



Financial Performance and Corporate Social Responsibility: Evidence from Mexican Stock Market Firms (2014–2024)

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Abstract. This study analyzes the relationship between corporate social responsibility (CSR), measured through ESG scores, and the financial performance of companies listed on the S&P/BMV Index of the Mexican Stock Exchange (BMV) during the period 2014 n–2024. Using a quantitative, longitudinal, and non-experimental approach, covariance models (ANCOVA), random forest algorithms, and probit models were applied to evaluate the influence of sustainable practices on key indicators such as ROA, ROE, EBITDA, liquidity, leverage, and volatility. The results reveal a positive and significant association between ESG and profitability indicators (ROA and ROE), while the rest of the indicators present heterogeneous effects. The random forest model confirms the predictive relevance of the ESG score, and the probit model indicates a higher probability of high financial performance among companies with better sustainable practices, although without robust statistical significance. reinforce the strength of the findings. These results, reinforced by cross-validation and robustness tests, confirm that CSR can be a competitive advantage, contributing to both the economic and social objectives of companies.

Keywords: Corporate social responsibility; Financial performance; ESG; Mexican Stock Exchange; Random Forest; Probit Model; ANCOVA.

Desempeño financiero y responsabilidad social empresarial: evidencia de las empresas del mercado bursátil mexicano (2014–2024)

Resumen: Este estudio analiza la relación entre la responsabilidad social corporativa (RSC), medida a través de puntajes ESG, y el desempeño

financiero de las empresas que cotizan en el Índice S&P/BMV de la Bolsa Mexicana de Valores (BMV) durante el período 2014–2024. Mediante un enfoque cuantitativo, longitudinal y no experimental, se aplicaron modelos de covarianza (ANCOVA), algoritmos de random forest y modelos probit para evaluar la influencia de las prácticas sostenibles en indicadores clave como ROA, ROE, EBITDA, liquidez, apalancamiento y volatilidad. Los resultados revelan una asociación positiva y significativa entre los puntajes ESG y los indicadores de rentabilidad (ROA y ROE), mientras que el resto de los indicadores presenta efectos heterogéneos. El modelo random forest confirma la relevancia predictiva del puntaje ESG, y el modelo probit indica una mayor probabilidad de alto desempeño financiero entre las empresas con mejores prácticas sostenibles, aunque sin significancia estadística robusta. Estos resultados, reforzados mediante validación cruzada y pruebas de robustez, confirman que la RSC puede constituir una ventaja competitiva, contribuyendo tanto a los objetivos económicos como sociales de las empresas.

Palabras clave: Responsabilidad social corporativa; Desempeño financiero; ESG; Bolsa Mexicana de Valores; Random Forest; Modelo Probit; ANCOVA.

1. Introduction

In the Mexican case, research indicates that corporate social responsibility (CSR) is linked to the financial performance of companies. There is new interest in CSR-related initiatives among Mexican companies, yet there is a gap in our understanding of how financial elements incentivize the adoption of CSR policies and their impact on organizational strategic decisions.

Although multiple studies have been conducted on the relationship between CSR and financial performance in international contexts, the empirical evidence for the Mexican case remains limited and scattered. A systematic search of databases such as Scopus and Web of Science reveals that less than 5% of studies on the CSR–financial performance nexus in Latin America focus specifically on Mexican listed firms (Godinez-Reyes et al., 2025; Ospina-Mateus et al., 2023). This limited empirical coverage, particularly in studies that employ hybrid methodological frameworks like the one presented here, underscores a persistent gap in the literature and reinforces the academic and practical relevance of this research.

While research has discussed the “impact” of CSR, it is important to clarify that the methodological design used allows for identification of adjusted associations but not for the establishment of strict causal relationships, as endogeneity is not completely controlled for and experimental or quasi-experimental strategies are not employed. This distinction is crucial for interpreting results rigorously.

According to Lara (2021), Min & Leong (2024), and Esparza-Rodriguez et al. (2024), CSR is a distinctive feature of some Mexican companies that generates benefits such as strengthened competitiveness through more solid profitability, improved corporate reputation, and greater internal cohesion.

On the other hand, Zúñiga (2024) noted that there is a strong direct association between environmental, social, and governance (ESG) scores, suggesting that Latin American companies are seeking to improve aspects related to CSR (Firmino & Peixoto, 2025; Hluzko et al., 2024; Possebon et al., 2024). Findings elsewhere highlight that a company’s decision to take CSR actions is linked to total asset size (Uyar et al., 2024).

In the case of financial performance, Coelho et al., (2023), Barauskaite & Streimikiene (2021) and Weber (2008) all pointed toward the need to measure the impact of CSR on a company’s financial results. However, as mentioned by Dzage and Szabados (2024), Lemana et al. (2025), López Pérez et al. (2024), and Méndez et al., (2019), there is no consensus among scholars on the direction and nature of this relationship, so this represents an area of opportunity in research.

On this basis, in the present study, CSR-related factors for companies listed on the BMV in the period 2014–2024 are identified. Therefore, the following research question is proposed: What is the relationship between CSR and financial performance in the case of BMV companies? More specifically, the purpose of this study is to evaluate the relationship between CSR implementation and the financial performance of BMV companies in the period 2014 to 2024, considering both traditional financial indicators and ESG metrics, in order to identify consistent patterns that guide future corporate and sustainable investment decisions.

Following this approach, the following general hypothesis is proposed:

H₀: Investment in CSR did not have a significant effect on the financial performance of BMV companies in the period 2019–2024.

This hypothesis will be empirically tested using statistical and machine learning techniques, based on a set of financial indicators and ESG metrics.

The remainder of this paper is structured as follows: the next section presents a review of the relevant literature and theoretical framework in support of the relationship between CSR and financial performance. Then, the methodology and data used in the empirical analysis are described. This is followed by a presentation of the results and a discussion of their implications. Finally, the paper concludes with key findings, limitations, and suggestions for future research.

Literature Review

CSR has become increasingly relevant as a key strategy in the global business environment. Several studies agree that sustainable investments have significantly increased in recent decades, consolidating CSR as a competitiveness factor. According to Al frijat & Elamer (2025), Renneboog et al., (2008), and Ziegler & Schröder (2010), CSR has generated growing interest from the financial market as a key component in business valuation, in both developed and emerging economies (Bonsu et al., 2024; Rahat & Nguyen, 2023). In the case of Mexico, this trend responds to increasing pressure from consumers, investors, and regulators towards more responsible practices, especially among companies listed on the BMV (Allen et al., 2025; López Sarabia et al., 2021; Sosa et al., 2022).

From a theoretical perspective, CSR is closely related to stakeholder theory. Freeman (2010) argued that managers should consider the interests of all groups that may be affected by corporate decisions, thus promoting more inclusive governance. In turn, Porter & Kramer (2019) developed the concept of shared value, whereby companies not only generate economic benefits but also strengthen social fabric through responsible practices. These

ideas are complemented by the argument ventured by Flammer (2013) that environmental initiatives—an essential component of CSR—have diminishing marginal returns, but their negative effects on financial performance are lower for firms with a more consolidated CSR culture.

Empirically, the relationship between CSR and financial performance has been the subject of extensive debate. Waddock and Graves (1997) proposed that companies with better financial performance have more resources to invest in sustainability, while Ben Saad and Belkacem (2022) demonstrated a positive correlation between the adoption of ESG practices and financial profitability indicators. In the Latin American context, Zúñiga (2024) found a significant association between ESG scores and the size of companies' assets, suggesting that large corporations lead the way in sustainability initiatives. Sharma and Chakraborty (2024) proposed that CSR contributes to improving financial performance, especially in highly competitive environments such as those faced by companies listed on the BMV.

Table 1
Relevant Studies On The Relationship Between CSR, ESG, And Financial Performance

Author(s)	Theoretical approach	Country / Region	Key results
Freeman (2010)	Stakeholder theory	Global	Decisions should consider all stakeholders.
Porter & Kramer (2019)	Shared value	Global	Companies generate economic and social value.
Flammer (2013)	Diminishing marginal returns	Global	Environmental CSR has a low negative impact if it is well established.
Waddock & Graves (1997)	Previous performance and CSR	EE.UU.	Better financial performance allows for greater investment in CSR.
Ben Saad & Belkacem (2022)	ESG and profitability	Global	Positive correlation between ESG and financial performance.
Zúñiga (2024)	ESG and asset size	Latin America	Large companies lead sustainability initiatives.
Sharma & Chakraborty (2024)	Competence and CSR	Emerging markets	CSR improves performance in competitive environments.

Source: Compiled by authors.

Overall, these theories and empirical findings support the premise that CSR not only responds to ethical imperatives but also represents a strategy with concrete financial implications. Based on this, and using statistical and machine learning models, the present study empirically examines the financial impact of CSR on a sample of companies from the S&P/BMV index.

