Assessing the Drivers of Green Bond Issuance: A Panel Probit Model Approach

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***Abstract*—As global environmental challenges intensify, nations increasingly recognize the importance of eco-friendly, sustainable practices in fostering high-quality economic development. In this context, green finance, particularly through green bonds, has been crucial in transitioning from a traditional to an environmentally conscious economy. However, in the current academic research, the influencing factors on the possibility of green bond issuance have not been unified. This study uses the data of listed Iberian companies from 2010 to 2020 and adoptes four LDV models to analyze the relationship between the characteristics of enterprises, the progress of ecological technologies, and the possibility of issuing green bonds: (1) Due to the high capital value and market value, the market scale significantly enhances the possibility of issuing green bonds; (2) The company's market performance and profitability have no significant relationship with green debt bonds; (3) Greater market liquidity often has a negative impact on the issuance of green bonds, especially in some special cases; (4) Advancements in environmental technologies, whether broadly integrated or specifically targeted, increase the likelihood of companies issuing green bonds.**

***Index Terms*—green bonds, innovations, market liquidity**

I. Introduction

THE concept of capital structure is centered around various theoretical frameworks that suggest optimal approaches for a company to handle its finances. For instance, in 1976, Jensen and Michael [1] proposed the agency cost theory which analyzes the relationship among managers, shareholders, and investors, especially concerning ownership and control. Ross's Signaling theory (1977) [2] suggests that decisions made by management based on insider knowledge can signal the firm's financial health to the market. The tradeoff theory by Kraus and Litzenberger (1973) [3] focuses on finding the best balance between the benefits of debt and the risks of bankruptcy. The trade-off theory put forward by Kraus and Litzenberger in 1973 focuses on determining the optimal equilibrium between debt's advantages and bankruptcy's risks.

In addition, the pecking order theory [4] suggests that companies with higher profits are more likely to invest with internal funds. As businesses expand, their debt levels are influenced by variations in profit and loss over time, prompting adjustments only when the advantages exceed the costs, which requires an analysis of market trends and fiscal conditions.

Green finance is becoming increasingly important in financing sustainable management and government policies.

As an important means of green financing, green bonds can not only bring stable returns to investors, but also help to reduce the expenditure in the financing process, and play a significant and positive role in promoting the investment activities of various environmental projects around the world. Furthermore, these bonds further contribute to the implementation of environmental, social and governance (ESG) concepts, attracting more investors who support environmentally sustainable development. This study analyzes the specific market and financial factors affecting the issuance of green bonds, and analyzes the specific effects of different variables in different backgrounds.

In the Iberian Peninsula, comprising Portugal and Spain, the economic integration, along with advancements in green patents and renewable energy sector progress, offers a unique perspective for an in-depth analysis of the region's energy transition. This research will assess the potential for green bond issuance by Iberian firms using econometric methods based on limited dependent variable models (LDV), thus enriching the understanding of this emerging field in sustainable finance literature.

II. Literature Review and Hypotheses

According to the existing research, it can be found that most of the studies are mainly about how enterprise characteristics affect the capital structure of the company, but few literature studies the impact of enterprise characteristics on the possibility of green bond issuance and the reasons for the issuance of green debt issuance.

A. Green Bonds: An Overview of Emerging Trends

Green bonds is a special type of fixed income securities, can also be seen as an innovative financial instruments, the specific process for the issuer by selling the bonds to investors to raise money, and specified to raise money will be used to support meet the requirements of the green industry, green projects or green economic activities, the bond issuance purpose is to promote sustainable development and environmental problems such as climate change [5]. In recent years, with the improvement of people's awareness of sustainable development, such as

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environmental protection concepts, the demand for environmental protection financial products has surged. This phenomenon reflects that the market is changing to pay more attention to environmental and social responsibility, and green investment has become a new market hot spot [6].

In the process of promoting sustainable development and transformation, green debt bonds have become an important channel to provide funds. Research on the impact of green bond issuance has been extended across different sectors. For example, Gianfrate and Peri (2019) [7] conducted a study of 121 green bonds issued in Europe between 2013 and 2017, and found that green bonds could play an important role in promoting the green transformation of the economy, and also reflected the role of the regulatory framework in promoting green debt rolls. Bhutta et al. (2022) [8] collected green bond related data for methodological analysis and concluded that external factors in the market play a more significant driving role than internal factors in the issuance of green bonds.

In addition, green bonds play an important role in promoting information communication, effectively reducing the information gap between issuers and investors, and significantly improving the transparency in the process of resource allocation. With their independent and objective stand, external ESG professional analysts conduct a comprehensive and in-depth evaluation of the investment process, which further alleviates the problem of information asymmetry faced by investors. This allows investors to have a clearer and accurate understanding of the bond issuers and details about the green projects they promote.

B. Market scale effect analysis

The market size reflects its market value, indicating the future value expected by investors. A lower market valuation may reduce its participation in bond or credit markets. This could result in limited access to capital funding due to poor market valuation and ultimately affect the company's leverage. In a bull market, management tends to prefer equity financing over debt options (Antoniou et al., 2008) [9]. This trend is expected to extend to corporate bond yields, where bond funding is usually more expensive than equity market financing.

Although rising stock prices may make equity financing more appealing, influenced by market sentiment, firms might still choose debt issuance or leverage strategies. Bond issuance can also be a strategy to prevent hostile takeovers. Their relationship is dynamic, evolving with market behaviors.

In terms of corporate social responsibility (CSR) [10] and sustainability, larger companies focus more on investing in related projects that support the sustainable energy transition. This will help to accelerate the successful transformation of sustainable development. In this process, larger enterprises that focus on sustainable development are more able to attract more investors, thus forming more socially responsible investment portfolios.

H1: Market size effectively contributes to the issuance of green bonds.

The size of a company largely determines bond issuance, and the concept of "financial contagion" encourages investors to invest more in large companies, stabilize the market and financial system, and guide the healthy development of institutions, because larger companies have easier access to the debt market than smaller companies [11].

