

HYDROGEN GREEN BOND FINANCING COSTS DETERMINANTS - GENDER DIVERSITY, CALLABLE BOND RISK & REAL EXCHANGE RATE

Geeta Duppati^{1*}

¹ Assistant Professor, Department of Accounting and Finance, Prince Mohammad Bin Fahd University, Al-Khobar, Saudi Arabia

*Corresponding author: gduppati@pmu.edu.sa

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Abstract

This study sheds light on the determinants of Hydrogen green bond financing costs. Three research questions are examined in this study: First, whether Female board representation affects the hydrogen green bond financing costs? Second, whether callable bond risk is an important determinant of hydrogen green bond financing costs? and third, whether the real exchange rate is an important channel for determining the interaction effects of gender diversity and Callable bond risk on the Hydrogen Green Bond financing costs? A sample of 212 corporate and government institutions across 36 countries engaged in the issuing of Hydrogen green bonds, namely, callable bonds or maturity bonds, is considered. This study employs a variety of statistical estimation techniques, including regression techniques (OLS and Quantile) and propensity score matching tests. The findings show that the presence of women significantly lowers bond coupon rates, which strengthens the argument in favor of laws mandating. This study provides deeper insights into existing literature on green bond pricing by examining a nuanced macro-financial channel, which is connected to gender diversity as a corporate governance mechanism, and Callable bond risk at the issuer level of financial instruments. It examines how external economic conditions affect the performance of sustainable financial instruments. Specifically, it offers insights into how real exchange rate appreciation affects call risk to callable bondholders, capital access for green bond issuers and opportunities for refinancing at a lower rate by calling back the bonds. This research has implications for climate action and social equity in a single investment and aligns with UN-SDG 5-Gender equality and SDG 13-Climate Action.

Keywords: *Green-hydrogen-bonds; Gender-diversity; Callable-bond-risk; Real-exchange-rates; SDGs 5 & 13.*

1. Introduction

This study shed light on a very important topic and has global implications, especially when corporations and governments across the world are transitioning towards clean energies for tackling the issues pertaining to mitigating carbon emissions and climate change adversaries. Green financing is crucial, and identifying the important determinants is very critical as it has implications to policy makers, investors, and societies at large. Besides, this study also provides insights into the female board representation from a masculinity perspective and focuses on gender balanced boards for breaking the glass ceiling barriers. Female board participation is a key component of ESG factors.

This study examines whether board female representation and bond Callable bond risk individually or jointly affect the issuing firms' hydrogen bonds financing costs. It predicts that corporations with higher female representation on their boards have lower financing costs than issuing organizations with lower female representation. Increasing

female representation on boards is seen as a method to dismantle masculine norms and transition to more inclusive and effective governance. The inclusion of women may encourage a more collaborative, ethical, and sustainable approach to company strategy. The real exchange rate can be an important transmission channel in the relationship between gender diversity and callable bond risk, as it affects international competitiveness, capital flows, and investor returns and the changes in the real exchange rate influence how attractive hydrogen green bonds are to global investors, thereby impacting their financing costs. Prior literature shows that real exchange rate fluctuations influence portfolio capital flows, particularly in bond and equity markets, hence enhancing financial interconnection (Goswami et al., 2023; Bathia et al., 2023).

When combined with gender diversity and callable bond risk, a stronger or more stable real exchange rate can reduce perceived risk, lowering yields. It can amplify or moderate the governance benefits of gender diversity (e.g., better risk management). It also affects investors' price callability risk, especially in cross-border green finance markets. Hydrogen, which was previously restricted to futuristic visions, is now swiftly becoming a tangible reality. Its capacity to decarbonize a wide range of sectors, including transportation, industry, and power generation, is undeniable. Green hydrogen, which is generated from renewable energy and water, is the most likely option for sustainable energy solutions, and it has garnered substantial investor interest. Green bonds have become a well-liked tool for sustainable investing because they are especially issued to fund projects that benefit the environment. Investors find them attractive due to factors including financial rewards, diversification, and targeted impact. For instance, they provide investors with a clear link to beneficial environmental change by actively sponsoring green projects. Similarly, the green bonds provide exposure to a rapidly expanding and morally aligned asset class, diversifying portfolios. Strong project fundamentals and competitive returns, frequently supported by government guarantees, draw in investors looking to make a profit while preserving the environment.