In addition, critical studies such as that of Ioannou and Serafeim (2011) have addressed the phenomenon of greenwashing, questioning whether some firms adopt ESG practices more out of reputational pressure than genuine commitment. Other more recent studies have warned of potential trade-offs between sustainability and short-term profitability, necessitating a contextualized evaluation (Thomsen, 2023).

2. Methodology

The present study adopts a quantitative, non-experimental, and longitudinal approach, in that variables are not deliberately manipulated and data collected over an extended period of time are analyzed. This methodological design allows for observing and modeling the relationships between CSR practices and the financial performance of companies over time, overcoming the limitations of cross-sectional observations. According to the classification proposed by Hernández-Sampieri & Torres (2018), the longitudinal design is ideal for examining relationships between variables at different time points, maximizing explanatory capacity in dynamic contexts.

The period 2014–2024 was strategically selected to coincide with a key stage of normative and structural transformation in Mexico; in particular, ESG-oriented legal provisions were adopted in Securities Market Law (2015), while the BMV progressively incorporated sustainability metrics starting in 2018. This time interval also allows for capturing the differentiated effects resulting from the economic and financial impact of the COVID-19 pandemic (2020–2022), an event that modified social investment patterns and corporate responsibility in multiple sectors. This combination of institutional and conjunctural factors analytically justifies the choice of study period, enhancing the robustness of the empirical evaluation of the relationship between CSR and financial performance.

The study population consists of the 145 companies listed on the BMV as at December 2023. Given the multisectoral focus of the analysis, the sampling formula recommended by Rahman (2023) was used to estimate a representative sample size with a confidence level of 95% and a maximum error of 5%. From this estimation, an approximate size of 105 companies was obtained. However, for this initial phase of the study, an intentional sample of 35 companies that make up the S&P/BMV IPC index was selected due to their representativeness in the Mexican stock market, as well as the availability and quality of financial and ESG information.

The empirical analysis took into account both financial performance indicators and corporate sustainability metrics. The financial indicators included were return on equity (ROE); return on total assets (ROA); earn-

ings before interest, taxes, depreciation and amortization (EBITDA); debt ratio; current liquidity; and stock volatility. Revenue growth was excluded from the final analysis due to the stability of annual series, which resulted in marginal variations. Instead, net income was incorporated as an alternative measure of operational performance.

The combined use of these indicators allows for a comprehensive view of financial performance, encompassing both profitability and operational stability and risk. Moreover, the selection of variables is based on their availability in standardized databases such as Bloomberg and their frequent use in previous research on the relationship between sustainability and corporate finance. This methodological strategy ensures the comparability over time and across companies, laying the groundwork for a robust empirical evaluation of the impact of CSR on the key determinants of financial value within the Mexican context.

The methodological choice combines three complementary approaches: analysis of covariance (ANCOVA), to estimate adjusted associations between CSR and financial performance; random forest, to capture non-linear relationships and evaluate the relative importance of predictors; and the probit model, to analyze the probability of high performance. This strategy aims for methodological triangulation, comparing findings under different statistical assumptions, which enhances the robustness of the empirical analysis.

While none of these methods in themselves allow for causal inference, their combined use enables the identification of consistent patterns that can guide future research with a more rigorous causal perspective.

Table 2
Variables Included in the Study

Variable	Type	Description	Unit / Measurement	Source
ROA	Dependent	Return on assets	Percentage	Bloomberg
ROE	Dependent	Return on capital	Percentage	Bloomberg
Income growth	Dependent	Percentage variation of income	Percentage	Bloomberg
EBITDA	Dependent	Earnings before interest, taxes, and depreciation	Millions of pesos	Bloomberg
Total debt / Total assets	Dependent	Debt ratio	Percentage	Bloomberg
Current liquidity	Dependent	Current assets / Current liabilities	Ratio	Bloomberg
Stock volatility	Dependent	Standard deviation of stock price	Percentage	Bloomberg
ESG Score	Independent	Composite ESG score	Index (0-100)	Bloomberg
Scores E, S, G	Independent	Scores for environmental, social, and governance dimensions.	Index (0-100)	Bloomberg
Company size	Covariate	Total assets	Millions of pesos	Bloomberg
Industrial sector	Covariate	Sector classification GICS	Nominal categorical	BMV
Years of operation	Covariate	Time since foundation	Years	Annual reports
Property structure	Covariate	Familiar / state / multinational	Nominal categorical	Own company

Source: Compiled by authors.

The sustainability indicators were obtained from the Bloomberg database and include the composite ESG score, as well as individual scores in the environmental (E), social (S), and governance (G) pillars. These metrics allow for a comprehensive assessment of each company's sustainable performance over time.

In order to ensure a more robust analysis, various covariates that may influence the relationship between CSR and financial performance were also incorporated. These include company size (measured by total assets), industry sector, accumulated years of operation, and ownership structure (family-owned, state-owned, or multinational).

Analysis of Covariance (ANCOVA)

The ANCOVA model was used to estimate the relationship between investment in CSR and financial indicators, adjusting for various structural and contextual covariates (Bachrach et al., 2022; Rajesh et al., 2022). This technique combines elements of linear regression and analysis of variance, allowing for the comparison of groups (e.g. companies with high vs. low investment in CSR), while statistically controlling for the influence of additional variables that could bias the results (Belarmino et al., 2024; Fadele & Rocha, 2025). The general model is specified as:

$$Y_{it} = \beta_0 + \beta_1 CSR_{it} + \sum_{k=2}^K \beta_k X_{kit} + \epsilon_{it}$$

Where:

- Y_{it} : Financial indicator for company i in period t (for example, ROA, ROE, or net income).
- CSR_{it} : Investment level or ESG score for company i in period t .
- X_{kit} : Vector of covariates for company i , such as size (total assets), economic sector, market age, and ownership structure.
- ϵ_{it} : Random error term.

This model allows for estimation of the adjusted relationship between CSR and financial performance, controlling for other contextual influences that could introduce biases if not accounted for. Methodologically, ANCOVA increases the precision of the analysis by reducing residual variance, providing indirect statistical control over non-experimental factors.

The application of ANCOVA in this study is based on the need to distinguish the net effect of sustainability investment from other structural characteristics of companies. A linear adjustment is carried out between covariates and the dependent variable, estimating a common regression coefficient. Subsequently, adjusted means of financial performance are compared between groups of companies with different levels of CSR. The significance of the model is validated through the F statistic, and standard errors and t-tests are calculated to verify whether the observed differences are statistically significant.

This procedure ensures that differences attributed to CSR investment reflect a real relationship with financial performance, and not simply a spurious correlation caused by the size, sector, or age of the company.

It should be noted that although the ANCOVA model allows for controlling the effect of structural covariates, its application in longitudinal contexts with multiple units of analysis, such as panels of companies, pres-

ents certain limitations. In particular, it does not fully control for persistent unobservable heterogeneity among firms. Therefore, it is recommended that future research incorporate fixed effects models or GMM estimators to improve causal validity and control for potential biases derived from unobservable factors.

Random Forest

Another of the algorithms implemented, random forest, is a supervised learning technique based on ensemble methods. Unlike a single decision tree, random forest builds multiple decision trees trained on random subsets of the data and features, and then combines their predictions by averaging (in regression problems) or majority voting (in classification) (Breiman, 2001). This methodology improves the model's accuracy by reducing the overfitting inherent in individual trees and by avoiding high correlation between predictors, thanks to the random selection of features in each partition (Cheng, 2024; Costa & Pedreira, 2023; Halabaku & Bytyçi, 2024; Montesinos López et al., 2022).

Among the key advantages of random forest are its ability to capture complex non-linear relationships, its robustness against noisy data, and its low need for parameterization, which facilitates its practical implementation (D'Amato et al., 2022). In addition, it enables evaluation of the relative importance of each predictor in the model, which is useful for identifying which financial or sustainability variables (such as ESG metrics) have a greater impact on predicting corporate performance (Chowdhury et al., 2023; Weston & Nnadi, 2023). This interpretative capability is particularly valuable in the analysis of strategic business decisions, where it is necessary to understand the specific role of each variable. While the method may be computationally demanding when working with large volumes of data, this study limits the number of predictors and uses a moderate sample of companies, making its application feasible.

This technique identifies non-linear relationships between variables and allows evaluation of the relative importance of predictors in financial performance. K-Fold cross-validation ($k=5$) was applied, and the out-of-bag (OOB) error was reported as a measure of generalization. The interpretation of variable importance was based on permutation-based rankings and cumulative importance charts, which provide a transparent understanding of the predictors' influence in line with the theoretical expectations for each financial indicator.

Probit Model

The final algorithm applied was a Probit model—an econometric technique suitable for analyzing binary phenomena in which the observed decision depends on an underlying process that is not directly observable (Greene, 2024). In this study, the probability of a company with higher levels of investment in CSR presenting superior financial performance is modeled. This relationship is based on a latent utility index, which represents the expected net benefit to the firm of adopting sustainability practices, and depends on various independent variables (such as company size, ESG metrics, economic sector, among others) (Dohrmann et al., 2024; Pronti et al., 2024).

