Vilnius University Press

Content lists are available at Vilnius University Press

Transformations In Business & Economics
2026, Vol. 25 No 1 (67), pp.155-173.

ISSN 1648-4460; E-ISSN 2538-872X
https://doi.org/10.15388/Tibe.2026.25.1.8

Chapter: Fostering Transformative Shifts in Sustainability and Environmental Behaviour

IMPACT OF ENVIRONMENTAL, SOCIAL AND GOVERNANCE INDICATORS – ESG ON AUTOMOTIVE CORPORATE SUSTAINABILITY

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Annotation. There has been a marked increase in stakeholder interest regarding the level of development of ESG criteria. This is reflected in the ESG score issued by various agencies. A high ESG score is associated with a company being more sustainable than another. It is imperative to analyse the relationship between different economic-financial variables of companies and their classification as a sustainable company. In this case, the objective is to analyse corporate financial sustainability in the automotive sector. For this purpose, a sample of 430 companies in the automotive sector was utilised. Different economic-financial variables corresponding to different dimensions such as liquidity, solvency, profitability and indebtedness were selected. Principal component analysis was used to condense the information provided by the different variables in each of the dimensions or factors. A stochastic Logit model is used to analyse the relationship between these factors and the financial sustainability of the companies. Conversely, the degree of financial sustainability, or financial sustainability index, can be determined by the coefficients of the Logit model transformed into an odds ratio. Consequently, the percentage variation in this index can be determined in the context of variations in each of the economic and financial factors. The findings indicate that, for this sector, an improvement in the ESG criteria means an increase in the financial sustainability index of around 72%. The factor related to solvency is also positively related. In this case, an improvement in the company's solvency means a 30% increase in financial sustainability. On the other hand, an increase in the profitability factor leads to a 74% decrease in financial sustainability. Finally, an increase in indebtedness also leads to a 84% decrease in sustainability.

Keywords: financial indicators, ESG indicators, automotive industry, sustainability.

JEL classification: M14, N70, R40.

Submitted on June 2025. Accepted on December 2025.

Introduction

With increasing global awareness of climate change and corporate social responsibility, automotive companies are experiencing more pressure to adopt sustainable practices in their activities. The automotive industry encompasses companies involved in the design, development, production, marketing and sale of automobiles. This sector is one of the most significant globally in terms of revenue (Miranda, 2007; Candelo, 2019; Rizvi *et al.,* 2023), but it is also among the biggest polluters (Gohoungodji *et al.,* 2020). According to the Organisation for Economic Co-operation and Development OECD/ITF (2015) and the International Transport Forum (ITF), it is estimated that by 2050, there will be an increase in the number of passengers globally by 120–230%, a change that will depend on fuel prices and government policies related to urban transport. In addition, road and rail freight transport is expected to grow by 230–420%, and the volume of international trade is expected to increase by more than 430% by the same year. The OECD/ITF also predicts that CO_2 emissions could increase significantly (OECD/ITF, 2015; Cassetta, 2017; EIA, 2022).

This sector has had to adapt to legal and social regulations to achieve business sustainability in environmental, social and economic terms, including governance (Kushwaha & Sharma, 2016; Schöggl *et al.,* 2017; Khodier *et al.,* 2018). Competition in the automotive industry is fierce, forcing companies to implement strategies and technologies that reduce their environmental impact and generate benefits for nature, manufacturing sustainable cars such as electric, hybrid and autonomous cars, as well as sustainable mobility solutions in cities (Calza *et al.,* 2017; Cassetta *et al.,* 2017; Munten *et al.,* 2021). Companies are increasingly aware of the damage their activity causes to the environment and seek to demonstrate sustainable practices to the public, which provides them with a positive image and increases their popularity, thus influencing their productivity and financial performance (Freedman & Stagliano, 2010; Alon, Vidovic, 2015). In this process, several independent rating agencies are involved, analysing the sustainability of companies utilising different criteria and establishing a ranking for the automotive industry (Yahoo Finance, 2023; RepTrack, 2023; S&P Global, 2023; RepTrack, 2025).

One challenge that has grown is the limited understanding of the importance of adopting sustainable practices in automotive companies. This is due to a number of reasons, one of the most common of which is the view held by business leaders, especially in the automotive sector, of the importance of adopting sustainable practices. It can be attributed to several reasons, one of the most common being the view held by entrepreneurs, especially SMEs, who believe that it is not profitable for their business. Despite the numerous benefits they offer, the integration of environmental, social and governance (ESG) indicators faces several obstacles, as there are no global standards for their measurement and no unified ESG reporting system, which generates doubts and confusion.

The lack of clear and coherent regulations in relation to corporate sustainability represents a significant challenge. In response, many countries have established regulations to address climate change, promote social justice and improve corporate governance, although the effectiveness and enforcement of these laws varies (Chatterji *et al.,* 2009). Companies therefore face difficulties in complying with ESG indices, due to upfront investment costs and resistance to change towards more sustainable practices. The adoption of these indicators is crucial to address growing environmental and social challenges and is critical to ensure the long-term success of companies. By incorporating these indicators, organisations can gain a competitive advantage and facilitate a more sustainable future; this corporate sustainability is seen as an opportunity for growth in responsible contexts that help reduce exposure to reputational risks and potential regulations in the future (Freedman, Stagliano, 2010; Alon, Vidovic, 2015).

The challenges of sustainable business are divided into internal and external issues, such as the need to balance short-term profits and the absence of global regulations. Despite this, sustainability is fundamental to ensuring a company's future success. To overcome these challenges, it is essential that companies, governments and consumers work together, establishing precise regulations and policies that enable growth without harming the environment or people (De Lucia *et al.,* 2020). Some automotive companies find it challenging to balance the adoption of sustainable practices with risk assessment, market expectations, and their financial goals (Escrig-Olmedo *et al.,* 2019; Gupta, Yadav, 2024; Merzlikina, Mogharbel, 2025). In addition, the resilience of companies that succeed in attracting investment also includes sustainability in financial, environmental and social domains. The incorporaton of ESG factors helps mitigate risks, boosts long-term performance, and provides benefits in a competitive global marketplace (Kulal *et al.,* 2023).