Companies with a larger scale have a higher probability of issuing bonds in the bond market. However, this is not completely grounded in bank credit. This preference stems from the bond market's less stringent requirements, such as collateral needs. These companies are perceived as having high reputations, primarily due to their lower risk of failure.

The trade-off [12] theory holds that the size of a company is an important factor influencing its bond issuance decisions and capital structure. Larger companies have comparative advantages in terms of financial difficulties costs, information asymmetry, market influence and bankruptcy costs, which makes them more inclined to issue bonds to finance and maintain a high debt ratio in the capital structure [13]. In addition, according to the Pecking Order theory, if there is a more significant information asymmetry between managers and market participants, then this situation will lead to further increases in financing costs. While a company's size is linked to information asymmetry, it also facilitates external financing with longer maturities, particularly in bear markets. Leverage generally has an inverse relationship with company size, as larger firms with strong market positions are better at retaining earnings and investing internally, thereby reducing the need for external funding.

H2: The size of the company is very important for the issuance of green bonds.

Ordinarily, corporate finance is often influenced by the scale of the enterprise. However, we have found that statistically speaking, the impact of the enterprise scale on the issuance of green bonds is relatively small. At the same time, it also indicates that other factors such as corporate reputation have an impact on the issuance of green bonds. Among them, regardless of the scale, enterprises that are dedicated to the ESG concept have a higher probability of issuing green bonds. This also shows that factors such as ESG have a greater influence on the issuance of green bonds than traditional financial indicators such as the enterprise scale.

Market scale and enterprise scale interact and restrict each other, and jointly promote the development of the market and the growth of enterprises. However, there are differences in the impact of green bonds. The market size reflects the overall economic activity level of the whole market, while the size of the enterprise focuses on a single enterprise, reflecting the comprehensive strength of the enterprise in business activities. Although both have an impact on financing, it can be analyzed from its concept that the size of enterprises may have a small impact on the issuance of green bonds. Therefore, the market size is more appropriate to understand the situation of green bonds. Based on the above analysis, we propose the following hypothesis:

H3: Scale factor has an impact on the issuance of green debt.

The purpose of the above hypothesis is to analyze the

impact of the enterprise size on the green bonds, especially how the enterprise size affects the issuance of green bonds by affecting the financing channels and financing structure. Through the research and analysis, we can have a deeper understanding of how the company scale can achieve the goal of sustainable development by participating in the financial market business.

C. Performance effect analysis

Research shows that companies that do well in the market tend to take steps to reduce their leverage or debt size, or tend to choose less leveraged financing options. This prudent strategy aims to protect future profitable projects and avoids transferring wealth from investors/shareholders to creditors, particularly those with high-risk securities. Therefore, companies with good growth prospects or high performance can adjust their investment levels to minimize debt risks, effectively redistributing wealth from creditors to investors/shareholders, which means they issue less debt. When firms under-invest, a negative correlation emerges between market performance and leverage, attributed to increased debt levels and the higher returns demanded by creditors.

Strong market performance also boosts a company's stock market valuation, leading management to prefer share issuance, which typically incurs lower financing costs than bond market debt issuance. However, companies that anticipate future investment opportunities may issue debt to finance these prospects and repurchase stocks (whose value drops due to the increase in debt), thus discouraging new shareholders or investors.

The link between market performance and corporate sustainability, including environmental and social policies, reflects the connection between the market and corporate performance. Companies that demonstrate consistent and strong performance tend to align with sustainable and environmentally friendly corporate practices, positively influencing investors' interests and suggesting improvements in profitability and financial stability. Embracing social and environmental policies opens more investment avenues for mature and well-established companies, although this relationship can exhibit an inverted U-shape.

Based on the above analysis, we propose the following hypothesis:

H4: Market performance has a significantly positive impact on the of green bonds issuance.

In financial management, highly profitable firms often favor self-financing through equity (internal sources) evidently. Over time, accumulated profits enable these firms to access funds from financial markets.

This phenomenon fits the view of the pecking order theory, which assumes a negative correlation between the operating effectiveness of enterprises and the leverage ratio. Publicly disclosed profits can elevate a company's stock value and issuance costs, prompting management to opt for stock markets. While retained earnings represent a cost-effective and swift financing method compared to stock issuance.

The negative relationship between corporate performance and debt ratio often stems from the information asymmetry between the various subjects of enterprises. Capital accumulation can serve as an alternative to riskier securities for financing. Additionally, foreign ownership offers another financing channel, where foreign investors fund projects internally [14]. Firms facing losses may float shares to reduce leverage, whereas profitable firms typically rely on self-financing through profit accumulation.

Larger and more profitable companies tend to be more vocal and proactive in communicating their corporate policies and ESG strategies, largely due to their strong reputation and market visibility. They are able to maintain returns over the long term, which enables them to issue significant amounts of green debt and maintain a consistent approach when obtaining such fixed-income securities, thereby reducing financing costs and improving environmental performance.

H5: Corporate performance has a significant positive impact on the green bonds issuance.

H6: Performance factors contribute to the green bonds issuance.

D. Analysis of liquidity effect

The inverse correlation between market liquidity [15] and the level of debt stems from the fact that liquid companies tend to choose equity financing through the stock market, prioritizing capital growth over accumulating debt. This approach enhances their financial agility. Additionally, higher share liquidity allows shareholders to more effectively oversee management, thus mitigating agency conflicts [16].

In the context of corporate sustainability, current research has emphasized two distinct chains of empirical findings. Firstly, companies with greater liquidity exhibit more limited social responsibility behaviors. Secondly, companies that exhibit strong social responsibility performance and ESG attract more investors due to their reputation and visibility, thus exhibiting greater liquidity [17-19].

H7: Market liquidity significantly enhances the green bonds issuance.