The dependent variable “high performance” was defined as equal to 1 when the company simultaneously exhibited an ROA and an ROE above the 75th percentile of the sample distribution in at least four out of the six years during the period 2014–2024. This classification is justified as a robust approximation to the concept of superior financial performance, by considering both profitability on assets and on equity, and by avoiding biases derived from atypical annual fluctuations.

The Probit model assumes that there is a critical threshold in the utility index: when the latent value exceeds this threshold, the company is classified as having “high financial performance.” Since this value is not observable, it is assumed to follow a standard normal distribution (mean zero and unit variance), which allows for the estimation of the conditional probability of success through the cumulative normal distribution function (CDF). In formal terms, the probability that a company i has superior performance is expressed as:

$$P(y_i = 1 | X_i) = \Phi(X_i'\beta)$$

Where Φ represents the standard normal cumulative distribution function, X_i is the vector of explanatory variables, and β are the coefficients to be estimated using the maximum likelihood estimation (MLE) method.

As well as allowing for identification of the marginal effect of each explanatory variable on the probability of high financial performance, this approach also captures non-linear relationships between firm characteristics and their market behavior. In addition, the goodness of fit of the model was verified using the McFadden pseudo R^2 statistic and generalized residuals were evaluated to confirm the adequacy of the fit (Chen, 2025).

3. Results

To analyze the relationship between CSR (measured through ESG scores) and the financial performance of companies listed on the BMV, ANCOVA models were applied to seven dependent indicators: ROA, ROE, EBITDA, revenue growth, debt ratio, current liquidity, and volatility.

Results of the ANCOVA Model

The general results show that the model has a reasonable fit for several variables. In particular, the ROA reported an adjusted R^2 of 0.243, with statistical significance for the coefficient of ESG ($p < 0.001$), indicating a positive and relevant relationship between sustainable practices and profitability. The ROE also showed a significant ESG effect ($p = 0.004$), although with a more modest fit (adjusted R^2 of 0.104). By contrast, the results for EBITDA, revenue growth, and volatility were not statistically significant with respect to ESG, although they showed sensitivity to company size and economic sector. These results are outlined in Table 3.

Table 3
Results of the ANCOVA Model For Each Dependent Financial Variable

Variable	R ² Adjusted	RMSE	p-value ESG	Shapiro-Wilk p
ROA	0.243	4.24	0.0000	0.5914
ROE	0.104	20.05	0.0041	0.0000
EBITDA	0.901	1143.53	0.8765	0.0000
Income growth	0.036	0.20	0.4078	0.0000
Debt ratio	0.676	128.73	0.7231	0.0000
Volatility	0.098	0.05	0.7664	0.0000
Current liquidity	0.720	0.76	0.3879	0.0000

Source: Compiled by authors.

As regards the assumptions of the model, the Shapiro-Wilk test was applied to the residuals of each of the estimated regressions. Only the model corresponding to ROA did not violate the normality assumption ($p = 0.591$), while the rest showed non-normal residuals, especially in the cases of ROE and EBITDA. This finding suggests that parametric inferences associated with these variables should be interpreted with caution. Histograms of residual distribution and scatter plots against fitted values, which allow for the evaluation of homoscedasticity and dispersion patterns, are presented in **Appendix A (Figure A1 and Figure A2)**.

As for multicollinearity, the variance inflation factor (VIF) was examined for the continuous and categorical covariates used in the models. The

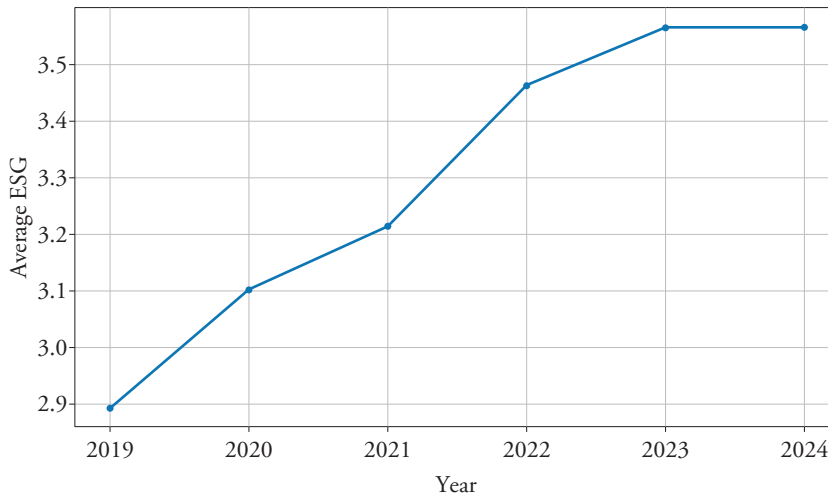
results show that there are no serious collinearity issues among the main explanatory variables, ESG score, company size, and years of operation, whose VIF values remain below the critical threshold of 10. However, some industrial sectors presented high values, attributable to categorical coding and the number of levels considered. Complete details of the VIF analysis are available in **Appendix B (Table B1)**.

Temporal evolution of ESG scores (2014-2024)

Before analyzing the effects of ESG on financial variables, the annual evolution of the average ESG score of the companies in the sample is presented. As shown in Figure 1, sustainability levels have shown an upward trend since 2019, partly driven by the intensification of regulatory requirements, the inclusion of ESG metrics in the BMV since 2018, and the growing pressure from institutional investors for greater corporate transparency.

In general terms, there has been a sustained increase in the average ESG score, which went from 2.89 in 2019 to 3.57 in 2024, with a faster growth rate between 2021 and 2022. This behavior suggests a greater adoption of ESG practices in the period following the pandemic, illustrating the relevance of examining their relationship with financial performance over this interval.

Figure 1
Temporal Evolution of the Average ESG Score (2014–2024)



Source: Compiled by authors.

Marginal Predictions of ESG

Marginal predictions of the ANCOVA model were generated for three levels of ESG percentile (25, 50, and 75), while keeping the other covariates constant. For the ROA variable, a projected increase in the adjusted value is observed as the levels of ESG increase, with ROA rising from 2.37 at the 25th percentile to 5.44 at the 75th percentile. This pattern is also replicated in ROE and, to a lesser extent, EBITDA. The complete results are described in Table 4.

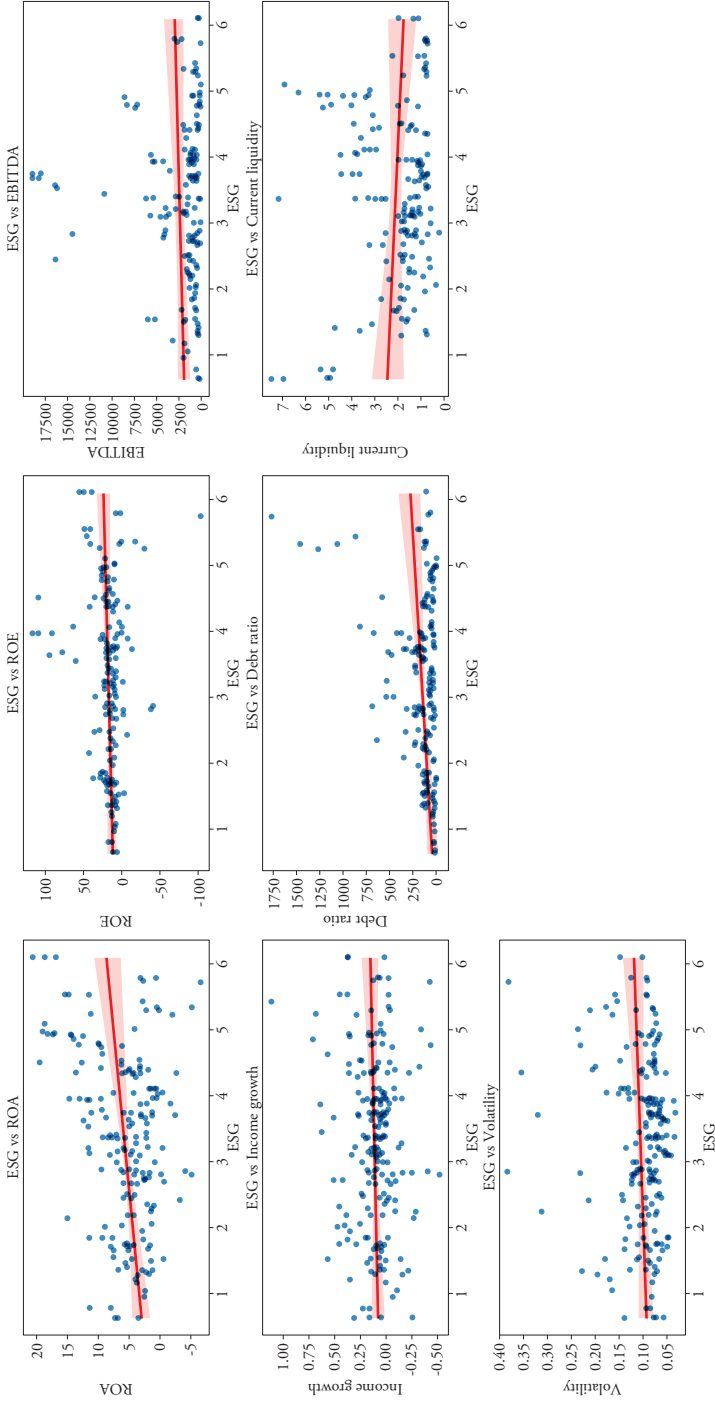
Table 4
Predictions of Expected Financial Variable Values by ESG Score Percentiles