As discussed, the lack of global norms and standards in sustainability presents challenges for companies, which vary by region and complicate the adoption of sustainable practices globally. In addition, the lack of a common framework allows for greenwashing, where companies appear to follow sustainable practices without making significant changes (Parguel *et al.,* 2011). Companies that prioritise sustainability are often less profitable in the short term, making it difficult for them to prioritise these principles in an environment that focuses on quarterly results (Whetman, 2017; Hahn *et al.,* 2018; Kulal *et al.,* 2023). While public pressure promotes corporate sustainability, the associated high costs discourage its adoption. This leads to a paradox: companies that are sustainable are often at a disadvantage compared to competitors that can produce at lower costs without implementing these practices (Morina, Dinaj, 2024).

It is important to note that financial sustainability in business means that companies must deal with risks related to climate change, resource scarcity, and social equity. These issues, in turn, affect the decisions of investors, regulators and consumers. Companies must therefore work to reduce costs, increase revenues and use their resources efficiently. Failure to take these elements into account can result in hidden costs, harsher regulations, and reputational damage, which can harm the viability and financial value of the company (Kapil, Rawal, 2023; Kulal *et al.,* 2023). Faced with this situation, the question arises: *How do ESG indicators affect the financial performance of companies in the automotive sector?* To address this concern, the objective is to study the impact of environmental, social and governance (ESG) indicators on the financial sustainability of the automotive industry through a stochastic Logit model. This model will allow to calculate the probability of financial sustainability according to ESG indicators and key financial ratios, allowing the identification of their effect on aspects such as liquidity, profitability, debt and solvency. The goal is to demonstrate how the adoption of ESG criteria can strengthen financial stability and reduce business risks, thus providing investors and managers with an analytical tool to assess corporate sustainability and make strategic decisions informed by quantitative data.

1. Literature Review

ESG (environmental, social and governance) indicators were designed to assess the performance and development of companies in these three areas (Maulina *et al.,* 2023). The environmental aspect focuses, among other things, on carbon footprint, resource use, and recycling practices within an organisation. The social aspect analyses how the company's actions affect the community, its employees, and human rights. Governance refers to management practices that ensure ethical and transparent decisions. Thanks to these indicators, investors and other stakeholders can assess the risks and benefits of companies in a way that goes beyond simply considering financial results, enabling them to make informed decisions and promote sustainable and ethical policies. Companies that care about their reputation and prioritise

sustainability through ESG indicators are the ones that enjoy consumer loyalty and appreciation for their social commitment (Kapil, Rawal, 2023).

Kulal *et al.* (2023) indicate that investment funds that focus on sustainable criteria tend to choose companies that show a strong commitment to sustainability. Similarly, Pirani and Patil, (2024) mention that companies that excel in ESG practices achieve higher risk-adjusted returns in the long term, thanks to their ability to use resources efficiently, attract talent, and avoid penalties from authorities. Organisations with good ESG scores tend to enjoy higher market valuations, as they are perceived as less risky and more sustainable, which in turn can lead to lower capital costs (Pava, Krausz, 1996; Alon, Vidovic, 2015).

Another aspect to consider is that, although developing ESG criteria in a company requires investment, in the medium to long term it improves operational efficiency with lower costs, for example in energy consumption. In addition, companies with good ESG indicators have greater access to financial markets and can take advantage of certain incentives promoted by different governments. In addition, there are investment funds such as MSCI and FTSE that prefer to invest in companies with high ESG values (Fowler, Hope, 2007; Jain *et al.,* 2019). Consumer loyalty also increases, which boosts revenue and profit margins, as people are willing to pay more for products from sustainable companies (Morina, Dinaj, 2024). ESG factors affect the financial performance of companies in both the short and long term. Although investments in sustainability may initially reduce operating margins, in the long term, they offer advantages such as reduced vulnerability to regulatory risks and a better market position (Ioannou, Serafeim, 2019; Kapur, 2023).

The environmental factor is decisive in some industries, such as the automotive industry, as it is directly related to CO_2 emissions. These companies must manage both their production processes and their final products to have a lower impact on ecosystems, not only in terms of emissions but also in terms of waste (Ahmad *et al.,* 2024; Eka *et al.,* 2024; Vijaya *et al.,* 2025). On the other hand, the social aspect can affect different areas such as employees, customers and the relationship between companies and the communities where they are located, highlighting the importance of diversity, inclusion, and labour rights as results of sustainable actions. Adopting socially responsible practices also improves both productivity and reputation, while disregarding them can lead to financial risks and loss of trust (Melo, Garrido-Morgado, 2012; Ajmal *et al.,* 2018;). Ethical governance promotes transparency, improves investor confidence and prevents scandals that could damage the organisation's reputation (Battiston *et al.,* 2021; Landi *et al.,* 2022). Companies that manage their risks effectively and make informed decisions about their social and environmental impact tend to have good governance. This allows them to reduce penalties and better adapt to regulatory changes (Xie *et al.,* 2019).

The aspects of sustainability, which encompass economic, environmental and social factors, are reflected in ESG criteria. These criteria affect a company's financial performance through their recognised factors (environmental, social, and governance). For example, an improvement in environmental practices can lead to an increase in operating margins in the long term, even if this involves short-term costs. Having strong governance policies can help mitigate legal risks and improve the company's valuation. To assess the likelihood of these effects, the stochastic Logit model is appropriate, allowing the prediction whether compliance with these ESG criteria will have a positive impact on key financial indicators, such as ROA or stock performance.

In relation to ESG factors and the financial aspects of companies, Rodríguez-Fernández *et al.* (2019) applied a binary regression Logit model to explore the connection between ESG indicators and financial

performance, focusing on metrics such as ROA and ROE. The results showed a significant positive influence of governance practices on financial performance. Similarly, De Lucía *et al.* (2020) used the ordered logistic regression Logit model to analyse the relationships between ESG investment decisions and financial metrics such as return on equity (ROE) and return on assets (ROA), finding a positive relationship between ESG practices and these financial measures.