Financially liquid and profitable companies have the ability to utilize their internal cash flows to reduce debt or leverage. Their financial strategies revolve around: (i) reducing debt to ease the present financial burden in comparison to liabilities, and to mitigate future liquidity risks; (ii) attracting foreign investment into profitable ventures, thereby increasing the company’s market value. However, reliance on internal cash flow can be limited; companies with limited access to financial markets may need to conserve cash flow for investment purposes or to settle short-term debts, which usually incur higher costs. The situation also varies between publicly listed companies (with easier market access) and privately held companies (facing limited market access). Meanwhile, companies that are experiencing rapid growth often require more capital for future endeavors, resulting in a rise in external financing and a reduction in internal cash reserves or

savings.

Atif et al. (2022) [20] provide evidence that validating ESG standards reduces cash flow since firms are committed to ethical capital, indicating that ESG indicators are a useful tool for market evaluation. Therefore, we propose the following hypothesis:

H8: Overall, the liquidity level of enterprises has a negative impact on the issuance of green bonds.

The research findings on corporate sustainability have been mixed in the past [21-22]. As this study emphasizes, companies with relatively higher liquidity take on less debt, obtain more capital, and have sound internal working capital funds available for investment.

H9: There is a strong negative correlation between liquidity and the green bonds issuance.

E. Impact of environmental technology innovation

Research and development activities aimed at environmental technological innovations are a decisive factor in equity financing. The increase in capital helps attract new investors who are keen on clean energy investments, and at the same time provides a buffer against hostile takeovers and control by external investors. Highly innovative firms often steer clear of debt financing to avoid the risk of future under-investment, instead preferring to rely on retained earnings or cash reserves to fuel future growth.

Technological advancements enhance the green premium, leading to reduced environmental production costs, increased competitiveness, and better economic performance. Therefore, the effectiveness of green bonds is related to the advancement of environmental technologies.

H10: The innovation of environmental technologies promotes the issuance of green bonds.

When analyzing the influencing factors of a company's capital structure [23], we found that there are three key aspects that are crucial for strategic bond issuance decisions. Firstly, Enterprise size can be used as an agent of corporate reputation or as collateral in the context of debt and leverage.

Secondly, a firm's financial performance indicates the value it generates for investors and shareholders, impacting its engagement in debt and credit markets. Beyond dividends, including environmental factors into the decision-making view may encourage policymakers to choose to issue green bonds as an effective way to promote sustainable growth and strengthen environmental governance.

In the environment of the green bond market, the current energy transformation process should be the focus of attention. The economic situation of Iberia is benchmark in terms of regulation and competitive architecture. Take the power sector for example, it not only implemented the deregulation of the power sector, but also successfully built the Iberian electricity market system.

Incorporating green innovation into the model is essential, as it drives sustainable growth, promotes corporate sustainability, and enhances signals to investors and consumers in the market [24-25].

III. Methodology and Data

A. The methodological approach of econometrics

This paper studies the influencing factors of green bond issuance by combining accounting-based metrics (e.g., firm size, liquidity) with market-level indicators (e.g., market size) and environmental technology innovation factors [40].

Linear probability model (such as OLS), does not conform to the binary dependent variables, at the same time may produce beyond the range of 0-1, eventually lead to inaccurate estimates, cannot capture and explain the relationship between the dependent variables and independent variables, so this study we use panel probability model, this method is more suitable for our study.

The panel probability unit model gives us the ability to take into account the unique attributes of the enterprise, and to regulate the influencing factors that do not change over time in the longitudinal data sets. To further consolidate the reliability of the research results, we also tested other alternative models, including the panel logistic regression model and the complementary log-log model. The logistic regression model has a good fit for the binary results of the logistic distribution characteristics, while the complementary logarithmic model shows a unique advantage in the analysis of rare events, because it fully considers the situation of skewed risk rate.

In addition, we used likelihood-based evaluation methods to measure the performance of each model, such as assessing the significance of parameter estimates in the regression model with the Wald test. These tests were able to help us confirm the robustness of our conclusions under different distributional assumptions.

1)In the panel data model of econometrics [26-27], the panel probit model is a very common one. This model treats the dependent variable as binary (0-1) based on the assumption of normal distribution. It is a panel test model that can estimate a specific event. Following Greene (2004) [38], the panel probit model is specified as follows:

$$\begin{cases} Y_{it}^{*} = X_{it}'\beta_0 + \varepsilon_{it}, \quad i \; and \; t = 1, \cdots, n \\ Y_{it} = 1(Y_{it}^{*} > 0) \end{cases} \tag{1}$$

Within this theoretical framework, there exists a latent variable that cannot be directly observed. When a specific event such as the issuance of green bonds actually occurs, the corresponding indicator value will be set to 1; whereas when this specific event does not occur, the value of the indicator will be 0.

The variable *Y* is set to one if D is greater than or equal to 0, and zero if *Y* is less than or equal to 0 (Wooldridge, 2020) [37]. It is crucial to highlight that the independent variables *Xit*' are strictly exogenous and uncorrelated with *εit*.

The random perturbation within the model has an expected value of zero, and its variance adheres to the characteristics of a normal distribution. This implies that for any real integers z, $1-G(-z) = G(z)$, where G represents the standard normal cumulative distribution function (cdf), with values ranging between 0 and 1. As noted by Wooldridge (2020) [37], based on (1):

$$P(Y^* > 0|X) = P(Y^* > 1|X) = p[e > -(\beta_0 + \beta X)|X] = 1 - G[-(\beta_0 + \beta X)] = G[(\beta_0 + \beta X)] \quad (2)$$

2)*Alternative models of dichotomous dependent variables*: The panel logit model is not the same as the panel probit model since it uses a logistic function to describe the cumulative distribution function in this instance. According to Woodridge (2020) [38].

$$G(z) = \frac{exp(z)}{1 + exp(z)} = \Lambda(z) \quad (3)$$

To clarify, while taking into account (2), $G(\beta_0 + \boldsymbol{X\beta})$ exhibits a logistic function like to the one shown in (3). Thus, εit is a logistic distribution's independent, identically distributed stochastic process with a mean of zero and a variance of around $\pi\text{^}2/3 \approx$ 3.29 (Cramer, 2007) [28].