Dependent variable	Prediction of ESG= 2.35	Prediction of ESG= 3.36	Prediction of ESG= 4.35
ROA	2.37	3.92	5.44
ROE	9.34	14.30	19.15
EBITDA	2268.07	2285.59	2302.77
Income growth	0.01	0.03	0.04
Debt ratio	101.28	105.16	108.96
Current liquidity	1.07	1.14	1.22
Volatility	0.08	0.08	0.08

Source: Compiled by authors.

The relationship between ESG and each dependent variable was visualized using scatter plots with 95% confidence intervals. These relationships are presented in Figure 2, where a significant positive slope in ROA and ROE stands out—unlike the flat or inverse relationship observed in other variables such as EBITDA or current liquidity.

Figure 2
Marginal Effect of ESG Score on Each Financial Variable with 95% Confidence Interval



Source: compiled by authors.

Comparisons Between ESG Groups

In order to analyze whether there are systematic differences in financial indicators based on the level of ESG commitment, companies were classified into three groups according to ESG score terciles: low, medium, and high.

In descriptive terms, companies with high ESG scores showed, on average, higher levels of profitability (ROA = 7.75, ROE = 22.57), but also a higher level of risk (Volatility = 0.12) compared to their counterparts with low ESG scores. Moreover, it was observed that the medium ESG group had the highest average EBITDA (3838.77), suggesting a possible non-linearity in financial performance in relation to sustainability levels (See Table 5).

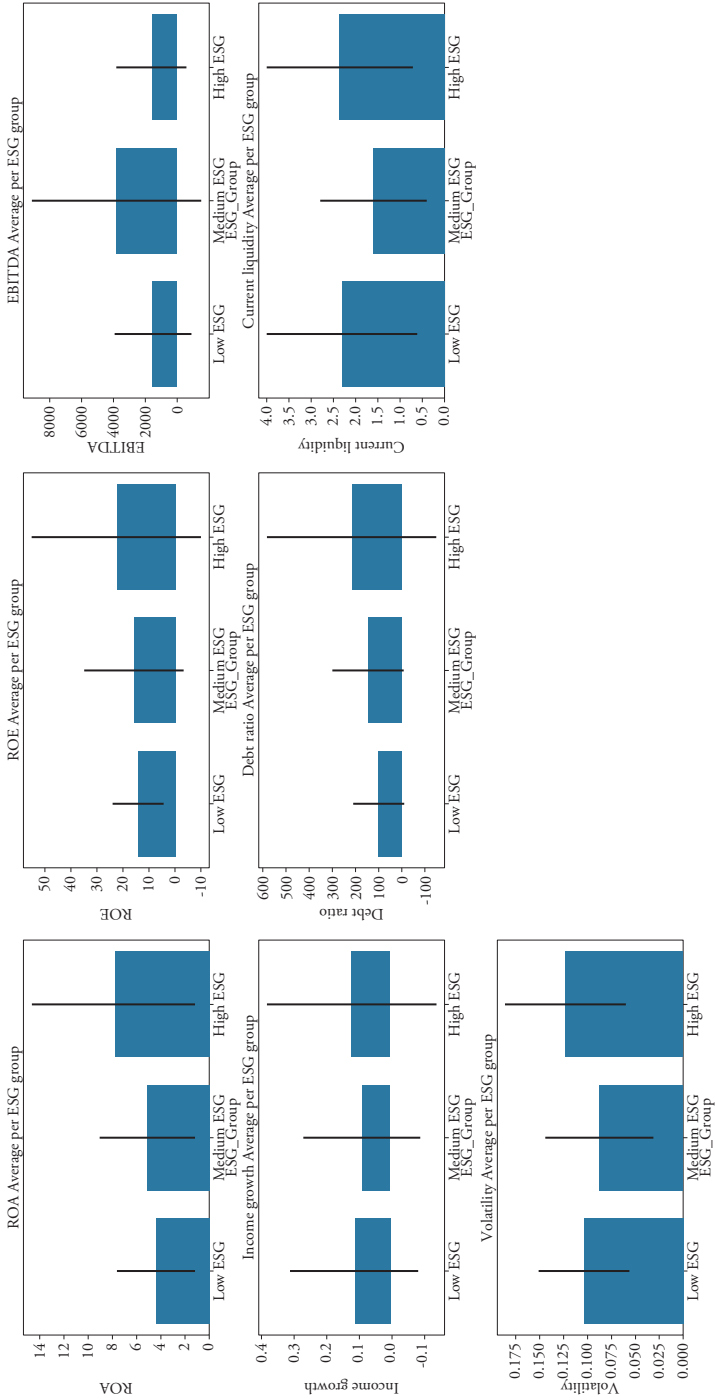
Table 5
Descriptive Statistics by ESG group for Each Dependent Variable

Dependent variable	ESG Group	Mean	Standard deviation	N
ROA	Low ESG	4.42	3.21	64
	Medium ESG	5.12	3.97	66
	High ESG	7.75	6.89	62
ROE	Low ESG	14.08	9.22	64
	Medium ESG	15.71	18.58	66
	High ESG	22.57	32.17	62
EBITDA	Low ESG	1528.60	2326.87	55
	Medium ESG	3838.77	5279.50	62
	High ESG	1627.60	2146.04	49
Income growth	Low ESG	0.115	0.197	64
	Medium ESG	0.092	0.179	66
	High ESG	0.125	0.260	62
Debt ratio	Low ESG	102.62	105.34	64
	Medium ESG	147.95	150.73	66
	High ESG	220.22	363.31	62
Current liquidity	Low ESG	2.30	1.68	44
	Medium ESG	1.59	1.16	59
	High ESG	2.36	1.63	57
Volatility	Low ESG	0.103	0.047	64
	Medium ESG	0.088	0.056	66
	High ESG	0.122	0.062	62

Source: Compiled by authors.

These differences are detailed in Table 4, where the averages, standard deviations, and sample sizes for each ESG group and financial variable analyzed are reported. Meanwhile, Figure 3 presents these comparisons through bar graphs with standard error, allowing for a clear visualization of central trends and dispersion within each group.

Figure 3
Comparison of Financial Indicators by ESG Group (Terciles: Low, Medium, and High)



Source: Compiled by authors.

Results of the ANOVA Analysis

The breakdown of variance explained by each component of the model was presented through a type II ANOVA analysis for each dependent variable. In the case of ROA, ESG was a highly significant predictor ($F = 18.47$; $p < 0.001$), with significant contributions also from the sector and company size. For ROE, ESG was also statistically relevant ($p = 0.004$), as were years of operation and ownership structure. Conversely, for variables such as EBITDA, income growth, and current liquidity, ESG did not show significance, although company size explained a large proportion of the variance, especially in the case of EBITDA ($F = 361.82$; $p < 0.001$). The complete details of this analysis are presented in Table 6.

Table 6
Type II ANOVA by Dependent Variable

Dependent variable	Factor	Sum of squares	gl	F	p-value
ROA	Industrial sector	909.55	10	4.63	0.000007
	Property structure	151.45	2	3.86	0.022965
	ESG	362.77	1	18.47	0.000028
	Company size	137.89	1	7.02	0.008789
	Years of operation	2.76	1	0.14	0.708249
ROE	Industrial sector	9832.61	10	2.24	0.017404
	Property structure	6287.07	2	7.17	0.001016
	ESG	3711.33	1	8.46	0.004090
	Company size	39.95	1	0.09	0.763135
	Years of operation	1851.41	1	4.22	0.041376
EBITDA	Industrial sector	1.87e+08	10	12.94	<0.000001
	Property structure	3.05e+06	2	1.05	0.351421
	ESG	3.51e+04	1	0.02	0.876458
	Company size	5.24e+08	1	361.82	<0.000001
	Years of operation	5.65e+06	1	3.91	0.049926
Income growth	Industrial Sector	0.76	10	1.73	0.078161
	Property structure	0.16	2	1.85	0.160084
	ESG	0.03	1	0.69	0.407776
	Company size	0.10	1	2.27	0.133916
	Years of operation	0.02	1	0.34	0.558236

Debt ratio	Industrial sector	5.82e+06	10	32.21	<0.000001
	Property structure	1.62e+05	2	4.48	0.012646
	ESG	2276.99	1	0.13	0.723085
	Company size	1.29e+05	1	7.16	0.008176
	Years of operation	6.80e+04	1	3.76	0.053973
Current liquidity	Industrial sector	182.10	10	28.05	<0.000001
	Property structure	8.47	2	6.52	0.001943
	ESG	0.49	1	0.75	0.387855
	Company size	1.99	1	3.07	0.081812
	Years of operation	12.73	1	19.61	<0.00001
Volatility	Industrial sector	0.081	10	2.78	0.003219
	Property structure	0.0003	2	0.06	0.943125
	ESG	0.0003	1	0.09	0.766411
	Company size	0.0010	1	0.34	0.561840
	Years of operation	0.00005	1	0.02	0.898249

Source: Compiled by authors.