Gao *et al.* (2022) conducted an analysis using a logistic regression model to examine the impact of ESG variables on the financial performance of companies, particularly during the pandemic. The authors emphasised the great importance of comprehensive ESG in the value of companies and the earnings per share of those listed on the stock exchange in China. On the other hand, Wang (2024) applied the fixed-effect Logit model to explore the connection between economic growth and ESG performance in emerging Asian economies. Their findings revealed that financial indicators have a notable impact on ESG performance. The analysis showed a positive correlation between economic growth and ESG practices, emphasising that financial development is a key factor in improving ESG performance in Asia.

Similarly, Alcaide González *et al.* (2020) used a multivariate linear regression model by Ordinary Least Squares (OLS) using information from rankings such as Green Ranking, RepTrack, Global 100 Most Sustainable Corporations, and Finance Yahoo Sustainability. This allowed them to investigate how these variables relate to different aspects of business performance and sustainability reporting (CSR), providing a comprehensive overview of business practices in relation to sustainability and social responsibility. Their objective was to analyse the most valuable brands in the IT industry from 2000 to 2017 and determine whether CSR performance and transparency in disclosure are related to various elements of corporate perception and performance. It was concluded that not all of the most valuable brands appear in sustainability rankings, highlighting the differences between brands and CSR rankings. It was also found that the level of contradiction is an important factor in CSR scores, suggesting the need to establish regulations to evaluate CSR and thus improve transparency on sustainability issues.

2. Methodology

2.1 Logit Model

The Logit statistical model is considered suitable for studying dependent variables of a dichotomous or binary nature. This model, initially introduced by Berkson (1953) and later developed in the field of statistical inference by Cox (1958), allows the probability of an event occurring to be estimated based on a set of explanatory variables, assuming dichotomous values (0 or 1). The use of classical linear models is inadequate in these contexts, as they can generate predictions outside the permitted probability range and violate essential assumptions such as homoscedasticity and normality of the residuals. Therefore, binary choice models, and in particular the Logit model, are positioned as statistically robust and methodologically rigorous tools for modelling the probability of occurrence of binary events (Amemiya, 1981; Hosmer *et al.,* 2013; Filippini *et al.,* 2018; Tutz, 2022). This model is used in areas such as economics, administration, and social sciences. Its application is particularly suitable for the analysis of decisions and behaviours expressed in terms of presence or absence, such as compliance with regulatory criteria, the adoption of sustainable practices or participation in corporate initiatives (Prasetyo *et al.,* 2020). In the present study, the use of the Logit model is justified by the binary nature of the dependent variable (probability of financial sustainability), which enables the accurate estimation of conditional probabilities associated with different explanatory factors. This methodological approach provides a robust basis for interpreting the impact of financial variables and ESG criteria in the automotive sector, providing relevant empirical evidence on sustainable business dynamics.

From a statistical perspective, the Logit model is based on the cumulative logistic distribution function, making it particularly suitable in situations where the relationship between the independent and dependent variables is non-linear. Its functional specification is as follows:

$$\mathrm{P}(Y = 1|X) = \frac{e^{x\beta}}{1+e^{x\beta}} \quad (1)$$

Where:

- P(Y=1|X) represents the probability of the occurrence of the event to be analysed,
- X is the vector of explanatory variables,
- β is the vector of estimable parameters.

Through natural logarithmic transformation, a linear relationship is obtained between the independent variables and the logarithm of the relative probabilities of occurrence (logit), which facilitates the interpretation of the estimated coefficients.

One of the main strengths of the Logit model is the use of odds ratios (OR), which allow for the analysis of the proportional change in the probability of occurrence in response to variations in the independent variables (Menard, 2002). Each OR associated with each independent variable is obtained as the natural antilogarithm of the corresponding estimated coefficient:

$$OR = \mathrm{e}^{\beta} \quad (2)$$

These odds ratios can vary between 0 and infinity, and their interpretation depends on their value relative to 1: an OR=1 indicates no association between the independent variable and the outcome; OR>1 suggests a positive relationship; and OR<1 suggests a negative relationship, implying that an increase in the independent variable reduces the probability of the event occurring.

The Logit model is estimated using the maximum likelihood method, which guarantees consistent and efficient estimates (Gujarati, Porter, 2009). The performance of the model can be evaluated using indicators such as McFadden's pseudo-R^2, Akaike's information criterion (AIC) and Bayesian information criterion (BIC), as well as goodness-of-fit tests (Hosmer-Lemeshow), residual analysis, and the ROC curve. In this research, the ROC curve has been chosen as the main metric for evaluating the predictive capacity of the proposed Logit model.

2.2 FSI Logit Model Applied to the Automotive Industry

As an essential part of the analysis of the automotive industry, the assessment of financial health and growth potential is based on the systematic study of financial indicators, grouped into four broad categories: liquidity, profitability, indebtedness, and solvency. A detailed examination of these metrics allows companies to identify trends, manage associated risks, and strengthen their competitiveness in dynamic markets (Liu *et al.,* 2023; Gomoi, 2024; Chap, Liu, 2024). Liquidity indicators assess a company's ability to meet short-term obligations without incurring significant losses. In the automotive sector, these indicators are continuously monitored through various financial variables and ratios (Hutajulu *et al.,* 2023; Ramanuj, Memon, 2023; Makhsunnah, Susilo, 2024). In terms of profitability, the sector uses metrics such as capital structure, company size, operational efficiency, revenue, and assets, all of which have a significant impact on the results achieved in terms of returns (Himawan *et al.,* 2024).

Debt indicators measure the ratio of debt to equity and typically analyse items such as total liabilities, current liabilities and net equity, thus reflecting the degree of dependence on external financing for both operations and expansion investments (Campos, Nakamura, 2015; Gajdosikova, Valaskova, 2022). Finally, solvency indicators examine the company's ability to meet long-term financial obligations, which is an indicator of stability and operational viability (Abey, Velmurugan, 2018), through ratios between total assets, liabilities and equity.