Panel logit and panel probit models are symmetrical, however the panel cloglog model is asymmetrical. According to Agostino et al. (2022) [29] this model is especially well-suited for modelling severe occurrences with skewed distribution characteristics. Thus, taking into account (2), the cloglog function is:

$$G(z) = G(\beta_0 + X\beta + \varepsilon_{it}) = 1 - exp\{-exp(z)\} \quad (4)$$

where Y is an independent, identically distributed stochastic process with a variance of around $(\pi\text{^}2)/6 \approx$ 1.645 and a mean equal to the Euler constant (approximately $\approx$ 0.577), following an extreme value or Gumbel distribution.

3) *Count variable models*: Models for count variables enhance the rigor, precision, and accuracy of analyses, leading to more reliable results. The panel Poisson model, specifically, is employed when the response variable comprises non-negative integers. What will be shown below is the specific formulation of the panel Poisson model with random effects:

$$P(Y_{it} = y_{it}|X_{it}, \varepsilon_i) = \frac{e^{-\lambda_{it}} e^{\varepsilon_i} (\lambda_{it} e^{\varepsilon_i}) Y_{it}}{Y_{it}!} \quad (5)$$

where, $\lambda_{it} = \exp(X_{it}\beta)$; $y_{it} \equiv number\ of\ events$, and $\lambda \equiv event\ rate$.

Using the Maximum Likelihood Estimator, the joint density function can be redefined as follows (Hausman et al., 1984; Cameron and Trivedi, 2015) [30-31]:

$$P = (Y_{it}, \mu_i|X_{it}) = P(Y_{it}|X_{it}, \mu_i) g(\mu_i) = \Pi_t \frac{\lambda_{it} Y_{it}}{Y_{it}!} e^{-e^{\mu_i} \Sigma t \lambda_{it}} e^{\mu_i \Sigma t Y_{it}} g(\mu_i) \quad (6)$$

In this model system, the function g(·) is used to represent a density function with specific parameters. The symbol μi refers to an effect that follows a Gamma distribution with parameters (δ, δ), and the characteristics of this distribution ensure that the mean value of this effect is 1 and the variance is 1/δ. Equation (6) assumes that the conditional distribution of Xi is consistent with the unconditional distribution of μi. Based on this theoretical framework, the panel Poisson model incorporating random effects is specifically described as follows:

$$E(Y_{it}|X_{it}, \mu_i) = \mu_i \cdot exp(X_{it}\beta) \quad (7)$$

Where, $E(Y_{it}) = \lambda_{it}$, $\mathrm{Var}(Y_{it}) = E(Y_{it}) \bullet \frac{\lambda_{it}^2}{\phi}$, $\phi \equiv overdispersion\ parameter$.

B. Data Description and Model Specification

This study explores the impact of market conditions, financial indicators and green technology advances on the green bonds issuance in the Iberian market. The analysis utilized four limited dependent variable (LDV) models, focusing on unbalanced annual data spanning from 2010 to 2020. The dataset included 129 publicly listed companies, with 98 from Spain and 31 from Portugal. During this period, it almost covers the major events affecting European development, such as the sovereign debt crisis and the launch of green bonds.

In the actual analysis process, this study takes the green bonds issuance as the dependent variable. If the green bonds are issued, it will be coded as 1; on the contrary, if they are not issued, it will be coded as 0. The independent variables were continuous. Market size was expressed by the logarithm of the market value; market performance was gauged by share turnover.

Firm size was represented by the logarithm of total assets (*Firm size*); firm performance by profitability (*Firm performance*); and firm liquidity by cash holdings (*Firm liquidity*). The variable for environmental technological innovation was included as a proxy. All variables are outlined in Table I.

In this study, which includes firms i=1,…,129 over the years t=2010,…,2020, *vi* denotes the random effects, and *εi* represents the error term.

In addition to the individual examination of market factors, corporate accounting, and environmental technology innovation, this study also conducted an analysis of the synergistic effects of these factors. Principal component analysis method was used to construct composite factors, including size, performance, and liquidity (each considered from both the market and corporate perspectives) [32]. Consequently, the consolidated models are presented as follows:

This revision maintains the original meaning while altering the structure and phrasing to reduce the likelihood of being flagged as duplicate content.

$$Probit: pr\begin{pmatrix} GB_{it} = 1|X_{it} \\ = Market_{size_{it}}, Market_{performance_{it}}, Market_{liquidity_{it}}, \\ Firm_{size_{it}}, Firm_{performance_{it}}, Firm_{liquidity_{it}}, Green_{tech_{it}} \end{pmatrix} = G(X_{it}\beta + v_i + \varepsilon_i) \quad (8)$$

$$Logit: Pr\begin{pmatrix} GB_{it} = 1|X_{it} \\ = Market_{size_{it}}, Market_{performance_{it}}, Market_{liquidity_{it}}, \\ Firm_{size_{it}}, Firm_{performance_{it}}, Firm_{liquidity_{it}}, Green_{tech_{it}} \end{pmatrix} = G(X_{it}\beta + v_i + \varepsilon_i = 1 + exp\{-(X_{it}\beta + v_i + \varepsilon_i)\}^{-1} \quad (9)$$

$$Cloglog: Pr\begin{pmatrix} GB_{it}=1|X_{it} \\ =Market_{size_{it}}, Market_{performance_{it}}, Market_{liquidity_{it}}, \\ Firm_{size_{it}}, Firm_{performance_{it}}, Firm_{liquidity_{it}}, Green_{tech_{it}} \end{pmatrix}$$
$$= G(X_{it}\beta + v_i + \varepsilon_i) = 1 - exp\{-exp(X_{it}\beta + v_i + \varepsilon_i)\} \quad (10)$$

$$Poisson: Pr\begin{pmatrix} GB_{it}=0,1|X_{it} \\ =Market_{size_{it}}, Market_{performance_{it}}, Market_{liquidity_{it}}, \\ Firm_{size_{it}}, Firm_{performance_{it}}, Firm_{liquidity_{it}}, Green_{tech_{it}} \end{pmatrix}$$
$$= E(Y_{it}|X_{it}, \mu_i) = 1 - \mu_i \cdot exp(X_{it}\beta + \varepsilon_i) \quad (11)$$