The convergence of hydrogen and green bonds results in a synergistic connection and favorable outcome to the environment. Green bonds offer a specialized funding mechanism for large-scale hydrogen projects, filling a gap between existing financing models and the sector's requirements. Government-backed green bonds can reduce the risks associated with emerging hydrogen technologies, attracting a larger investment base. Increased investment in hydrogen projects backed by green bonds hastens technical development and market uptake, eventually making green hydrogen cheaper. However, the investments in hydrogen projects also involve uncertainty with regard to the economic environment and financial stability, causing interest rate changes. Under these circumstances, the issuers of bonds are inclined to issue callable bonds (Booth et al., 2014). Callable bonds allow issuers to manage interest rate risk in the sense that if rates decline, the bonds can be redeemed and replaced with lower-cost debt. Investors demand a coupon premium for giving issuers this option (Kalotay, 2008). This study hypothesizes that the interaction effects of increased female representation and lower Callable bond risk will result in lower financing costs for hydrogen green bonds. The risk

associated with bond Callable bonds can substantially influence the financing costs of hydrogen. Hydrogen initiatives, particularly substantial infrastructure expenditures, may necessitate long-term debt financing, which involves greater risks, including interest rate risk, credit risk, and inflation risk. Bonds with longer maturities generally yield higher coupon rates, consequently raising the total financing cost for hydrogen initiatives. To alleviate these concerns, corporations may choose callable bonds, short-term bonds, or green bonds, each possessing distinct cost effects.

Three research questions are addressed in this study:

1. Whether Female board representation affect the Hydrogen Green Bond financing costs?
2. Whether Callable bond risk is an important determinant of Hydrogen Green Bond financing costs? and
3. Does the real exchange rate play an important channel for determining the interaction effects of gender diversity and Callable bond risk on the Hydrogen Green Bond financing costs?

This paper addresses its research issues by examining a sample of 212 corporate and government institutions across 36 countries engaged in the issuing of Hydrogen green bonds, namely, callable bonds or maturity bonds. The data is obtained from the Bloomberg database, and information on the issuing of hydrogen green bonds is only available from 2024 onward. The mature period ranges from one year to thirty-one years. This study addresses the research concerns mentioned using a variety of statistical estimation techniques, including regression techniques (OLS and Quantile) and propensity score matching tests. The theories considered in the study include masculinity theory, agency theory, and the study's findings. The empirical evidence demonstrates that female presence on boards significantly influences bond financing costs. An increase of one per cent in the number of female board members would reduce financing costs by 28.36% for the overall sample, and by 46.45%, 34.31%, and 27.65% for the 25th, 50th, and 75th percentiles, respectively. Despite a notable negative relationship between female board representation and financing costs, firms situated in the lower segment of the bond coupon rate distribution (i.e., those with comparatively lower bond costs) exhibit a decrease in bond coupon rates with increased female board representation, in contrast to the 50th, 75th, and overall average distributions. This indicates that gender diversity may exert varying effects based on the firm's bond financing conditions, such as the issuer's financial status, credit rating, tax regulations, and macroeconomic issues like inflation. The study results confirm that female representation is a very important determinant of the hydrogen bond financing costs and are robust to testing with different samples, specifications, and explanations. Cross-sectional analysis suggests that female board involvement has a considerable impact on bond financing costs when the board has more than 35% female representation.

Contributions of the study: This study adds to the literature in several ways. 1. This study's findings confirm that female representation on boards leads to reduced bond coupon rates across various quantiles. This supports the notion that gender diversity enhances corporate

governance and risk management. If the benefit is higher for firms with low coupon rates, it may indicate that diversity provides an extra layer of governance rigor to firms whose bondholders already perceive lower risk. As a result, policymakers, owners, and stakeholders may advocate for increased gender diversity on corporate boards, arguing that it will lead to more responsible governance and lower financing costs, benefiting both shareholders and bondholders. 2.

