a variety of variables to investigate regarding the multitude of environmental variables. Overall, the impact of certain environmental factors on a company's performance has been highlighted, and the study's conclusions demonstrate that environmentally-focused enterprises can reduce risk and achieve superior long-term financial results, translating into significant economic benefits and performance growth.

Acknowledgment

This paper was co-financed by The Bucharest University of Economic Studies during the PhD program.

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