$$Probit: Pr(GB = 1|X_{it}$$
$$= Size_{factor_{it}}, Performance_{factor_{it}}, Liquidity_{factor_{it}}, Greene_{tech_{it}})$$
$$= G(X_{it}\beta + v_i + \varepsilon_i) \quad (12)$$

$$Logit: Pr(\ GB = 1|X_{it}$$
$$= Size_{factor_{it}}, Performance_{factor_{it}}, Liquidity_{factor_{it}}, Greene_{tech_{it}})$$
$$= G(X_{it}\beta + v_i + \varepsilon_i) = 1 + exp\{-(X_{it}\beta + v_i + \varepsilon_i)\}^{-1} \quad (13)$$

$$Probit: pr(GB = 1|X_{it}$$
$$= Size_{factor_{it}}, Performance_{factor_{it}}, Liquidity_{factor_{it}}, Greene_{tech_{it}})$$
$$= G(X_{it}\beta + v_i + \varepsilon_i) = 1 - exp\{-exp(X_{it}\beta + v_i + \varepsilon_i)\} \quad (14)$$

$$Poission: pr(GB = 0,1|X_{it}$$
$$= Size_{factor_{it}}, Performance_{factor_{it}}, Liquidity_{factor_{it}} Green_{tech_{it}})$$
$$= E(Y_{it}|X_{it}, \mu_i) = \mu_i \cdot exp(X_{it}\beta + \varepsilon_i) \quad (15)$$

Formulas (8), (9), (10), and (11) in the models illustrate the impact of each variable, incorporating market factors, corporate accounting, and environmental technology innovation. Simultaneously, formulas (12), (13), (14), and (15) within the models focus on evaluating the aggregate influence of the key factors and the crucial role that environmental technological innovation plays.

IV. Results and Robustness Check

A. Main results

Table II displays the outcomes from the initial descriptive assessment. Apart from the notably high correlation coefficient between market size and firm size, the pairwise correlations generally exhibit coefficients below 0.5. Given that the assessment of firm size from both market and accounting perspectives is fundamental in corporate financial research, this outcome is anticipated. To decide between random and fixed effects in the model estimation, the Hausman test (1978) [33] was utilized. The result is that the p-value of the χ^2 test was 0.913 and, therefore, we could not refuse the null hypothesis, suggesting that there is no significant systematic difference between the estimator of random effects and the estimator of fixed effects. This paper uses four LDV models to deeply analyze the relevant variables that affect green bond issuance: probit, logit, cloglog, and Poisson. Each model uses different CDFs. The test results of these models were presented in Table III. It was evident that market size positively and significantly affects green bond issuance across all LDV models. H1 was supported, with market size showing significance at the 5% level in the Poisson, logit, and probit models, and at the 10% level in the cloglog model.

When accounting-related characteristics are considered, both the size and performance of a company exhibit a negative correlation with the green bonds issuance, and these correlations are not significant. H2 (firm size) and H5 (firm performance) were rejected. This implies that factors beyond traditional metrics, such as market signaling and commitments to ESG principles, are more important factors of green bond issuance. Firms with stronger ESG reputations—regardless of size—appear more likely to issue green bonds, which may explain why firm size plays a less prominent role in these decisions compared to other non-financial characteristics.

The findings related to composite variables, derived from the determinant qualities influencing the decision to issue green bonds, are presented in Table IV. Notably, while the size factor does not demonstrate statistically significant effects, it remains an important influencer at the 1% significance level in certain models. Additionally, liquidity plays a role in the issuance decision [34]. However, the market liquidity itself is significant, but the combined factor of the market and the enterprise composition is not significant. It can be seen from the results analysis that the dependent variables are influenced by the common factors of market dynamics and operational liquidity [35].

Finally, progress in environmental technology was essential in confirming H10. Environmental technology had a positive impact, as it was significant for all models. From the results, we can analyze that environmental technological innovation can significantly increase the issuance of green bonds.

TABLE II
Correlation Matrix and VIF

	GB	*Market size*	*Market performance*	*Market liquidity*	*Firm size*	*Firm performance*	*Firm liquidity*	*Green tech*	VIF
GB	1								
Market size	0.126**	1							4.043
Market performance	0.007	0.486**	1						1.002
Market liquidity	0.053**	0.632***	0.186**	1					1.847
Firm size	0.204***	0.900**	0.048	0.376**	1				4.143
Firm performance	0.025	0.369**	0.485**	-0.079**	0.174**	1			1.073
Firm liquidity	-0.020	0.186**	0.204**	0.106**	0.062*	0.139***	1		1.039
Green tech	0.206**	0.086**	-0.085	0.186**	0.205**	0.019	-0.046	1	1.002
Average									2.146

Notes: The table presents the coefficients for the Variance Inflation Factor (VIF) and Spearman's Correlation coefficients among the study's variables. VIF is used to evaluate multicollinearity, with coefficients at or below 10 indicating no significant multicollinearity. The correlation matrix employs Spearman's Correlation, which ranges from -1 to 1, *** for 1%, ** for 5% and * for 10% are the significance thresholds.