Alternatively, if female representation has a weaker or no effect on bond coupon rates, as evident in the upper quantiles, for firms with higher coupon rates, it implies that gender diversity may not have a substantial impact on investor perception in riskier firms. Furthermore, the firm's intrinsic riskiness might outweigh any governance benefits associated with board diversity. 3. The findings show that the presence of women significantly lowers bond coupon rates, which could strengthen the argument in favor of laws mandating or promoting gender diversity on corporate boards. In addition to advancing equity, these policies may enhance corporate performance by reducing capital expenditures. Thus, if the financial benefits of more gender diversity are reflected in lower bond coupon rates, governments and regulatory bodies may have a stronger case to implement quotas or other measures to encourage gender diversity on corporate boards. The rest of the paper proceeds as follows: Section 2 provides a review of the literature; Section 3 provides a brief outline of the data and methodology used. We present our results in Section 4, and we present our discussion, implications and concluding remarks in Section 5.

2. Review of Literature and Hypotheses Development

This study takes into consideration the Masculinity theory for interpreting the female representation on the boards. Increasing female representation on boards is seen as a method to dismantle masculine norms and transition to more inclusive and effective governance. Prior literature shows that gender-balanced boards are associated with conservative accounting disclosures while gender imbalanced boards are less conservative in accounting disclosures (Jun et al., 2023), and others find female board representation is linked to enhanced governance and effective monitoring (Adams & Ferreira, 2009) and thereby eventually results in reduced equity costs. Gender balanced boards are effective because the masculine barriers are reduced and ensure inclusive board participation. A recent study (Fauver et al., 2024) finds that gender diversity reforms in the boardroom give socially aware foreign institutional investors more influence over governance changes that increase value.

This study views that green bonds are issued especially to finance initiatives that are environmentally friendly. A lot of their investors have a clear objective and are looking for both financial gains and positive environmental effects. Compared to ordinary bonds, green bonds' callable feature interacts uniquely with the coupon rate due to the issuer's objectives and demand dynamics. Therefore, the investors could see an opportunity for investing in callable funds with an added premium as they are hedged against the interest rate fluctuations to the issuers. Further, Callable green bonds require careful structuring to ensure that the

higher coupon rate adequately compensates investors for the risk while still aligning with the issuer's sustainability and financing goals. Research has connected increased female representation on corporate boards to enhanced performance, risk management, and corporate governance. This study assumes that the interaction between the Callable bond risk, callable bonds and gender balanced boards will enhance efficiency and eventually affect coupon rates negatively.

Therefore, the above review of literature prompts the study to propose the following research hypotheses:

Research Questions and Hypotheses Development

Research Question 1: Whether Female board representation affects the Hydrogen Green Bond financing costs?

Hypothesis H1: Female Board representation is negatively associated with hydrogen bond coupon rates.

Research Question 2: Whether Callable bond risk is an important determinant of Hydrogen Green Bond financing costs?

Hypothesis H2: Hydrogen Bond Maturity risk is negatively associated with hydrogen bond coupon rates.

Research Question 3: Can the Female boards and Bond Callable bond risk jointly affect the Hydrogen Green Bond financing costs?

Hypothesis H3: Interaction effects of female representation and Callable bond risk are negatively associated with hydrogen bond coupon rates. The variables used in the study are described in Table 1 below:

Table 1: Description of the variables used in the study

Variables	Acronyms	Description
Dependent Variable		
Hydrogen Bond Financing Costs	HBFC	Hydrogen bond coupon rate is proxied for HBFC
Independent Variables		
Gender Diversity	GD	Female Board Representation
Gender Balanced Boards	DVGBB	Dummy variable (dv) one is assigned for the boards higher than 35% female representation and Dummy variable zero for boards lower than 35%
Callable bond Risk	MTR	Dummy variable (dv) one is assigned for the hydrogen bonds with callable Callable bond and zero for those with non-callable Callable bond

Bond Issuers Sector	IS	If Hydrogen bond issuing sector belongs to financial/banking a dummy variable of zero is assigned and if it is non-financial/non-banking sector a dummy variable of one is assigned
Control Variables		
Market Value	MV	Market capitalization of the issuer of the Hydrogen Green Bond
Bond Age	BA	Bond Age expressed as a difference between the issuance period to maturity
Debt to EBDITA	DEBDITA	Expressed as a ratio of debt to earnings before depreciation, interest, taxes and amortization
GDP	GDP	Gross Domestic Product – Log transformed
Bond Issuer Sectors	BIS	If the Hydrogen bond issuing sector is financial or banking, a dummy variable of zero is assigned. If it is non-financial or non-banking, a dummy variable of one is assigned.