The results allow us to conclude that the ESG score has a significant relationship with profitability indicators (ROA and ROE), even after controlling for structural covariates such as company size, industry sector, years of operation, and ownership. This finding suggests that companies adopting sustainable strategies not only improve their perception among stakeholders but also demonstrate superior financial performance in operational terms.

However, this positive effect does not extend uniformly to all financial dimensions. Variables such as EBITDA, debt, or liquidity appear to be more influenced by internal structural factors rather than by the ESG dimension, which aligns with the findings of previous studies regarding the heterogeneous effects of corporate sustainability depending on the indicator and industry.

Therefore, the results partially support the hypothesis that investment in CSR positively impacts financial performance, particularly with regard to indicators related to operational efficiency and asset profitability.

Robust Validation Using Random Forest

In order to complement the findings obtained through the ANCOVA model, a random forest model was implemented for each of the financial variables considered as dependent variables. This machine learning approach allowed for the identification of non-linear patterns and the evaluation of the relative relevance of the predictors under a more flexible scheme. The

results obtained are outlined in Table 7, where the R^2 values and the root mean square error (RMSE) for each model are reported.

Table 7
Random Forest Performance by Dependent Variable (R^2 and RMSE)

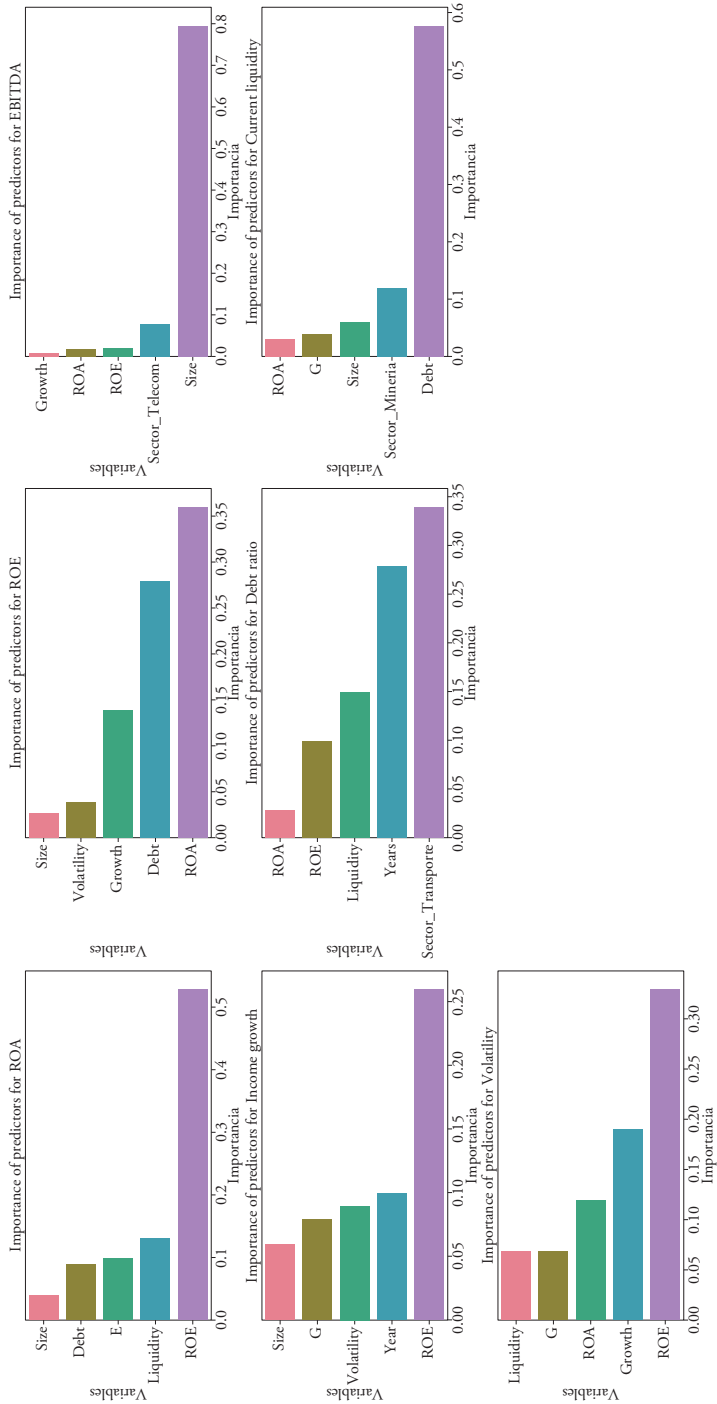
Dependent variable	R^2	RMSE
ROA	0.885	1.81
ROE	0.815	11.02
EBITDA	0.834	1850.84
Income growth	0.219	0.17
Debt ratio	0.898	62.40
Current liquidity	0.691	0.95
Volatility	0.384	0.05

Source: Compiled by authors.

The high values of R^2 in variables such as ROA, ROE, EBITDA, and debt ratio attest to the substantial predictive capacity of the model, reinforcing the significant effects observed previously in the ANCOVA. This is particularly true for ROA for which the random forest model explains 88.5% of the total variance, supporting the strength of the impact of the previously identified ESG score.

The relative importance of the predictors is presented in Figure 4, where the five variables with the greatest influence for each model are visualized. It is notable that company size, the ROE indicator, and the ESG score, as well as their individual components (E, S, G), consistently appear as variables with high predictive relevance.

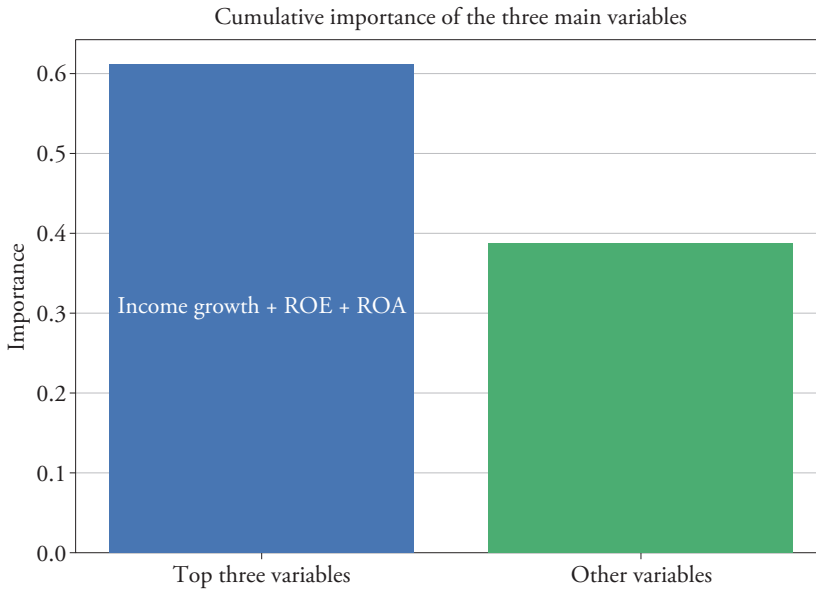
Figure 4
Importance of Predictors in Random Forest Models for Dependent Variables



Source: Compiled by authors.

The cumulative importance explained by the three most relevant variables in the ROA model was also calculated. As shown in Figure 5, these three variables—ROE, income growth, and ROA—explained more than 63% of the total model variance, demonstrating the concentration of explanatory power in a reduced subset of indicators.

Figure 5
Cumulative Importance of the Three Main Variables



Source: Compiled by authors.

These findings not only reinforce the results obtained through ANCOVA but also provide additional evidence of the relevance of ESG factors and the operational context of companies as drivers of financial performance. The convergence between traditional statistical methods and machine learning techniques confirms that the relationship between ESG and financial performance is robust and holds even under more complex and non-parametric approaches.

Application of the Probit Model

In order to delve into the relationship between financial performance and ESG factors, a Probit model was implemented to model the probability of a company exhibiting high performance (binary variable: High_Performance). This approach is particularly useful for capturing the latent and probabilistic nature of the phenomenon, while also evaluating the marginal effects of explanatory variables.