These four sets of financial indicators, also known as financial ratios, together with ESG ratings, form the core of the explanatory variables used in the Logit model specification. Their integration allows for a multidimensional assessment of financial health and corporate sustainability. Specifically, the dimensions or reason analysed are:

1. Financial Reason Liquidity (FRL): Revenue, CAPEX, Cash and other equivalents.

2. Financial Reason Profitability (FRP): ROA, Asset turnover, ROE, Earnings per Share.

3. Financial Reason Debt (FRD): Total debt, Assets/Equity, Current and Non-current liabilities, Net debt, WACC, Financial leverage, Interest expense.

4. Financial Reason Solvency (FRS): Total Assets, Working Capital, EBIT, EBITDA, PER, Enterprise value.

5. Environmental Indicator (EI): Impact on the environment.

6. Social Indicator (SI): Relationships with employees, communities and customers.

7. Governance Indicator (GI): Business structure and ethics.

Given the correlation between many of these variables, principal component analysis (PCA) was used to reduce the dimension and facilitate interpretation. PCA transforms the original set of correlated variables into orthogonal principal components, whose loadings determine the relative weight of each variable on the corresponding synthetic indicator (Rencher, Christensen, 2012). For example, the financial debt ratio (FDR) is constructed as a weighted combination (according to the eigenvalues and eigenvectors of the covariance matrix) of the indicators that make up this group.

After this statistical synthesis process, the financial ratios and ESG indicators obtained are used as explanatory variables in the Logit model specification. The dependent variable is dichotomous and identifies the financial sustainability index (FSI) of the company: a probability P(FSI=1) indicates a financially sustainable organisation, while P(FSI=0) indicates the opposite. The probability is modelled using the inverse logit function:

$$P\ (ISF = 1) = \frac{1}{1+e^{-(a+\sum \beta_j FR_{ij}+\sum \delta jESG_{ij})}} \quad (3)$$

Where:

- β_j: Estimate coefficient for financial reasons (FR),
- δj: Estimated coefficient for the ESG indicators,
- α: Model intercept.

These coefficients (βj, δj) describe the marginal effect of each variable on the probability of sustainability: positive values reinforce the probability of FSI=1, while negative values reduce it. Their interpretation can be refined by transforming them into odds ratios: the antilogarithm of the estimated coefficient ($OR = e^{\beta}$) allows to estimate the proportional change in the probabilities associated with a unit variation in the independent variable. An OR>1 indicates a positive association with financial sustainability; OR<1, a negative association; and OR=1, no association. In addition, the percentage change in odds following a unit increase is calculated using $[e^{\beta}-1]\times100$.

In conclusion, the systematisation of financial indicators and ESG factors, together with their integrated analysis using principal components and Logit modelling, provides a robust methodology for quantifying, classifying and interpreting the financial sustainability of automotive companies in contemporary scenarios characterized by complexity and regulatory requirements.

3. Analysis and Results

3.1 Database and Sample

The sample used in this research consisted of global automotive and auto parts companies, specifically classified under NACE Rev. 2 (2910) and NAICS Rev. 2 (3361) codes, which group together motor vehicle manufacturers and associated components. The main source of information was the Bloomberg platform, widely recognised for the rigour and breadth of its coverage of financial data and ESG metrics. The data collection process was carried out between 3 October and 30 December 2024, considering an initial population of 1,203 companies with available information. From this universe, 430 companies that met the requirement of having complete and consistent records for both financial variables and ESG indicators over a continuous period of eleven years (2013–2024) were selected. This inclusion criterion ensured the robustness and reliability of the sample, allowing for comparable and sustained analysis over time.

The variables were structured into two macro groups: (a) financial ratios, including indicators such as EBITDA, common equity, ROE, net debt, and total liabilities; and (b) ESG indicators, divided into environmental, social, and governance dimensions. The detailed composition and scope of the information collection instrument is summarised in *Table 1*, which provides a comprehensive overview of the variables analysed and their operationalisation throughout the study.

Table 1. Discriminated Population of Companies in the Automotive Sector

Automotive Sector (2013–2024)	Auto Parts Manufacturers	Car Manufacturers	***Total***
Companies with no data for one or more years	632	131	763
Companies with complete financial and ESG data	**368**	**62**	**430**
Total - Companies	1000	203	1203

Source: created by the authors.

The information elements considered in the study were organised into two broad categories of variables: (a) financial reasons and (b) ESG indicators. This classification made it possible to systematically structure the data collected and facilitate its statistical analysis, as detailed in *Table 2*.

Table 1. Variable Description for Financial and ESG Sustainability Analysis

Ticker	ESG data	EBITDA	Cash and others	Total liabilities
Industry	Assets	ROA %	Capital	Non-current liabilities
Name	Liabilities	PER	Total capital and liabilities	Current liabilities
Market cap.		WACC %	EBIT	Net debt
ROE %		Interest expenses	Total debts	Net assets
P/E		Incomes	Total return YTD	Assets/equity
Revenue		Profits	Financial leverage	
EPS		Capex	Working capital	Enterprise value
		Environmental, Social and Governance (ESG) Indicators		
		Company		
		Ticker		
		Industry		
		S. Environmental		
		S. Social		
		S. Governance		
		S. ESG		

Note: Cap = Capitalisation, YTD = Year To Date, EPS = Earnings Per Share, S = Score.

Source: created by the authors.

3.2 Descriptive Analysis of the Sample

A descriptive analysis of the sample was carried out for 430 vehicle and auto parts manufacturers worldwide between 2013 and 2024 (see *Table 3*). As can be seen, in general terms, there is considerable variability in many of the variables. This may be due to factors related to company size, economic crises, supply chain disruptions, fluctuations in demand, and regulatory changes, all of which may have influenced the profitability, indebtedness, and liquidity of these companies.

Some of the results obtained, highlighted in bold in *Table 3*, are worth noting. For example, liquidity, measured as cash and cash equivalents, stands out for its average value of 1,307.77 and a standard deviation of 5,880.30, which indicates high dispersion. This difference between companies may reflect different approaches to working capital management, as well as the availability of cash flow to meet short-term obligations or invest in operational improvements. A good liquidity position, although desirable, must also be analysed in conjunction with other indicators such as working capital or leverage, in order to understand whether that liquidity is the result of an efficient financial structure or low reinvestment.