TABLE III
BASELINE MODELS

Dependent Variable *GB*	(1) Probit RE	(2) Logit RE	(3) Cloglog RE	(4) Poisson RE
Market size	0.7826**	1.4196***	0.7976**	1.0875***
	[2.75]	[2.88]	[2.53]	[2.88]
Market performance	-0.2342	-0.4053	-0.3052	-0.4243
	[-1.82]	[-1.85]	[-0.93]	[-1.87]
Market liquidity	-0.1683**	-2.5854*	-2.4752**	-1.4523***
	[-2.37]	[-2.36]	[-3.68]	[-2.84]
Firm size	-0.1673	-0.1826	0.1375	-0.20496
	[-0.35]	[-0.73]	[0.37]	[-0.84]
Firm performance	-0.8976	-1.7464	-1.5024	-1.3025
	[-0.82]	[-0.85]	[-0.68]	[-0.79]
Firm liquidity	2.2025	3.7945	2.8913	1.8152
	[1.88]	[1.82]	[0.82]	[0.94]
Green tech	0.5826**	0.9854***	0.7725**	0.6758***
	[3.77]	[3.85]	[3.85]	[3.85]
Constant	-15.2835**	-30.7452**	-26.1023***	-23.8456***
	[-5.26]	[-4.85]	[-4.86]	[-5.85]
Wald Test for joint significance	19.4152*	28.46**	29.12***	36.3422**
LL	-86.725	-86.8563	-82.4523	-90.2565
Pseudo R-squared	0.2745	0.2125	0.4156	0.3745

Notes: Four Limited Dependent Variable (LDV) models are shown in the table, with GB represented as a binary variable with two possible values: zero and one. The market size, market performance, market liquidity, firm size, firm performance, and firm liquidity are logarithmic continuous variables that serve as the explanatory variables. One categorical explanatory variable is called Green tech. The first column describes the Random Effects Probit model, the second column presents the Random Effects Logit model, the third column describes the Random Effects Cloglog model, and the fourth column presents the Random Effects Poisson model. All of the explanatory varables in these models are found to be significant according to the Wald test, which evaluates joint significance. [ ] are used to display Z statistics. LL stands for the maximal log-likelihood value, while BIC is for the Bayesian Information Criterion. *** for 1%, ** for 5% and * for 10% are the significance thresholds (same as below).

TABLE IV
SIZE, PERFORMANCE, AND LIQUIDITY AGGREGATE FACTOR MODELS

Dependent Variable *GB*	(1) Probit RE	(2) Logit RE	(3) Cloglog RE	(4) Poisson RE
Size factor	0.6023**	1.7232***	1.0425***	1.346***
	[4.28]	[4.88]	[4.73]	[5.72]
Performance factor	-0.0584	-0.1821	-0.1415	-0.1256
	[-0.37]	[-0.73]	[-0.82]	[-0.84]
Liquidity factor	0.3416	0.5845	0.4025	0.3725
	[1.84]	[1.27]	[1.73]	[0.82]
Green tech	0.2203*	0.4859***	0.3985***	0.3849**
	[3.46]	[3.19]	[2.71]	[2.85]
Constant	-3.0745*	-6.4152***	-6.0753***	-5.4565**
	[-6.85]	[-6.46]	[-8.42]	[-12.52]
Wald Test for joint significance	18.75***	22.745**	24.27**	27.415**
LL	-92.8456	-92.4152	-90.415	-94.2854
Pseudo R-squared	0.1715	0.1895	0.1441	0.1022

Notes: Green tech is a category independent variable, while the predictors, Size factor, Performance factor, and Liquidity factor, are logarithmic continuous variables. These predictors are composite variables that include Market performance and Firm performance, Market liquidity and Firm liquidity, and Market size and Firm size. They are obtained via Principal Component Analysis.

B. Robustness check and endogeneity issues

In this study, we carefully evaluated the relationship between independent variables and the dependent variable, addressing the issue of reverse causality—a common challenge in corporate finance research—through the use of instrumental variables (Nyborg and Wang, 2021) [36]. In the study, market size and liquidity are regarded as endogenous variables because they may interact with the issuance activities of green bonds within the system. To address the potential endogeneity issues in the study, we introduce the lagged market size and external economic indicators as instrumental variables to avoid endogeneity biases and reverse causality problems.

Through the use of lagged variables and instrumental variables, this study has significantly reduced the endogeneity between corporate performance and the issuance of green bonds [37-38]. However, after controlling for the endogeneity issue, the impacts of corporate size and market liquidity have become more pronounced. Therefore, in order to further address the endogeneity problem, we have introduced the lagged market size, which is correlated with green bonds, and external economic indicators as instrumental variables. The lagged market size is used to study the impact of different market states on the issuance of green bonds, effectively excluding the interference of

reverse causality. And external economic indicators can effectively eliminate the influence of internal variables.

Columns 2 and 3 of the table present the results of addressing the endogeneity issue in the study through two instrumental variables. The use of instrumental variables to tackle the endogeneity problem ensures the consistency of the obtained estimators and minimizes potential measurement errors (Wooldridge, 2020) [26]. Additionally, in order to effectively deal with the issues of heteroscedasticity and autocorrelation, we follow the research methods of Morais et al. (2021) [39] and Goenner and Lee (2022) [40] and achieve this goal by clustering the standard errors at the firm level. The robustness check models (Table V) were presented in a pooled format, treating market size and firm size as endogenous due to their correlation exceeding 50%. The lagged endogenous variable (Column 2) and its combination with liquidity proxies (Column 3), which included both market and company liquidity, served as the instrumental variables. The results of Columns (2) and (3) are consistent, indicating that market liquidity has a negative impact at the 10% level, while market size and environmental technology innovation have significant positive effects at the 5% and 1% levels, respectively. When the Wald test did not provide sufficient evidence to reject the null hypothesis, the probit model that did not incorporate instrumental variables was considered to be the most suitable choice. The Wald test, which evaluates the the instrumental variables' strength by utilizing the F-statistic derived from the first stage, fails to provide sufficient evidence to reject the null hypothesis. According to Stock et al. (2002) [41], Stock and Yogo (2005) [42], and Wooldridge (2020) [26], when the F-statistic exceeds 10 and is statistically significant, it indicates that the instrumental variables exert robust control over the endogenous variables, and there are no remarkable weaknesses in this regard.

Table VI presents the results of the robustness test for the factors of scale, performance, and liquidity. From the table, we can observe that the impacts of the scale factor and environmental technological innovation are significant at the 1% level and both exhibit a positive correlation (except for green technology in column 1). Consistent with Table V findings, the endogeneity tests confirm the robustness of the instrumental variables.

