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The Moderating Role of Board Gender Diversity on the Relationship Between Audit Committee Financial Expertise and Corporate Green Innovation: Evidence from GCC Countries

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Abstract: This study investigates the influence of board gender diversity and audit committee financial expertise (ACE) on corporate green innovation. Unlike previous research, it emphasizes the moderating role of board gender diversity in the relationship between ACE and green innovation within Gulf Cooperation Council (GCC) countries. Analyzing data from listed GCC firms from 2015 to 2024 and employing various robust methods, the study finds that ACE positively impacts green innovation. Additionally, results indicate that board gender diversity enhances sustainable practices by promoting green innovation. The research further reveals that gender diversity on boards strengthens the link between ACE and green innovation, highlighting its moderating effect. These findings underscore the significance of board gender diversity and ACE in fostering sustainability by establishing effective internal controls, which can mitigate business risks and support green innovation adoption. The results are consistent across different estimation techniques, including System GMM, lagged models, and Blau's Index. This research provides valuable insights for policymakers and corporate leaders aiming to align governance structures with sustainability objectives.

Keywords: Audit committee, GCC, gender diversity, governance, green innovation.

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INTRODUCTION

In the face of worsening global climate change, green innovation is vital for sustainable business growth (Ji, Yu, Tian, Wang, & Wen, 2025). Empirical studies indicate that corporate governance mechanisms are crucial for strengthening green innovation (Oyewo, 2023; Pozzoli, Pagani, & Paolone, 2022; Wang et al., 2025). The key pillars of corporate governance are board gender diversity (BGD) and the audit committee (AC). The role of BGD in improving corporate sustainable performance has garnered significant attention (e.g., Fan, Hua, Wang, & Wang, 2024; Lu & Herremans, 2019; Peng & Chandarasupsang, 2023; Sahu, Alahdal, Pandey, Baatwah, & Bajaher, 2025; Zhu & Chen, 2025). For instance, Fan et al. (2024) suggest that women leaders enhance decision-making quality and communication, positively influencing sustainable practices. Zhu and Chen (2025) indicate that BGD improves financial outcomes and promotes green innovation adoption. Driven by increasing global interest in sustainable practices, this study explores the influence of BGD on green innovation in the Gulf

Cooperation Council (GCC). The research aims to determine whether BGD and AC financial expertise drive green innovation in GCC countries. Green innovation encompasses the use of eco-friendly materials and green technologies, which meet consumer demand for sustainable products and support corporate sustainability efforts (Farooq, Tabash, & Ahmed, 2025).

Recent studies have explored the relationship between audit committee (AC) characteristics and corporate sustainability practices (Abdalla, Alodat, Salleh, & Al-Ahdal, 2025; Alkurdi, Al Amosh, & Khatib, 2024; Arif, Sajjad, Farooq, Abrar, & Joyo, 2021; Pozzoli et al., 2022). For instance, Pozzoli et al. (2022) suggested that AC features can enhance corporate sustainable performance (CSP) by improving audit quality, financial reporting, and economic decision-making. Additionally, Adam et al. (2025) found that effective ACs increased the quality of green disclosures among Malaysian firms.

This research aims to address gaps in empirical literature from two perspectives: First, it is motivated by the lack of studies examining the relationship between BGD and corporate green innovation in GCC countries. Understanding the influence of BGD and audit committee (AC) on sustainable corporate practices in GCC economies is crucial. The GCC's economic and financial sectors are among the fastest-growing globally (Wang et al., 2025). Additionally, these economies are leading petroleum and gas exporters, facing significant environmental challenges due to oil extraction and degradation (Abusharbeh, Hanaysha, & Samara, 2025). Many GCC nations are implementing strategies to strengthen their economic structures and adopt green technologies, reflecting a regional focus on advanced technological solutions. Furthermore, GCC countries have introduced regulations to enhance corporate sustainability performance. Notably, firms have increased female managerial representation to improve performance (Jizi, Nehme, & Melhem, 2022). According to the GCC Board Gender Index Report 2025 by Heriot-Watt University, women occupy 6.8% of board seats. Second, most empirical research has overlooked the impact of BGD on the relationship between AC financial expertise and environmental innovation. Therefore, this study aims to fill this gap by exploring how BGD moderates the link between AC financial expertise and corporate green innovation, contributing to the understanding of governance and sustainability in GCC economies.