The results of the model (see Table 8) indicate that company size (Company size, $p=0.001$) and economic sector (Industrial_Sector_Code, $p=0.004$) are significant variables in explaining the probability of high performance, with negative effects on the expected probability. In the case of ownership structure (Property_Structure_Code), the effect is positive and marginally significant ($p=0.056$). Although the coefficient associated with the ESG score is not statistically significant ($p=0.274$), its positive sign supports the theoretical hypothesis of a favorable association between sustainability and financial performance.

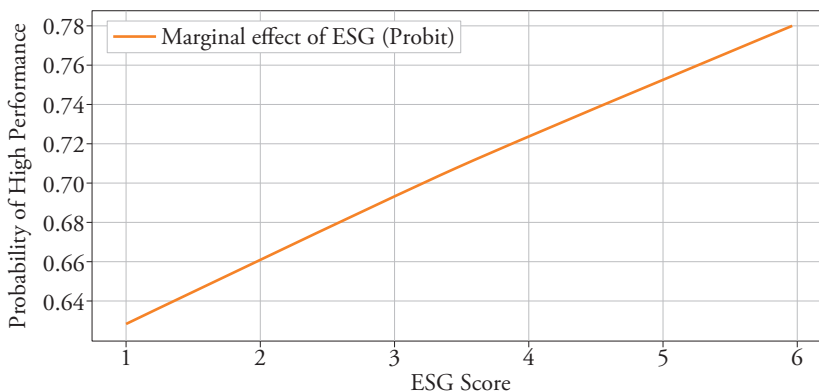
Table 8
Results of the Probit Model

Variable	Coef.	Std.Err.	z	P> z	[0.025	0.975]
const	0.2380	0.3795	0.6273	0.5304	-0.5057	0.9818
ESG	0.0888	0.0811	1.0943	0.2738	-0.0702	0.2478
Company size	-0.0000	0.0000	-3.2936	0.0010	-0.0000	-0.0000
Years of operation	-0.0019	0.0021	-0.8866	0.3753	-0.0061	0.0023
Industrial_Sector_Code	-0.1133	0.0391	-2.8961	0.0038	-0.1899	-0.0366
Property_Structure_Code	0.3166	0.1654	1.9142	0.0556	-0.0076	0.6407

Source: Compiled by authors.

In visual terms, Figure 6 shows the estimated marginal effect of ESG on the probability of high performance. A positive trend is observed: as the ESG score increases, so does the estimated probability of belonging to the group of companies with better performance, which is consistent with the results obtained by ANCOVA and random forest.

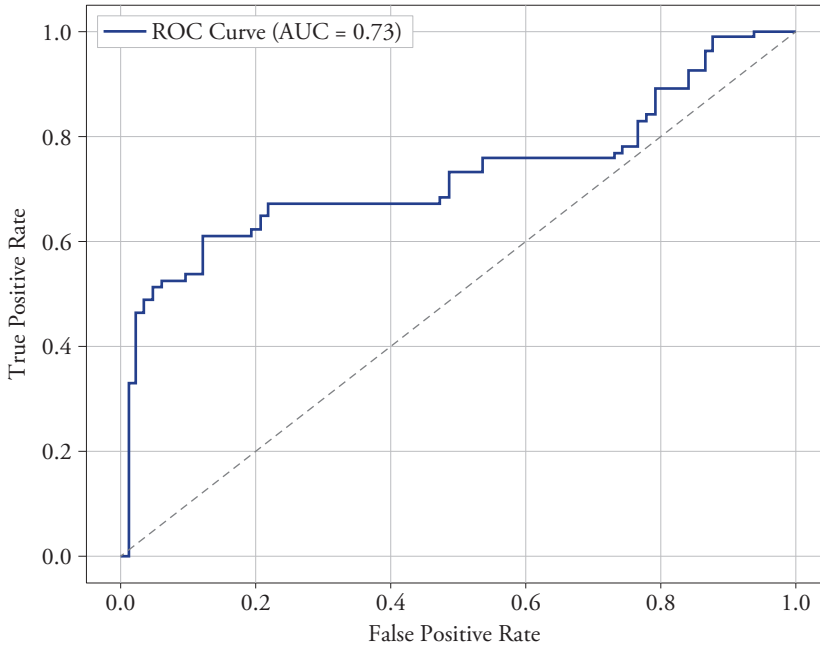
Figure 6
Marginal Effect of ESG On Predicted Probability (Probit Model)



Source: Compiled by authors.

To verify the validity of the model, the ROC curve and confusion matrix were calculated (see Figure 7 and Figure 8). The ROC curve yielded an AUC of 0.73, indicating an acceptable level of discrimination for the Probit model. The confusion matrix shows a correct classification rate of 60.4% of cases, suggesting a reasonable predictive performance.

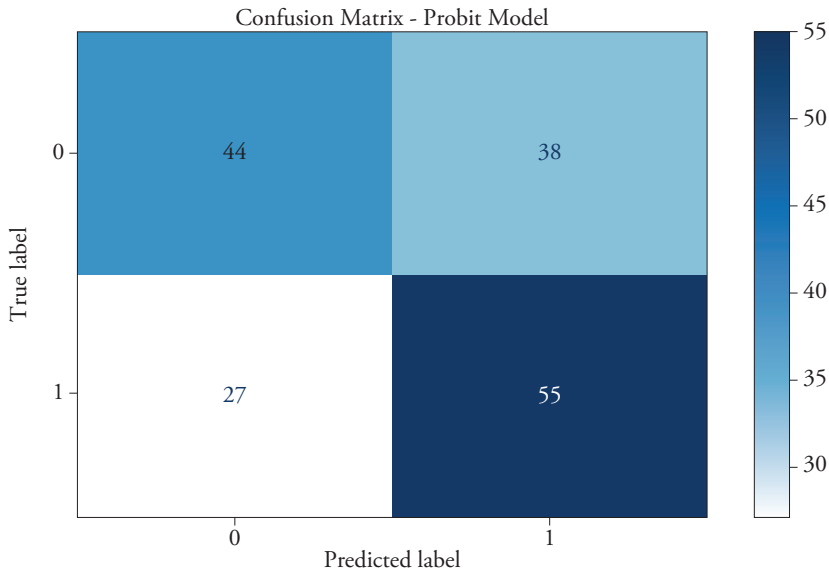
Figure 7
ROC Curve of the Probit Model (AUC = 0.73)



Source: Compiled by authors.

The ROC curve allows evaluation of the model’s ability to distinguish between companies with and without high financial performance. An AUC value of 0.73 indicates an acceptable discriminative ability—better than a random model. Below, the confusion matrix illustrates the distribution of correctly and incorrectly classified observations:

Figure 8
Confusion Matrix of the Probit Model

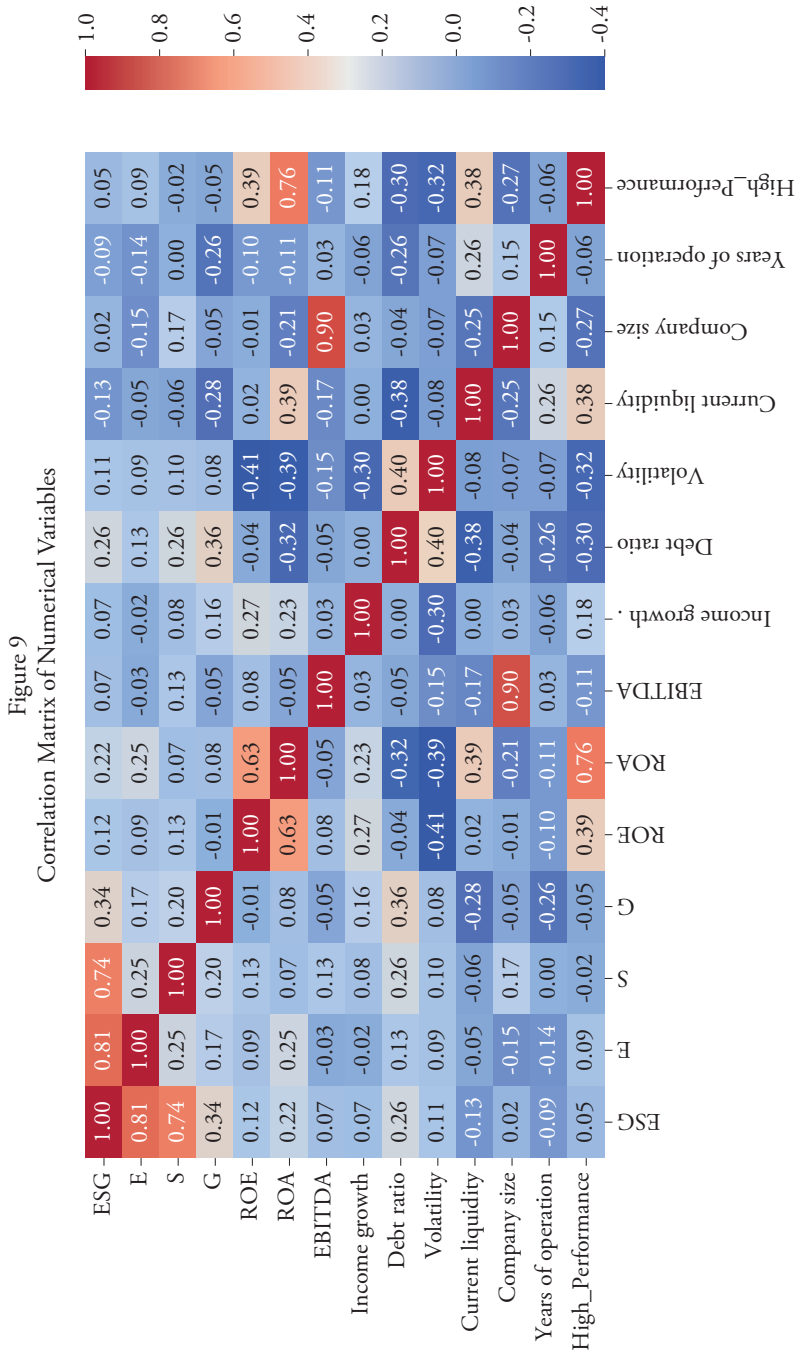


Source: Compiled by authors.

On the other hand, the analysis of collinearity using the VIF confirmed the absence of severe multicollinearity among the explanatory variables used in the Probit model. All VIF values for key quantitative covariates—including ESG, company size, and years of operation—were below the critical threshold of 10, indicating low redundancy among predictors. However, some coefficients corresponding to controlled categorical variables, particularly industrial sectors, showed high VIF values as a result of their dummy coding and included sectoral segmentation. Detailed results of this analysis are reported in Table B2 of Appendix B.

To compare the robustness of the probit specification, a logit model was also estimated using the same explanatory variables. Both models yielded consistent results in terms of variable significance and coefficient magnitude. However, the logit model had a lower AUC (≈ 0.56 on average in five-fold cross-validation) and a slightly lower fit (Pseudo $R^2 = 0.1033$) compared to the probit model (Pseudo $R^2 = 0.1036$).

Finally, the correlation matrix (see Figure 9) confirms the positive relationship between ESG and performance variables such as ROA ($r = 0.22$) and High_Performance ($r = 0.05$), although the latter is weak. These correlations align with the positive effects observed in the probit model and the marginal effects graph.



Source: Compiled by authors

Taken together, the results obtained through the ANCOVA model, random forest algorithm, and probit specification converge to highlight the robust importance of sustainability performance, measured by ESG score, as a factor associated with higher levels of profitability (ROA, ROE) in Mexican stock market companies. Although the effects of ESG are not consistent across all financial indicators, its positive and statistically significant influence on certain key dimensions reinforces the hypothesis that responsible practices can be a competitive advantage. Cross-validation using different econometric and machine learning approaches not only strengthens the empirical evidence but also underscores the importance of considering non-financial factors in corporate performance analysis. These findings serve as the basis for the practical and theoretical implications discussed in the conclusions section.

4. Discussion and Conclusions

The results obtained through the different methodological approaches—ANCOVA, random forest, and probit model—allow for the identification of consistent and complementary patterns in the relationship between financial performance and corporate sustainability. In particular, the statistical significance of the ESG score on profitability indicators, such as ROA and ROE, aligns with previous studies like those of Aydoğmuş et al. (2022) and Yang et al. (2025), both of which found a positive correlation between ESG practices and financial performance. This evidence supports the hypothesis that investments in sustainability can translate into competitive advantages in both reputational and operational terms.

However, as Lemana et al. (2025) and Hluszko et al. (2024) have warned, there is a critical line of questioning of the direct link between CSR and financial performance, suggesting that in certain contexts sustainable commitment may respond more to reputational or regulatory pressures than to a strategic conviction. In this sense, phenomena such as greenwashing or financial trade-offs should be considered as possible explanations for non-significant findings, especially in variables such as EBITDA or liquidity.

Furthermore, the findings of this study are consistent with those reported by Hamdoun et al. (2022) and Deng et al. (2023), who argued that CSR enhances financial performance in highly competitive environments, such as the stock market. However, as proposed by Benlemlih et al. (2021), Nguyen et al. (2021), and Serolin (2023), the results also show that this relationship is not uniform: variables like EBITDA, leverage, and liquidity seem to respond more to internal structural conditions, such as company size or age, than to its sustainability levels.

A possible explanation for the lack of a significant relationship between ESG and variables such as EBITDA or liquidity is that these financial dimensions may be more influenced by internal operational practices, short-term investment horizons, or specific sectoral differences. In addition, sustainability investment may require longer horizons to make an impact in these indicators, limiting its detection in studies with annual or five-year analysis windows. Sector-specific or company-size segmented analysis would be a relevant avenue for future research.

This interpretation is supported by recent empirical evidence that documents sectoral and size heterogeneity in the effects of ESG practices on specific financial indicators. Liang et al. (2023), for example, showed that ESG scores do not uniformly affect the risk of stock market liquidity: while in sectors like agriculture they significantly reduce this risk, in others, like wholesale trade, the relationship is weak or even adverse. Similarly, Iazzolino et al. (2023) pointed out that the energy, materials, consumer, and technology sectors respond more sensitively to ESG factors, while the financial, health, industrial, and public services sectors show little or no reaction. On the other hand, Shaikh (2022) found that the environmental and social dimension can be negatively related to profitability in larger companies—unlike governance, which is positively associated. Finally, Moussa and Elmarzouky (2024) warned that comprehensive disclosure of ESG information may coincide with higher capital costs, except when corporate governance is particularly strong. Taken together, these findings indicate that the lack of statistical significance in variables such as EBITDA or liquidity in the present study can be explained as a reflection of heterogeneous effects, dependent on both the sector and the business scale, rather than as evidence of a lack of a relationship between sustainability and financial performance.

From a machine learning perspective, the random forest model provided an additional perspective by confirming the relevance of ESG as a predictor in non-linear models, with a high explanatory capacity in key variables. This ability to capture complex relationships reinforces the methodological proposal of D'Amato et al. (2021) and Momparler et al. (2025) related to the use of hybrid models in sustainable finance. As to the probit model, although the ESG coefficient was not significant, its positive sign and the AUC value of 0.73 suggest a trend consistent with the other approaches, highlighting the suitability of probabilistic models for evaluating latent phenomena such as corporate “high performance.”

However, this result should be interpreted with caution: It could be due to the binary definition of performance, model specification, or the method's

sensitivity to sample sizes. In this regard, the methodological literature has pointed out that binary definitions of corporate performance may offer clarity and interpretive ease, but tend to oversimplify complex and dynamic phenomena, which can lead to loss of information and classification biases (Abdallah, 2021; Gove et al., 2017; Panchal et al., 2025). In particular, the reduction of performance to a dichotomous threshold may conceal relevant intermediate and temporal dynamics, diminishing the predictive validity of the model. Likewise, comparative studies show that the performance of probit estimators is highly sensitive to sample size and model specification, such that small samples or the use of weak instruments can increase bias and reduce statistical power (Adkins, 2008; Murè et al., 2021). Even in investigations with extensive samples, the selection of proxies and construct validity issues has been shown to limit the reliability of results (Bolibok, 2024; Bouten et al., 2017). Together, these findings suggest that the absence of statistical significance in our probit model should be interpreted as a reflection of these inherent limitations rather than a denial of the association between ESG and financial performance. Far from invalidating the approach, this result highlights the need to move towards causal models that explore the robustness of the ESG–performance relationship under different definitions and contexts.

From a theoretical standpoint, the findings of this study strengthen the shared value proposition of Porter and Kramer (2019) by empirically demonstrating that responsible practices not only serve an ethical or regulatory compliance function but also positively impact the economic value generated (Arango-Home et al., 2023; Leal Filho et al., 2024; Ospina-Patiño et al., 2023). In practical terms, the results are particularly relevant for financial managers, institutional investors, and policymakers: Incorporating ESG criteria into decision-making is not only a best practice but also a profitable strategy in financial terms.

In terms of knowledge contribution, this research reaffirms that the relationship between corporate social responsibility and financial performance is not univocal or linear but dependent on sectoral context, internal structure, and selected indicators. By integrating traditional econometric methods with machine learning techniques, a more comprehensive and robust view of the phenomenon is offered.

Future research could extend the analysis to other Latin American countries for comparative studies, as well as incorporating macroeconomic and institutional governance variables that could mediate this relationship. Moreover, the use of longitudinal methodologies featuring dynamic panel or causal models such as synthetic control can help validate

these findings while furthering understanding of the long-term effects of CSR on corporate value.