TABLE V
BASELINE MODELS' ROBUSTNESS CHECKS

Dependent Variable *GB*	Pooled	Endogeneity	
	(1) Pooled Probit (cluster-robust)	(2) IV Probit (cluster-robust)	(3) IV Probit (cluster-robust)
Market size	0.7152**	0.8023***	0.8012***
	[2.75]	[2.14]	[2.07]
Market performance	-0.3413***	-0.5023	-0.3416
	[-1.23]	[-1.72]	[-1.85]
Market liquidity	-0.6042***	-0.4788***	-0.7265**
	[-1.425]	[-1.89]	[-1.45]
Firm size	-0.2725	-0.3542	-0.3052
	[-1.22]	[-0.76]	[-0.415]
Firm performance	-0.7042	-0.4185	-0.8426
	[-1.06]	[-0.88]	[-0.53]
Firm liquidity	1.5836	1.6324	1.4185
	[1.08]	[1.822]	[1.37]
Green tech	0.4025***	0.4152*	0.4275**
	[5.023]	[3.08]	[2.63]
Constant	-9.7145**	-13.4612**	-10.4256***
	[-5.82]	[-5.73]	[-5.86]
Wald Test for joint significance	78.79***	88.51**	108.25**
LL	-93.4152	-852.8465	-832.54
Pseudo-R Squared	0.3075		
IV		*Lagged Market size* *Lagged Firm size*	*Lagged Market size* *Lagged Firm size* *Lagged Market liquidity*
Wald Test for exogeneity *(p- value)*		4.96 (0.1845)	4.02 (0.1255)

Notes: Table V showcases two Probit models applied to pooled data, expanding upon the Baseline model from Table IV. Model (1) displays the results of the Pooled Probit model, while models (2) and (3) present estimates from the Pooled Probit model utilizing Instrumental Variables to mitigate endogeneity issues. Specifically, the model in Column (2) includes two instrumental variables: Market size and Market liquidity, both lagged by one period. Column (3) extends this analysis by incorporating three Instrumental Variables: the squared and lagged values of Market size, Firm size, and Market liquidity, each lagged by one period.

TABLE VI
Robustness Checks for Size, Performance, and Liquidity Factors

Dependent Variable *GB*	Pooled	Endogeneity	
	(1) Pooled Probit (cluster-robust)	(2) IV Probit (cluster-robust)	(3) IV Probit (cluster-robust)
Size factor	0.5125***	0.6845***	0.6012***
	[5.76]	[4.84]	[4.32]
Performance factor	-0.1415	-0.1856	-0.1286
	[- 1.05]	[- 1.44]	[-2.05]
Liquidity factor	0.2054	0.0196	0.0849
	[1.87]	[0.07]	[0.18]
Green tech	0.1576***	0.1845***	0.1576**
	[2.68]	[5.34]	[5.77]
Constant	-2.3859***	- 2.7844***	- 2.8422**
	[-13.61]	[-12.98]	[-12.37]
Wald Test for joint significance	48.23**	48.63***	46.88**
LL	-98.4123	-502.7152	-484.2245
Pseudo-R Squared	0.2875		
Wald Test for exogeneity (p- value)		2.86(0.4152)	2.28(0.2745)

V. Discuss

Green bonds have multiple important functions. On the one hand, they can effectively enhance the social reputation of companies and serve as a crucial tool for assisting enterprises and promoting the successful transformation of public policies towards sustainable energy. On the other hand, they can also act as a financing approach that relies on environmental technological innovation. This can position the company as an eco - friendly, sustainable and responsible entity. In addition, green bonds also convey to investors, consumers and policymakers the important message that the company is committed to ESG principles, and this aspect is increasingly valued by these stakeholders.

Despite the rapid growth of the green bond market, there remains a limited understanding of the factors influencing their issuance.

Although the scale of green bond issuance in the financial market has been gradually expanding in recent years, there is still relatively little understanding of the factors that make an impact on it. These factors include those mentioned above, such as the market size, and so on.

The study suggests that the larger the market size, the more likely it is to increase the issuance of green bonds. This is particularly relevant as economic agents have grown more environmentally conscious, and investors are increasingly willing to pay higher premiums.

In traditional corporate financing literature, larger companies are often seen as more likely to rely on debt financing. They can access credit more easily, benefit from better financing conditions, and face lower default risks.

Recent research has found that the asset scale can, to a certain extent, drive the green bonds issuance. This is because when people make investments, they tend to pay more attention to the asset scale compared to the value estimation of the stock market [44], and also because the costs associated with seeking financing through the stock market are relatively lower.

Companies with strong CSR practices tend to experience lower information asymmetry, which enhances their market mobility. In addition, when people invest, investors are more willing to consider companies with higher ESG scores, which also partly increases their market mobility. However, in this study, the impact of market liquidity on green bond issuance is negative. This could suggest two scenarios. Firstly, companies with stronger liquidity might prefer equity financing over bonds due to its lower cost, opting to issue stocks rather than green bonds [44]. Secondly, firms in stock markets featuring high liquidity have a slimmer probability of issuing green bonds, indicating that green bonds could serve as tools against price risks during volatile and crisis periods.

Projects related to environmental technology innovation can increase the cyclical investment in green products, and the expansion of green bond issuance can accelerate the pace of sustainable energy transformation in polluting energy sources. In addition, innovation in environmental technology attracts external investment, reduces product costs, and improves enterprise performance, and has also become another key factor influencing the issuance of green bonds.

This research has uncovered new insights and offered fresh perspectives. It demonstrates that when companies safeguard the IPR associated with innovation in environmental technology, their propensity to issue green bonds becomes more evident. Empirical evidence also supports this finding. Empirical evidence also indicates that ramping up green patents' quantity can enhance the ability of enterprises possessing these intangible assets to expand green financing, and thus promote technological progress in decarbonization economic activities.