3. Data and Research Methodology

This study is among the very few to focus on the hydrogen green bond financing costs. The issuance of these bonds began in 2024, according to the Bloomberg database. Given the nature of the data, this study employs cross-sectional regression analysis, quantile regression analysis and undertakes propensity score matching to ensure robustness checks. Quantile regression is a statistical method used to estimate the conditional quantiles (such as the median or other percentiles) of the dependent variable based on a set of independent variables. Compared to ordinary least squares (OLS) regression, which calculates the conditional mean, quantile regression provides a more complete view by modelling how the independent variables affect different points (quantiles) of the outcome distribution. It enables the examination of correlations over multiple quantiles, rather than just the mean. Because it does not rely on the mean, it is less sensitive to outliers, making it more robust to them. For instance, setting quantile (.25) yields an estimate of the parameters describing the conditional distribution's 25th percentile (first quartile), and setting quantile (.75) yields an estimate of the parameters describing the conditional distribution's 75th percentile (last quartile).

Propensity Score Matching: Propensity score matching (PSM) is used to account for gender diversity endogeneity and idiosyncratic risk. The board representation and gender diversity of a firm are influenced by its valuation and business environment. Demsetz and Lehn (1985) propose that corporate ownership and board composition vary continuously to maximise value and reduce financing costs. Considering that board structure and financing

costs are intrinsically related, we expect gender diversity to be similarly influenced. In summary, we account for observable differences in board characteristics between the issuance firms of hydrogen bonds owned by female board representation and firms that are marginally represented by female board members. Each firm with female representation above 35%, are matched with firms below 35%, using a propensity score. Individual firms are assigned to treatment and control groups at random (Rosenbaum and Rubin, 1983). Dehejia and Wahba (2002) show that PSM can accurately reproduce the results of a randomised experiment.

4. Empirical Findings

This study employs OLS to analyze the impact of gender diversity alternately referred to as female board representation (independent variable) on the costs of hydrogen bond financing. The study also employs quantile regression analysis for understanding the effects of gender diversity over multiple quantiles in the hydrogen bond financing costs distribution, rather than focusing solely on the average (as OLS does). The findings of OLS and Quantile Regression for analyzing the first question are displayed in Table 3. The findings are provided in four models, as indicated in Table 3. Female board representation significantly affects bond financing costs. A one-per cent increase in the number of female board members would cut financing costs by -65% for the entire sample, and by -63%, -11.39%, and -10.15% for the 25th, 50th, and 75th percentiles. Although there is a significant and negative relationship between female board representation and financing costs, it has been observed that firms in the lower part of the bond coupon rate distribution (i.e., firms with relatively lower bond costs) experience a reduction in bond coupon rates when there is more female representation on the board compared to the 50th, 75th, and overall average distributions. The test results support research hypothesis one, which states that female board representation is negatively associated with hydrogen bond coupon rates.

Although there is a significant and negative relationship between female board representation and financing costs, it has been observed that firms in the lower part of the bond coupon rate distribution (i.e., firms with relatively lower bond costs) experience a reduction in bond coupon rates when there is more female representation on the board compared to the 50th, 75th, and overall average distributions. This suggests that gender diversity may have differential effects depending on the firm's bond financing conditions, like the issuer's financial condition, credit rating, tax policies, macro-economic factors like inflation.

Table 2: Effects of Gender Diversity on the Hydrogen Green Bond Financing Costs

	Model-1	Model-2	Model-3	Model-4
Variables	OLS	Quant-0.25	Quant-0.50	Quant-0.75
Female	-0.657***	-0.673***	-1.139***	-1.015***
	-0.206	-0.224	-0.306	-0.359
DEBDITA	0.014	-0.009	0.499	0.008

	-0.279	-0.247	-0.432	-0.306
Market Capitalization	1.207***	1.530***	1.518***	1.051***
	-0.237	-0.445	-0.265	-0.291
Bond Age	-0.261	-0.601	-0.629	0.346
	-0.676	-0.598	-0.808	-0.645
GDP	1.154	-0.419	3.551	1.844
	-1.614	-1.061	-2.206	-2.333
Sector-Bond Issuer	29.59***	32.92***	36.08***	23.06***
	-6.144	-7.574	-7.568	-8.389
Constant	22.29	34.51	-48.07	35.45
	-45.22	-27.68	-62.57	-64.51
Observations	206	206	206	206
R-squared (&Pseudo R2)	0.239	0.1876	0.171	0.1339