In order to facilitate a more accurate interpretation of the relative dispersion between the different indicators, the Coefficient of Variation (CV%) will be used as the central tool for comparative analysis. This measure allows variables with different scales, such as monetary amounts, percentages or scores, to be compared, identifying which ones show greater stability or, conversely, high variability between companies. Its use is particularly relevant in this study, given the focus on identifying patterns of financial and sustainable performance in the automotive sector, allowing for a more objective comparison between traditional indicators and those associated with ESG criteria.

Table 3. Descriptive Statistics

	ROA	ASSETS ROTATION	ROE	EPS
CV%	0.49	**2.08**	0.37	0.30
Mín	-40.65	0.00	-128.29	-33.69
Max	63.50	4.34	237.67	54.00
Mean	3.23	**0.93**	6.31	0.91
SD	6.56	**0.45**	17.14	3.03
	TOT. DEBTS / TOTAL ASSETS	**ASSETS / EQUITY**	**TOTAL LIABILITIES**	**NON-CURRENT LIABILITIES**
CV%	1.58	1.82	**0.19**	0.17
Mín	0.00	1.00	0.35	0.00
Max	76.17	21.39	452,641.97	249,369.62
Mean	24.33	2.39	**6,265.00**	2,828.43
SD	15.44	1.31	**32,286.42**	16,371.35
	CURRENT LIABILITIES	**NET DEBT**	**NET ASSETS**	**WACC**
CV%	0.21	**0.03**	0.24	**2.86**
Mín	0.32	-60,214.03	2.50	-3.85
Max	203,272.35	113,869.35	223,386.15	33.43
Mean	3,436.57	**142.53**	3,496.11	**11.89**
SD	16,359.56	**4,913.59**	14,739.46	**4.15**
	CAPITAL STOCK_	**CAPITAL STOCK / TOTAL LIABILITIES**	**FINANCIAL LEVERAGE**	**FINANCIAL INTERESTS**
CV%	0.24	0.21	1.23	0.24
Mín	2.50	4.00	1.00	0.00
Max	215,909.58	607,721.87	63.88	3,341.93
Mean	3,289.69	9,674.45	2.65	36.23
SD	13,857.08	45,550.96	2.15	150.28
	TOTAL ASSETS	**WORKING CAPITAL**	**EBIT**	**EBITDA**
CV%	0.52	0.24	0.21	0.22
Mín	14.80	-22,985.08	-4,518.52	-1,476.82
Max	610,903.39	45,057.51	26,678.54	54,250.50
Mean	22,786.21	777.79	364.22	740.34
SD	43,979.62	3,243.61	1,749.35	3,432.02
	COMPANY VALUE	**PER**	**CAPEX**	**INCOME**
CV%	0.18	0.43	0.20	0.25
Mín	-2,727.87	0.01	-33,731.21	0.00
Max	1,053,847.01	576.64	0.00	296,008.61
Mean	4,818.20	13.41	-376.79	6,477.76
SD	26,836.32	31.08	1,913.65	25,849.22
	CASH AND OTHER	**ESG**		
CV%	0.22	**0.68**		
Mín	0.00	0.00		
Max	84,226.69	6.57		
Media	1,307.77	1.15		
SD	5,880.30	1.68		

Source: created by the authors.

It was possible to identify the Coefficient of Variation (CV%), which, together with the mean and standard deviation (SD), allows for the evaluation of the relative dispersion of financial indicators, facilitating comparisons between variables with different scales. Therefore, in *Table 3*, the two indicators with the

highest CV% are WACC (2.86) and Asset Turnover (2.08). WACC, with a mean of 11.89 and a standard deviation of 4.15, reflects high variability in the average cost of capital among companies, possibly due to differences in risk, financial structure, and access to financing. Asset turnover, with a mean of 0.93 and a standard deviation of 0.45, also shows significant dispersion, suggesting marked differences in operational efficiency.

On the other hand, the two indicators with the lowest CV% are Net Debt (0.03) and Total Liabilities (0.19). Although net debt has a high standard deviation (4,913.59), its mean is also high (142.53), which reduces its relative variability, indicating that most companies maintain net debt levels proportional to their size. Total liabilities, with a mean of 6,265.00 and a standard deviation of 32,286.42, also show low relative variability, suggesting a certain homogeneity in total debt levels. Taken together, these results allow us to identify areas of greater financial uncertainty (such as cost of capital and operating efficiency) compared to more stable areas (such as net debt and total liabilities), which is key to assessing risks and strategies within the global automotive sector.

In terms of profitability, instability is detected in ROE and earnings per share, suggesting high financial risks within the industry. With regard to indebtedness, heterogeneous strategies are identified, with some companies highly leveraged and others with more conservative capital structures. Regarding solvency, greater stability is observed, as EBIT and EBITDA show moderate variations, indicating that operating profitability has remained relatively constant. Finally, the ESG component reflects a mixed approach to the adoption of sustainable practices, showing that the industry is at different stages of integrating environmental and social criteria.

The ESG score used in this analysis is expressed on a scale of 0 to 10, where 10 represents the maximum compliance with environmental, social and governance sustainability criteria. This scale is based on studies that have demonstrated a positive relationship between ESG performance and financial performance, as noted by Friede et al. (2015). The average score achieved by the companies in the sample is 6.57, indicating an acceptable, albeit not outstanding, level of commitment to ESG principles. This rating suggests that the automotive sector has made progress in terms of sustainability, although there is still room for improvement, particularly in areas such as emissions, labour rights and corporate transparency, as detailed in other sections of the analysis.

Finally, the ESG indicator has a coefficient of variation (CV%) of 0.68, an average of 1.15, and a standard deviation (SD) of 1.68, indicating high relative variability in the adoption of sustainable practices among companies in the automotive sector. The observed dispersion reflects that while some companies have made significant progress in integrating these criteria, others still lag significantly behind. This heterogeneity may be due to differences in local regulations, investor pressures, or corporate strategies.