Finally, a limitation of the study is the sole focus on companies from the S&P/BMV IPC index, which could restrict the generalizability of the findings to the entire Mexican stock market. It is recommended that future research include more heterogeneous samples segmented by size or sector to validate the results obtained.

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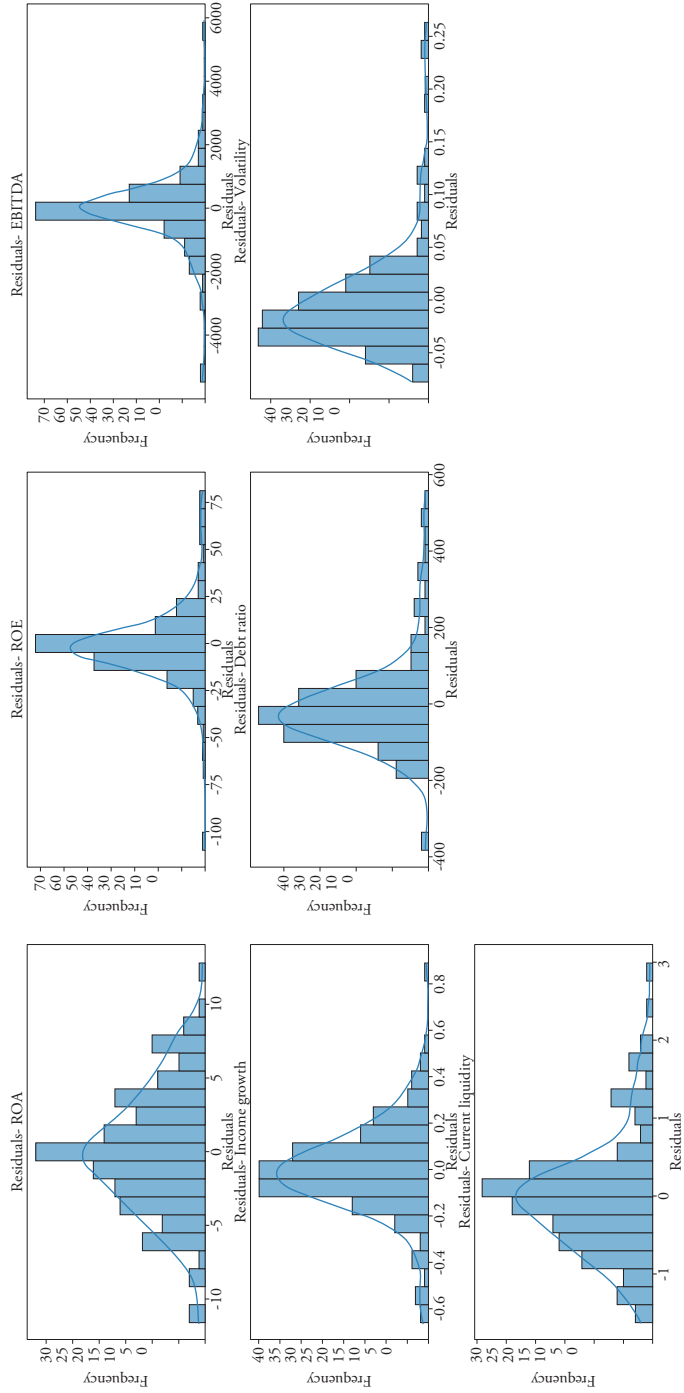
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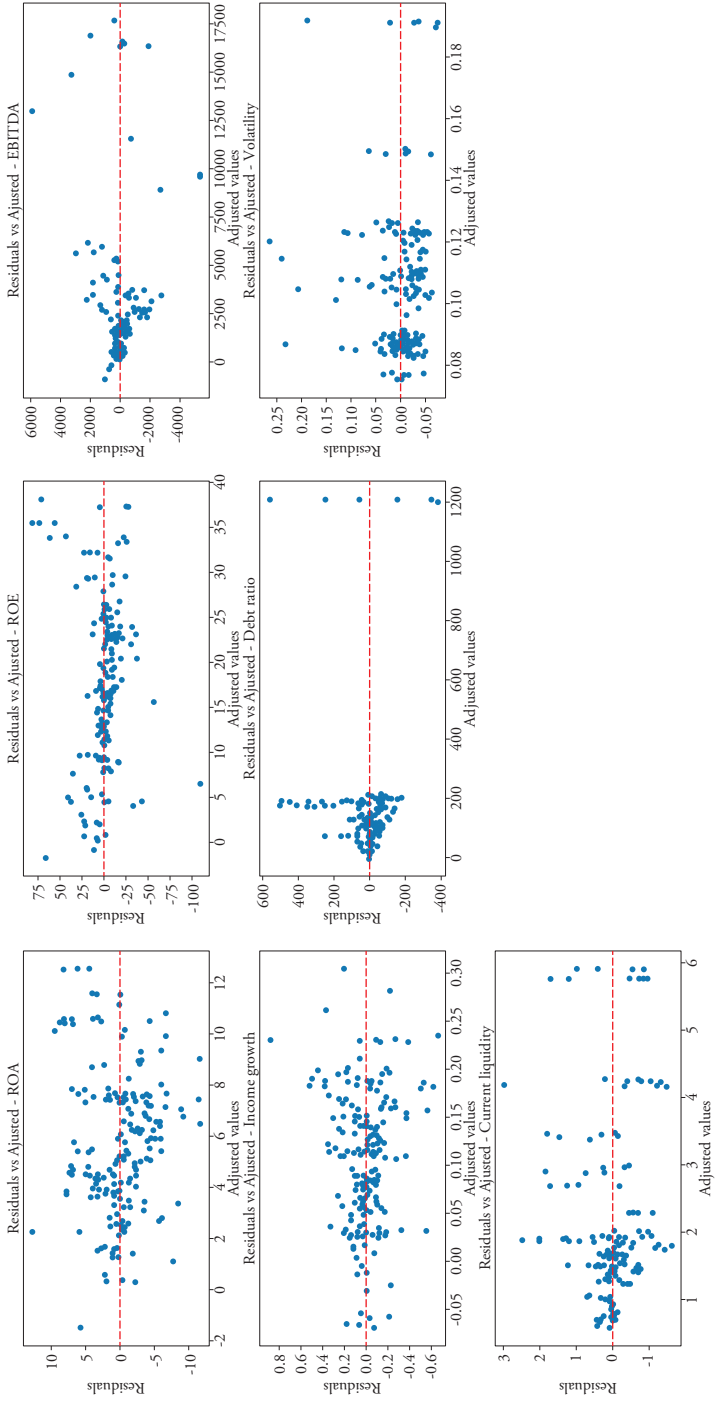
Appendix A

Figure A1
Residual histograms by financial variable (normality assessment)



Source: Compiled by authors

Figure A2
Residual plots vs adjusted values by variable.



Source: Compiled by authors

Appendix B

Table B1
Variance inflation factors (VIF) for independent variables used in the models.

Variable	VIF
Intercept	64.601242
C(Q("Industrial Sector"))[T. Commerce]	5.545674
C(Q("Industrial Sector"))[T. Industrial conglomerate]	5.305143
C(Q("Industrial Sector"))[T. Infrastructure]	3.177382
C(Q("Industrial Sector"))[T. Manufacture]	11.936737
C(Q("Industrial Sector"))[T. Media and entertainment]	2.775390
C(Q("Industrial Sector"))[T. Mining]	4.897224
C(Q("Industrial Sector"))[T. Services]	6.313264
C(Q("Industrial Sector"))[T. Financial services]	10.359096
C(Q("Industrial Sector"))[T. Telecommunications]	3.747678
C(Q("Industrial Sector"))[T. Transportation]	3.096881
C(Q("Property structure"))[T. Mixta]	2.205772
C(Q("Property structure"))[T. Multinational]	2.669924
ESG	2.160126
Q("Company size")	2.047931
Q("Years of operation")	1.560276

Source: Compiled by authors

Table B2
Diagnosis of multicollinearity (VIF)

Variable	VIF
Intercept	71.098736
Industrial_Sector_Code[T.5]	6.925062
Industrial_Sector_Code[T.1]	6.639696
Industrial_Sector_Code[T.7]	3.789086
Industrial_Sector_Code[T.0]	13.602990
Industrial_Sector_Code[T.8]	3.311059
Industrial_Sector_Code[T.6]	6.115605
Industrial_Sector_Code[T.2]	6.618861
Industrial_Sector_Code[T.4]	8.534238
Industrial_Sector_Code[T.3]	4.807714
Industrial_Sector_Code[T.10]	3.702100
Property_Structure_Code[T.2]	2.567338
Property_Structure_Code[T.0]	2.919822
ESG	2.427595
Q("Company size")	2.792440
Q("Years of operation")	1.524309

Source: Compiled by authors