Note: Coefficients are presented in the first row and the Standard errors in the second row. *** p<0.01, ** p<0.05, * p<0.1

Table 3 below presents the results obtained from using OLS and Quantile Regression estimations for the second research question raised in the study. The findings are provided in four columns, as indicated in Table 3. It is clear that callable bonds-Callable bond risk has a considerable impact on hydrogen bond financing costs. A one-per-cent increase in the Callable bond risk (callable bond) would cause the financing costs to go down by -13.21% for the entire sample, -19.45%, -23.61%, and -12.58% for the 25th, 50th, and 75th percentiles.

Although there is a significant and negative relationship between the Callable bond risk and financing cost, except for quantile 75 in the Model-4, it is observed that firms in the lower part of the bond coupon rate distribution experience a reduction in bond coupon rates compared to the 75th and overall average distributions. The test results support research hypothesis two, which states that Hydrogen Bond Maturity risk is negatively associated with hydrogen bond coupon rates.

Table 3: Effects of Callable bond risk (MTR) on the Hydrogen Green Bond financing costs

Variables	Model-1	Model-2	Model-3	Model-4
	OLS	Quant-0.25	Quant-0.50	Quant-0.75
Callable Bonds-MTR	-13.21**	-19.45**	-23.61***	-12.58
	-5.599	-8.597	-7.417	-8.054
DEBDITA	-0.0754	-0.21	0.24	0.0883
	-0.293	-0.429	-0.41	-0.266
Market Capitalization	1.195***	1.650***	1.275***	1.245***
	-0.248	-0.338	-0.206	-0.339
Bond Age	-0.222	<0.001	-0.775	0.763
	-0.652	-0.939	-0.822	-0.733
GDP	0.864	<0.001	4.082**	2.521

	-1.716	-2.68	-1.963	-2.119
Sector-Bond Issuer	28.95***	19.55**	37.11***	23.01***
	-6.519	-8.294	-9.198	-7.714
Constant	25.24	18.55	-68.09	1.545
	-47.89	-75.13	-54.35	-58.87
Observations	206	206	206	206
R-squared (&Pseudo R2)	0.226	0.2022	0.171	0.1339

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

It is evident from the table below that the interaction effects between the female representation (gender balanced boards) and the Callable bond risk are not significant for the overall sample (OLS) and across the three quantiles 25th, 50th and 75%. The results do not support the research hypothesis, which proposes that the interaction effects between female representation and Callable bond risk will reduce the hydrogen bond coupon costs.

Table 4: Interaction Effects of Gender Diversity and Callable bond risk on the Hydrogen Green Bond financing costs

Variables	Model-1	Model-2	Model-3	Model-4
	OLS	Quant-0.25	Quant-0.50	Quant-0.75
Female (GD)	-0.861***	-1.101***	-1.347***	-1.228**
	-0.241	-0.237	-0.334	-0.478
Callable Bonds-Callable bond (CTMR)	-23.88**	-38.12	-34.71**	-10.53
	-10.09	-24.53	-16.07	-18.04
GD * CMTR	0.701	1.262	1.12	0.488
	0.462	0.985	0.717	0.783
DEBDITA	0.0305	-0.0477	0.592	-0.112
	-0.302	-0.393	-0.389	-0.358
Market Capitalization	1.229***	1.596***	1.384***	1.197***
	-0.254	-0.361	-0.271	-0.287
Bond Age	-0.232	0	-0.443	0.0902
	-0.674	-0.715	-0.768	-0.705
GDP	1.365	1.273	4.412*	1.87
	-1.782	-1.215	-2.454	-2.457
Sector-Bond Issuer	29.45***	28.36***	36.67***	27.79***
	-6.341	-9.037	-8.806	-8.125
Constant	23.63	0.14	-65.33	38.05
	-49.18	-34.75	-70.07	-67.58
Observations	206	206	206	206
R-squared (&Pseudo R2)	0.265	0.2478	0.2002	0.1363

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Checks – Exogenous Robustness variable