3.3 Analysis of the FSI Logit Model

An FSI Logit model has been constructed to determine the relationship between companies' financial variables and their possible classification as sustainable or not. The companies in the sample were categorised according to the financial sustainability index (FSI), previously defined in the methodology section. To facilitate the interpretation and subsequent classification, the continuous value of the FSI was transformed by rounding it to a discrete scale ranging from 0 to 1, with increments of 0.1. This discretisation generates ten distinct levels of sustainability, allowing for simplified comparative analysis and clear visualisation, which groups companies into two main categories: sustainable and non-sustainable.

Due to the structural and dimensional diversity of the economic and financial variables involved, a dimensionality reduction process was carried out using principal component analysis (PCA). To this end, the variables were grouped into financial ratios corresponding to liquidity, profitability, solvency and indebtedness, and an additional factor that condensed the different individual ESG scores into a single component.

PCA analysis identified the variables with the greatest contribution to the weight of each financial ratio (see *Table 4*). In the Liquidity Ratio, there is a significant positive loading for CAPEX (0.57), while Cash and Cash Equivalents (-0.58) and Income (-0.58) have negative loads, suggesting that companies with greater liquidity tend to invest less in fixed assets. In the Profitability Ratio, negative loadings stand out for ROE (-0.64), ROA (-0.63), and Basic Earnings per Share (-0.34), indicating a particular inverse relationship in the ability to generate profits within the specific context studied. For the Solvency Ratio, the main variables are EBITDA (0.49), EBIT (0.48), and Total Assets (0.47), thus reflecting that both profit generation and company size are determinants of financial stability. Finally, in the Debt Ratio, structural variables such as Total Liabilities (0.39), Capital and Total Liabilities (0.39), and Non-Current Liabilities (0.38) have greater weight, indicating that the degree of indebtedness is more closely linked to the configuration of liabilities than to operational or performance indicators.

These loadings represent the relative importance of each variable within the associated principal component, thus facilitating the understanding of how each indicator contributes to shaping the different financial ratios included in the model (see *Table 4*).

Table 4. Composition of Financial Ratios

FRD	***Loading***	**FRS**	***Loading***	**FRP**	***Loading***	**FRL**	***Loading***
TOTAL_DEBTS_TOTAL_ASSETS	0.10	TOTAL_ASSETS	0.47	ROA	-0.63	CAPEX	0.57
ASSETS/EQUITY	0.11	WORKING CAPITAL	0.37	ASSETS ROTATION	-0.28	CASH_AND OTHERS	-0.58
TOTAL LIABILITIES	0.39	EBIT	0.48	ROE	-0.64	INCOME	-0.58
NON-CURRENT LIABILITIES	0.38	EBITDA	0.49	EPS	-0.34		
CURRENT LIABILITIES	0.38	COMPANY VALUE	0.33				
NET DEBT	-0.13	PER	0.25				
NET ASSEST	0.36						
WACC	0.00						
CAPITAL STOCK	0.36						
CAPITAL STOCK/TOTAL LIABILITIES	0.39						
FINANCIAL LEVERAGE	0.10						
FINANCIAL INTEREST	0.32						

Source: created by the authors.

Once the different factors have been calculated, a Logit model (Logit FSI) is estimated to determine whether these reasons or factors can explain or determine whether a company is financially sustainable, as measured by the financial sustainability index (FSI). As can be seen in *Table 5*, the FRL factor has proved

to be insignificant. Therefore, it was decided to re-estimate the model without this factor (see *Table* 6). In this case, all factors were significant.

Table 2. Estimated FSI Logit Model with All Factors

Variable	$\hat{\beta}$	Error S	Z-valor	Valor p
FRL	0.36	0.38	0.94	0.35
FRP	-1.35	0.07	-18.71	0.00
FRD	-1.68	0.22	-7.79	0.00
FRS	0.32	0.08	3.85	0.00
ESG	0.55	0.05	10.76	0.00
Constant	-2.87	0.16	-17.54	0.00

Source: created by the authors.

Table 6. Final Estimated FSI Logit Model

Variable	$\hat{\beta}$	Error S	Z-valor	Valor p	Odds ratio
FRP	-1.34	0.07	-18.71	0.00	0.26
FRD	-1.81	0.18	-9.89	0.00	0.16
FRS	0.26	0.05	5.4	0.00	1.30
ESG	0.54	0.05	10.74	0.00	1.72
Constant	-2.84	0.16	-17.7	0.00	0.058

Source: created by the authors.

The last column presents the odds ratios calculated for each factor. It can be seen that the Financial Solvency Ratio (FSR) has a positive coefficient of 0.26 and an odds ratio of 1.30, indicating that an increase in the financial variables associated with solvency (FSR factor) raises the probability of the event FSI=1, i.e., the achievement of financial sustainability, by approximately 30% (1.30 - 1). It is important to remember that the odds ratio is a measure used in the Logit model that expresses how much the probability of a given event occurring increases or decreases when one independent variable varies, while the others remain constant. A value greater than one suggests that the variable increases the probability of the event (greater financial sustainability), while a value less than one implies that it reduces it.

Similarly, the ESG criterion has a positive coefficient of 0.54 and an odds ratio of 1.72, indicating that better environmental, social and governance practices increase the probability of financial sustainability by 72%. On the other hand, the model reveals that an increase in profitability (FRP) is associated with a 74% reduction in the probability of financial sustainability (FSI = 1), given that its odds ratio is 0.26, less than one. Likewise, a higher level of indebtedness (FRD) is related to an 84% decrease in the probability of financial sustainability, with an odds ratio of 0.16, also less than one. These results suggest that, within the automotive sector, a higher level of financial leverage significantly compromises financial sustainability, directly affecting the capital structure of companies.

Finally, based on the coefficients estimated in the Logit FSI model, the financial solvency index is calculated individually for each company, following the procedure detailed in the methodology section.