The rest of this research is organized as follows: Sections 2 and 3 present the theoretical framework, empirical literature, and methodology. Section 4 discusses the results and analysis, while Section 5 provides the conclusion.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Theoretical Framework

To address diverse stakeholder interests, companies focus significantly on green innovation, as highlighted by (Moreno-Ureba, Bravo-Urquiza, & Reguera-Alvarado, 2022). In this context, corporate governance emerges as a key factor in promoting sustainable practices. The study relies on stakeholder theory, which explains the relationship between corporate governance such as board governance and audit committee attributes and sustainability performance. This theory posits that firms aim to satisfy all stakeholder interests, not just shareholders, as noted by (Asni & Agustia, 2022). It further suggests that disclosures about sustainable practices act as governance tools to meet stakeholder expectations, supported by (Oyewo, 2023). The audit committee plays a crucial role in enhancing transparency and disclosures related to sustainability. Consequently, the study indicates that audit committees can positively influence green innovation by increasing transparency and sustainability disclosures.

On the other hand, compared to homogeneous corporate boards, diversified boards are more effective in decision-making due to their varied perspectives and higher quality of information and communication (Lestari & Soewarno, 2024). Additionally, the absence of strong female representation on boards can be seen as a negative indicator, potentially leading to conflicts of interest. Stakeholder theory posits that firms appointing women to their boards are better positioned to manage and meet stakeholder interests, including environmental protection (Lakhal, Hamrouni, Jilani, Mahjoub, & Benkraiem, 2024). The presence of women on corporate boards can positively influence sustainable practices, encouraging the adoption of green technologies and products (Zhang, Zhu, & Ding, 2013). Consequently, the study indicates that female board

members may prioritize green sustainability initiatives, contributing to increased environmental responsibility and sustainable development within organizations.

AC Expertise and Corporate Green Innovation

The existing literature indicates that audit committee (AC) attributes positively influence the quality and reliability of financial reports, aligning firm decisions with stakeholder interests and promoting corporate sustainability practices (e.g., Gong, Song, & Zhou, 2025; Pozzoli et al., 2022). Studies suggest that AC members with expertise enhance monitoring activities, leading to more sustainable practices. Kent, Routledge, and Stewart (2010) found that AC financial expertise positively impacts corporate sustainability efforts. Pozzoli et al. (2022) also reported that increased AC independence improves ESG disclosures in European firms. Recently, Gong et al. (2025) proposed that an AC's environmental background fosters green innovation by raising environmental awareness among management, increasing environmental investments, and ensuring compliance. Based on these empirical findings, the hypothesis is formulated that AC attributes significantly influence corporate sustainability and environmental performance.

H_1: AC *Financial expertise significantly impacts corporate green innovation.*

Board Gender Diversity and Corporate Green Innovation

Several studies have shown that increased female representation in firms can positively influence corporate sustainable practices. Peng and Chandarasupsang (2023) suggest that higher female representation can foster green product innovation and technologies. Lu and Herremans (2019) argue that female managers tend to discourage unsustainable activities during corporate strategy development. Sahu, Mishra, Alahdal, and Sami (2025) indicate that board gender diversity (BGD) can promote green practices by prioritizing stakeholder interests. He and Jiang (2019), analyzing panel data from Chinese public firms, found that BGD encourages green product innovation. Nadeem, Bahadar, Gull, and Iqbal (2020), studying U.S listed firms, observed that BGD drives environmental innovation within American companies. Recently, Dwekat, Abu Alia, Abdeljawad, and Meqbel (2025) used data from European economies between 2010 and 2021, confirming the positive impact of female board representation on green innovation. Mansour, Shubita, Lutfi, Saleh, and Saad (2024), analyzing data from the Asian industrial sector, suggested that BGD enhances eco-friendly practices. Overall, these studies indicate that greater board diversity strengthens decision-making at board meetings, leading to improved corporate performance. Based on this literature review, the second hypothesis of this study is proposed as:

H_2: Corporate gender diversity significantly promotes green innovation.