For ensuring robustness checks, this study uses an exogenous variable, the real exchange rate (REER), which is determined by broader macroeconomic forces such as interest rates, inflation, trade flows, and central bank policies and on which the bond issuers have no influence or control. Therefore, the results presented in Table 5 offer comprehensive insights into the interaction effects of gender diversity and callable bond maturity risk on the financing costs of hydrogen green bonds from the perspective of the macro environment. Changes in the real exchange rate are represented by the difference between the current year REER and the previous year REER (CY-PY/PY). Further, a dummy variable 1 is assigned when there is a decrease in the REER and 0 when it increases. The results of Table 5 show that the interaction effects of gender diversity and callable bonds have a significant and negative effect on the hydrogen green bond financing costs at 1% for Models 1, 2 and 3, and significant at 5% for Model 4. These results show that a decline in the real exchange rate makes exports cheaper, enhancing trade competitiveness (DV 1 indicates lower export costs).

Table 5: Interaction Effects of Gender Diversity and Callable bond risk on the Hydrogen Green Bond financing costs (decrease in the real exchange rate)

Variables	Model-1	Model-2	Model-3	Model-4
	OLS	Quant-0.25	Quant-0.50	Quant-0.75
Female (GD)	-0.388	-0.749***	-0.728*	-0.108
	-0.374	-0.265	-0.404	-0.575
Callable Bonds-Callable bond (CTMR)	83.15***	65.27***	95.89***	63.26**
	18.26	20.37	17.54	24.14
GD * CMTR	-2.788***	-2.180***	-3.061***	-2.500**
	-0.761	-0.67	-0.698	-1.138
DEBDITA	-0.741	-1.475***	-0.628	-0.0958
	-0.509	-0.368	-0.808	-0.637
Market Capitalization	0.634*	0.518	0.632	0.855***
	0.334	0.352	0.668	0.295
Bond Age	0.272	-0.663	-1.245	1.631
	0.978	-0.615	-1.051	1.238
GDP	5.560*	4.196*	7.806***	4.249
	2.987	2.129	2.566	5.56
Sector-Bond Issuer	14.77	20.18*	19.90*	4.747
	9.73	10.6	11.14	14.46
Constant	-104.9	-72.28	-159.4**	-54.27
	-83.82	-57.99	-67.88	-153.6
Observations	98	98	98	98
R-squared (&Pseudo R2)	0.313	0.2699	0.2359	0.1598

Note: The variable real effective exchange rate (REER) is obtained from the International Monetary Fund database. It measures a currency's value relative to a weighted average of several foreign currencies, adjusted by a price deflator or cost index. The weights are calculated by

taking a three-year average of the trading partners' combined value of imports and exports with the focal country and dividing it by the total combined value of imports and exports of the focal countries. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6 below presents the results on the interaction effects of gender diversity and Callable bond risk on the hydrogen green bond financing costs (increase in the real exchange rate). Evidently, the interaction between gender diversity and callable bonds Callable bond risk on hydrogen green bonds is insignificant and hence not an important determinant of the hydrogen green bond financing costs under the scenario of increased real exchange rate. The results show that the effects of callable bond costs on the financing costs of hydrogen bonds are negative. This is because, if the real exchange rate rises, exporters may incur losses due to a decline in the currency's value. An increase in the real exchange rate (RER) causes the domestic currency to appreciate in real terms (becomes stronger relative to foreign currencies). This can lead to lower export revenues for domestic firms, increased pressure on GDP growth in export-reliant economies, and reduced inflation due to cheaper imports. Consequently, central banks are likely to lower interest rates. This causes credit risk to callable bondholders as the issuers of green callable bonds can refinance at lower rates by calling back the bonds early and reissuing new ones at a lower coupon rate.

Table 6: Interaction Effects of Gender Diversity and Callable bond risk on the Hydrogen Green Bond financing costs (Increase in the real exchange rate)

	Model-1	Model-2	Model-3	Model-4
Variables	OLS	Quant-0.25	Quant-0.50	Quant-0.75
Female (GD)	-0.492	-0.0827	-0.154	-0.391
	-0.357	-0.283	-0.285	-0.498
Callable Bonds-Callable bond (CTMR)	-35.98***	-32.85***	-40.52***	-36.67**
	-10.53	-5.77	-9.516	-17.17
GD * CMTR	1.253	0.575	1.530***	1.384
	0.763	0.691	0.494	1.351
DEBDITA	0.453	0.323	0.787**	0.468
	0.432	0.448	0.328	0.305
Market Capitalization	1.343***	1.259***	1.148***	0.784
	0.369	0.27	0.309	0.707
Bond Age	0.00545	<0.001	<0.001	-0.0685
	0.621	0.101	0.835	-1.204
GDP	0.387	-4.16	-3.312	0.791
	3.079	-2.497	-3.088	3.45
Sector-Bond Issuer	31.30***	6.975	41.17***	53.87***
	9.564	10.6	14.38	9.607
Constant	36.97	150.1**	131	36.94
	83.62	75.02	84.52	95.21
Observations	81	81	81	81
R-squared (&Pseudo R2)	0.47	0.3659	0.3834	0.3549