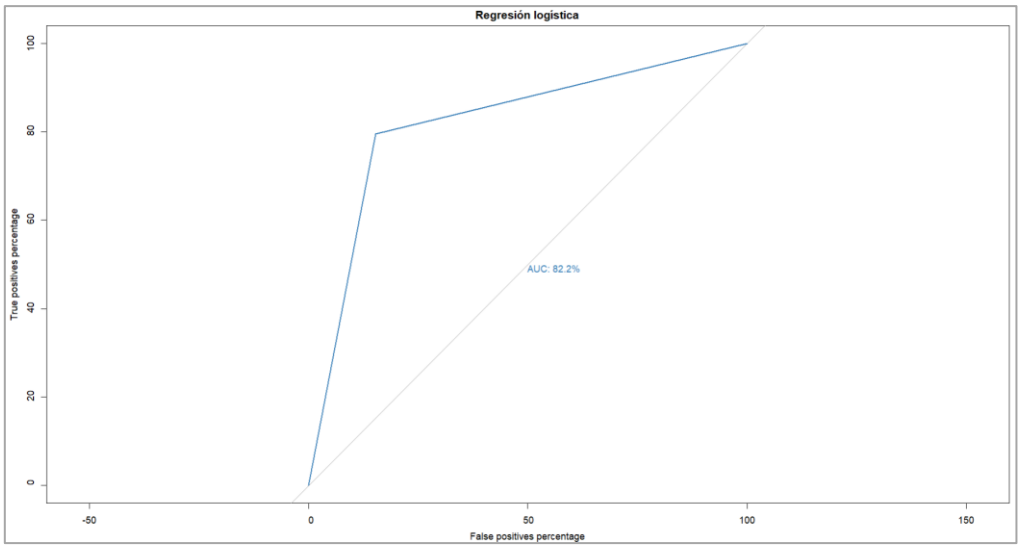
$$Z_i = FSI_i = -2.84 - 1.34 * FRP - 1.8 * FRD + 0.26 * FRS + 0.54 * ESG \quad (4)$$

$$Pr(FSI_i = 1|FR_i) = \frac{1}{1+e^{-(-2.84 - 1.34*FRP - 1.8*FRD + 0.26*FRS + 0.54*ESG)}} \quad (5)$$

The results obtained in the research indicate that the coefficient associated with the ESG indicator was positive, implying that effective management of environmental, social and governance aspects significantly increase the likelihood of a company being financially sustainable. Conversely, the profitability ratio showed a negative coefficient, interpreted as an adverse effect of high profitability on financial sustainability. This relationship could be explained by the fact that, in certain cases, high profitability is achieved at the expense of compromising sustainable practices or may reflect the presence of volatile profits that compromise long-term stability. In contrast, the debt ratio had a positive effect on the model, suggesting that a moderate level of leverage can help maintain financial viability, especially in capital-intensive sectors such as the automotive industry, where investments in fixed assets are significant.

To evaluate the predictive capacity and fit of the model, the percentage of correct classifications of the FSI variable was estimated by comparing the predicted values with the observed values. A standard probability threshold of 0.5 was adopted to distinguish sustainable companies (FSI = 1 for probability ≥ 0.5) from non-sustainable companies (FSI = 0 for probability < 0.5). This choice is in line with standard practice in binary logistic regression when there is no explicit preference for minimising false positives or false negatives, providing a balanced interpretation of the estimated probability (Cohen et al., 2017). It should be noted that this threshold can be adjusted depending on whether sensitivity or specificity is to be prioritised.

The ROC (Receiver Operating Characteristic) curve assessment measures the accuracy of the dichotomous model by comparing the true positive rate and the false positive rate for different cut-off points. As shown in *Figure 1*, the area under the curve (AUC) was 82.2%, indicating a good ability to discriminate between sustainable and non-sustainable companies. The curve rises rapidly, indicating that the model achieves a high true positive rate with a relatively low number of false positives, confirming its effectiveness in correctly identifying corporate financial sustainability. This performance of the model reaffirms the relevance of the Logit approach for analysing financial sustainability, allowing for a high degree of certainty in classifying the probability that an automotive company will meet financial and ESG criteria aligned with sustainability.



Source: created by the authors.

Figure 1. ***ROC Curve***

Based on the results observed in this section, it can be concluded that the identification of financial indicators or ratios for liquidity, profitability, indebtedness, and solvency, together with the ESG score, are key to assessing a company's financial sustainability. Traditional financial ratios, such as current liquidity, ROA, financial leverage and solvency, provide a clear picture of the economic and financial performance of an automotive organisation's ability to generate financial value over time. However, in the context studied, where environmental, social and governance aspects are increasingly critical to the valuation of companies, ESG indicators are becoming increasingly important. This is in line with the findings of Rodríguez-Fernández et al. (2019), who have highlighted the importance of ESG criteria for companies to be financially sustainable over time.

Additionally, the Logit model identified that ESG factors increase the probability of financial sustainability by 72% (Odds Ratio = 1.72), reinforcing the idea that effective ESG management is correlated with greater financial stability. Factors related to financial solvency also increase financial sustainability when they increase. However, factors related to profitability and indebtedness had odds ratios below unity, and therefore an increase in these factors would imply a reduction in the probability of achieving financial sustainability. This suggests that companies must find a balance between ESG investment, financial solvency, profitability, and indebtedness. Therefore, financial and sustainability strategies must be considered together in corporate decision-making.

Integrating ESG indicators into assessments considers not only financial performance but also the long-term implications for critical factors such as environmental sustainability, social responsibility, and corporate governance quality. This combined approach enables investors and corporate management to make more informed, balanced decisions that prioritise both financial stability and long-term sustainability. Consequently, it offers a holistic perspective on corporate value, reducing risks and maximising opportunities in markets where corporate responsibility and social commitment are essential. Ahmad et al. (2024) affirm that incorporating ESG factors is a vital practice for sustainable business decision-making.