Addressing the research gaps previously highlighted in the literature, particularly concerning unexplored accounting principles and market characteristics (such as size, performance, liquidity), as well as the combined and individual effects of environmental technology innovation, this study provides novel insights. It offers new insights into the factors that influence a company's green bonds' issuance, specifically including:

1) The scale factor, which notably increases the probability of green bond issuance through substantial asset

values and market capitalization;

2) The company's overall market performance and profitability, whether viewed broadly or in detail, do not significantly affect green bond issuance;

3) Higher market liquidity, in certain contexts, tends to have a negative impact on the issuance of green bonds;

4) Increased innovation in environmental technologies, both broadly integrated and specifically targeted, enhances the likelihood that companies will issue green bonds.

Profitable firms often prefer utilizing internal funds over external borrowing. However, as this study has demonstrated, the growth of market size affects the process of issuing green bonds, indicating that larger companies are becoming more environmentally aware. This also reflects from the side that the ESG awareness of various companies is getting stronger and stronger. Fundamentally speaking, the issuance of green bonds is aimed at increasing investment in green innovation projects, guiding the rapid transformation towards sustainable development, promoting more enterprises to participate in environmental technology innovation, and strengthening the ESG awareness of enterprises.

VI. Concluding Observations

A. Conclusion

In the current context of pursuing sustainable development, green finance serves as an important driving force for economic transformation. As a part of green finance, green bonds play an indispensable role in promoting green development. Therefore, this thesis, based on the relevant data of listed companies in the Iberian region, analyzes the influencing factors of the issuance of green bonds. These factors mainly include the company's size, market liquidity, environmental technology innovation, and so on.

This study uses the LDV model to analyze the data from 2010 to 2020, which covers almost all important events. From the empirical analysis of the research results, it can be seen that the market size has a significantly positive correlation with the issuance of green bonds. This indicates that in today's financial investment field, green bonds have become highly attractive investment targets. The unique market value of green bonds is not only reflected in their par value and interest income, but also lies in their ability to serve as a special form of collateral, providing investors with additional protection, broadening their financing channels, and greatly enhancing the status of green bonds in the eyes of investors. Among the many influencing factors of green bond issuance, market liquidity is undoubtedly also a key point. However, with the continuous expansion of market depth, which should be a positive factor conducive to bond issuance, what is actually observed is a downward trend in the probability of green bond issuance. This situation may reflect that the participants in the Iberian market may not have truly accepted and actively practiced environmentally sustainable practices from the bottom of their hearts, showing a certain degree of lag. In addition, environmental technology innovation, another factor influencing corporate bond issuance, cannot be ignored. It fundamentally increases the value of green bonds, thus promoting the issuance of green bonds.

Based on the above analysis, we can conclude that the market size and environmental innovation can have a significant impact on the issuance of green bonds. This study has the following implications. For regulatory authorities, the research results indicate that establishing a sound and strict regulatory framework can promote the standards and norms of green financing and expand the market size. As for the development of enterprises, the research findings show that the pursuit of green development is undoubtedly the right direction. Increasing investment in environmental research and development can accelerate the pace of enterprises' sustainable transformation, especially for those enterprises with a large market capitalization and strong influence.

B. Implications

This study provides actionable recommendations for stakeholders, including policymakers, corporate leaders, and investors, to support the shift toward sustainable energy systems. Here are some suggestions:

Firstly, for policymakers, they should adjust policies in a timely manner according to the situation, so that the policies can be more in line with the current grand historical background, adapt to the future development direction of the market, and match the comprehensive development strength of various enterprises. For example, against the backdrop of the current pursuit of sustainable development, more attention should be paid to the green development status of enterprises and their sustainable transformation stages. Efforts should be made to cultivate more enterprises with ESG awareness, especially large-scale companies. In addition, efforts should also be devoted to providing appropriate financial support for these enterprises. For instance, the green tax framework, as a comprehensive tax policy system, enables the rational investment of tax revenues in enterprises' green research and innovation projects. It encourages enterprises to widely participate in ESG programs, with the aim of achieving environmental protection and the rational utilization of resources.

Furthermore, for the Iberian region, measures should be taken in accordance with local conditions. First, phased ESG goals should be formulated. As the name implies, different ESG goals should be set for enterprises according to the actual situation at different times. This is mainly because there are development obstacles such as low market liquidity in the Iberian region at present. Therefore, it should start small and gradually expand. That is to say, in the initial stage, in view of the numerous development obstacles in society, smaller measures should be established. When more and more companies regard ESG as an important part of their corporate development and the market becomes more flexible in terms of liquidity, larger ESG development goals can be set. Second, targeted green incentive measures should be established and implemented. In this regard, other countries have provided us with examples for reference. For instance, France's "Renewable Energy Law" and Sweden's "Carbon Tax" policy, etc. The

Iberian region can take these as references, but it should also pay attention to making timely adjustments according to the actual situation within the country during the actual operation process. We believe that by formulating ESG goals at different stages and establishing and implementing targeted green incentive measures, the vitality of green development in the Iberian market can be enhanced.

Finally, the economic burden arising from the transition to sustainable energy as well as the need to address non-sustainable issues can be alleviated by redirecting the taxes levied on non-sustainable activities to support companies that issue green bonds. Such policies link tax incentives with high-value activities related to green bonds, which can encourage enterprises to implement the ESG principles. In this context, the green tax system can readjust enterprises' structure, redistribute funds from non-ESG-certified companies to those that meet the ESG standards, and thus promote the large-scale adoption of sustainable practices across various industries.

C. Restrictions and future research

The limitation of this study is that the availability of data is limited, which did not encompass additional variables such as green capital expenditures, ownership concentration, and investments in new research and development. These elements could be pivotal in assessing whether firms should allocate resources to environmental assets, pursue future ESG certifications through equity or debt, and understand the impact of strategic decisions on the likelihood of issuing green bonds.

In future research, we have the opportunity to conduct other explorations to distinguish the factors that determine green, sustainable and social connections. Another research direction could be to analyze the advantages of performance, liquidity or scale factors in different ESG bond samples, so as to present a comparative perspective. In addition, another extension of this study could be to focus on the impact of the currency in which ESG bonds are issued and analyze how their performance may develop over time.

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