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 below presents the propensity score matching results for dealing with sample selection bias. To implement the PSM method, we use a probit model where the dependent variable is female board representation above 35%. Firm-level explanatory variables determine the presence of the female representation (e.g., Demsetz and Lehn, 1985; Boubaker et al.,2016). In line with the literature, we use bond age, dummy variable of net exporting countries of hydrogen, independent directors, energy intensity to sales and market value as firm-level characteristics. After calibrating the probit model, we use the nearest-neighbour strategy to replace each bond-issuing firm with female representation with the closest weak female representation firm within 1% (Dehejia and Wahba, 2002). This provides a 211-observation matched sample with propensity scores. The treatment effect is calculated by averaging the observed and anticipated outcomes for each individual. Female DV = 1 (if female representation is equal to or above 3) else 0. The results from Table 7 confirm the significance of female board representation that ensures gender balance and results in reduced financing costs.

Table 7: Propensity Score Matching- Coupon Rate

Treatment-Effect Estimation	Coef	Std. Err.	z	Significance
Dummy variable – Female Representation				
Avg Treatment Effects (ATE)	-23.6067	10.0714	-2.34**	5% Level
ATET	-23.1554	11.4918	-2.01**	5% Level
ATET-nearest-neighbor	-32.3222	10.2755	-3.15***	1% Level
Dummy variable – Hydrogen Bond Maturity Risk				
Avg Treatment Effects (ATE)	-9.0262	7.1775	-1.26	NS
ATET	-7.7307	8.2788	-0.93	NS
ATET-nearest-neighbor	-6.0389	6.6229	-0.91	NS
Dummy variable – Interaction effects of Female Representation and Hydrogen Bond Maturity Risk				
Avg Treatment Effects (ATE)	-13.4404	7.2526	-1.85*	10% Level
ATET	-13.9926	7.3807	-1.68*	10% Level
ATET-nearest-neighbor	-24.1992	7.3807	-3.28***	1% Level

5. Discussion, Implications, and Conclusions

It is evident from the above analysis that the female board representation, which is a key component of ESG factors, is a very critical determinant of financing costs. This suggests that for companies with higher coupon rates, even a slight impact of female board representation on decreasing bond financing expenses might be significant in absolute terms. High-risk companies with female participation may indicate enhanced governance standards and positively influence bondholder thoughts. Therefore, firms with higher financing costs ought to consider board diversity as part of their overall strategy to demonstrate greater governance and minimize perceived risks, potentially leading to more favorable debt financing terms. Furthermore, the inclusion of real exchange rate dynamics in the analysis of green callable bonds contributes to the literature by bridging macroeconomic variables with sustainable

finance and corporate debt structure. From an international finance perspective, it offers insights into the impact of currency movements on firm-level financing decisions and investor risk-return expectations, specifically regarding green bonds and ESG instruments. Specifically, it offers insights into how real exchange rate appreciation affects call risk to callable bondholders, and capital access for green bond issuers and opportunities for refinancing at a lower rate by calling back the bonds. This study provides deeper insights into existing literature on green bond pricing by examining a nuanced macro-financial channel, which is connected to gender diversity as a corporate governance mechanism, and Callable bond risk at the issuer level of financial instruments. It examines how external economic conditions affect the performance of sustainable financial instruments. To summarize, the quantile regression approach enables the investigation of the heterogeneity of the link between female representation and bond coupon rates over the bond financing cost distribution. Key implications include possible benefits for low-risk organizations, the usefulness of gender diversity in governance and risk management, and the significance of board diversity as an ESG issue. The findings may have larger policy, regulatory, and strategic consequences, especially if gender diversity is demonstrated to consistently lower bond coupon rates across enterprises.

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