Furthermore, an analysis of the relationship between financial indicators and ESG criteria reveals a high degree of consistency and correlation between them. These metrics directly influence one another, enabling companies to manage financial risks more effectively. For instance, improved profitability is often linked to enhanced operational efficiency and reduced leverage, thereby reinforcing a company's financial stability and supporting financial sustainability. This aligns with Kapur (2023), who underscores the significance of ESG criteria as tools for bolstering long-term financial stability and management. The findings indicate that while ESG indicators may not demonstrate an immediate financial impact (as evidenced by correlation), they remain pertinent due to their strategic contributions over the long term. These criteria are crucial for mitigating structural risks, including exposure to environmental regulations and increasing social demands. Therefore, while financial ratios have a strong interrelationship that facilitates direct management of economic performance, ESG factors enhance value from a broader perspective by fortifying organisational resilience and establishing robust financial sustainability for the future, as noted by Kapur (2023).

The application of the FSI stochastic Logit model to quantify financial sustainability, predicated on the interplay between financial and ESG indicators, serves as a solid methodological tool validated by various authors in academic literature. This approach allows companies to probabilistically identify and evaluate the factors affecting their sustainability while maintaining their solvency, thus enabling the analysis of how various combinations of indicators influence long-term financial viability and social responsibility. Our

results align with the findings of De Lucía et al. (2020), who employed a stochastic Logit model to assess the impact of ESG decisions on key financial metrics, underscoring the utility of this approach for interpreting complex variable interactions. Similarly, Wang (2024) conducted an analysis using a Logit model within an Asian context, investigating the connections between ESG and financial indicators and demonstrating their significance for understanding both financial and social viability of companies. These studies validate the effectiveness of the proposed model and reinforce the evidence that sound sustainability practices contribute markedly to financial stability.

Conclusions

The present research has provided a comprehensive understanding of the interrelationship between financial variables and ESG criteria in the automotive sector, fully fulfilling the stated general objective and systematically addressing each of the specific objectives. By applying a rigorous mixed methodological approach, a holistic view of financial sustainability was constructed, integrating statistical, logical, and multi-criteria tools that enrich traditional analysis based exclusively on financial or sustainable indicators separately.

One of the main contributions of this article was the development of the Financial Sustainability Index (FSI), which synthesises the financial performance of companies through four key factors: liquidity, profitability, indebtedness, and solvency. This index enabled the operation of financial sustainability in a quantifiable and replicable manner, facilitating its comparative analysis in a sector characterised by its high competitiveness and exposure to regulatory, technological, and environmental risks.

The application of the Logit FSI model enabled the estimation of the probability of a company achieving financial sustainability, demonstrating that variables such as working capital, debt levels, and EBITDA have a significant impact on organisational performance. These results are consistent with the correlation analysis, which showed strong associations between key financial indicators, while ESG scores exhibited weak or no relationships with these financial metrics. This finding is particularly significant because it reveals that financial strength does not always align with ESG assessments, which, while reflecting non-financial commitments, may not adequately capture the economic stability of organisations. This disconnect between financial and sustainable aspects underscores the need for integrative approaches, such as the one proposed in this research, that combines both types of variables to achieve a more complete and accurate perspective on corporate sustainability.

Among the most notable findings, it is emphasised that companies with balanced financial structures, particularly those with adequate solvency and debt levels, are more likely to achieve financial sustainability, even when their ESG scores are not the highest. This implies that financial sustainability should be conceived as a multidimensional phenomenon, in which operational efficiency, risk management, and commitment to sustainability are integrated into a coherent whole. On the other hand, the lack of significant correlations between ESG criteria and key financial indicators suggests that their influence on the sector's financial structure remains limited. Essentially, the sector's financial stability depends predominantly on operational efficiency and the balance between internal and external financing sources. Therefore, this analysis contributes to a deeper and more nuanced understanding of sustainability in the automotive sector, providing empirical and methodological foundations for the formulation of corporate strategies that integrate financial and sustainability aspects harmoniously and effectively.

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APLINKOSAUGOS, SOCIALINIŲ IR VERSLO VALDYMO VEIKSNIŲ (ESG) ĮTAKA AUTOMOBILIŲ GAMYBOS ĮMONIŲ TVARUMUI

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SANTRAUKA. Suinteresuotieji subjektai vis labiau domisi ESG kriterijų plėtros lygiu. Tai atsispindi įvairių agentūrų ESG reitinguose. Aukštas ESG reitingas reiškia, kad įmonė yra tvaresnė. Būtina analizuoti įmonių įvairių ekonominių ir finansinių kintamųjų santykį ir jų priskyrimą tvarioms įmonėms. Šiame straipsnyje tiriamas finansinis automobilių sektoriaus įmonių tvarumas. Tirta 430 automobilių sektoriaus įmonių. Buvo atrinkti įvairūs ekonominiai ir finansiniai kintamieji, atitinkantys skirtingus aspektus, pvz., likvidumą, mokumą, pelningumą ir įsiskolinimą. Siekiant suglaudinti skirtinguose aspektuose ar veiksniuose pateiktą įvairių kintamųjų informaciją, buvo atlikta pagrindinių komponentų analizė. Šių veiksnių ir įmonių finansinis tvarumo ryšys išanalizuotas tikimybiniu Logit modeliu. Finansinio tvarumo laipsnis (arba finansinio tvarumo indeksas) taip pat gali būti nustatomas remiantis Logit modelio koeficientais, juos transformuojant į santykinius rodiklius. Taip galima įvertinti šio indekso procentinį pokytį, atsižvelgiant į kiekvieno ekonominio ir finansinio veiksnio kitimą. Rezultatai rodo, kad nagrinėjamo sektoriaus atveju ESG kriterijų gerėjimas siejamas su maždaug 72 % finansinio tvarumo indekso padidėjimu. Su mokumu susijęs veiksnys taip pat daro teigiamą įtaką: įmonės mokumo pagerėjimas lemia apie 30 % finansinio tvarumo augimą. Pelningumo veiksnio didėjimas susijęs su 74 % finansinio tvarumo sumažėjimu, skolos augimas taip pat lemia reikšmingą – apie 84 % – tvarumo mažėjimą.

Reikšminiai žodžiai: finansiniai veiksniai; ESG veiksniai; automobilių gamybos sektorius; tvarumas.