Moderate the Role of Board Gender Diversity

The role of the audit committee (AC) in green innovation significantly influences a company's economic performance and sustainable practices. To strengthen connections with a broader range of corporate stakeholders beyond just financial ones, the AC should increase disclosures related to sustainable practices (Sun, 2024). Sustainable practices, such as adopting green innovation, are increasingly vital in corporate strategies by addressing stakeholder needs, which in turn enhances sustainable corporate performance (Nirino, Santoro, Miglietta, & Quaglia, 2021). Green innovation enables firms to improve both financial and environmental outcomes, helping them maintain sustainable advantages in long-term competition (Wang et al., 2025). Additionally, female board members tend to demonstrate greater concern for environmental issues and corporate sustainability than their male counterparts. More women directors are often more aware of stakeholder needs and pay closer attention to ecological innovation issues. Konadu, Ahinful, Boakye, and Elbardan (2022) emphasize that BGD is crucial for advancing green innovation and resource allocation decisions that promote green practices. To achieve this, female board members should align corporate strategies and governance with sustainable development goals. The presence of female directors and AC members with financial expertise can positively influence green and sustainable practices by establishing robust internal

control systems, which reduce business risks and facilitate green innovation adoption. Consequently, the combined effect of BGD and AC involvement can drive green innovation.

H_3: Corporate gender diversity enhances audit committee expertise and promotes green innovation.

DATA AND METHODOLOGY

Data and Sample

This paper investigates the impact of gender diversity and AC financial expertise on green innovation within GCC firms. The empirical analysis is based on a refined sample of 124 non-financial listed companies, after removing incomplete data and merging issues. The final dataset comprises 650 firm-year observations. Financial firms are excluded due to their distinct reporting requirements, which differ significantly from those of non-financial companies (Dwekat et al., 2025). The data are collected from the London Stock Exchange Group (LSEG) database. Table 1 shows the sample distribution of the tested economies per country.

Table 1: The study sample distribution per-country

Country	No of Firms.	Obs.	%.
Bahrain.	7	44	6.769
Kuwait.	8	54	8.308
Oman.	4	35	5.385
Qatar.	29	162	24.923
Saudi Arabia.	39	224	34.462
UAE.	37	131	20.154
Total	124	650	100.00

Note: This table reports the number of observations per country.

Variable Measurement

Corporate Green Innovation

The primary dependent variable in this study is corporate green innovation, measured by the Green Innovation (GI) score from the London Stock Exchange database. This index reflects the extent of green products, activities, technologies, and processes within firms, providing a comprehensive measure of their environmental innovation efforts (Moreno-Ureba et al., 2022; Zaid, Issa, Deari, Kijkasiwat, & Kumar, 2025). This index ranges from 0 (with no green innovation) to 100 (Highest green innovation).

Independent Variables (Gender Diversity and AC Financial Expertise)

The main independent variables in this research are BGD and AC financial expertise. BGD is measured by the proportion of women directors relative to total board members, ensuring clarity and grammatical accuracy (García-Meca & Martinez-Ferrero, 2025). ACs with financial expertise are defined as having at least three members, including at least one financial expert (Sahu, Alahdal, et al., 2025).

Control Variables

The study uses firm characteristics and corporate governance variables as control variables, following several previous studies (Donkor, Appiagyei, Kwakye, & Korankye, 2025). In this context, we examine AC independence (ACI), board size (BS), and independent board members (IBM). ACI is measured as the proportion of independent AC members relative to the total AC members. Board size (BS) is represented by the total number of board members. The number of board meetings (NBM) indicates board activity. Additionally, we control for firm leverage (FL), current ratio (CR), capital expenditures (CE), and firm size (FS). FL is calculated by dividing total debt by total assets. CR is the ratio of total current liabilities to total current assets. CE and FS are measured as the logarithms of total expenditures and total assets, respectively.

Econometric Model

To estimate the hypotheses (1-3) of this study, the econometric models can be formulated as follows:

$$\mathrm{GI}_{it} = \alpha_0 + \alpha_1 BGD + \alpha_2 ACE_{it} + \alpha_3 ACI_{it} + \alpha_4 IBM_{it} + \alpha_5 BS_{it} + \alpha_6 NBM_{it} + \alpha_7 FL_{it} + \alpha_8 CR_{it} + \alpha_9 CE_{it} + \alpha_{10} FS_{it} + \text{Industry effects} + \text{Years effects} + \epsilon_{it} \quad (1)$$

$$\mathrm{GI}_{it} = \alpha_0 + \alpha_1 BGD * ACE_{it} + \alpha_2 ACI_{it} + \alpha_3 IBM_{it} + \alpha_4 BS_{it} + \alpha_5 NBM_{it} + \alpha_6 FL_{it} + \alpha_7 CR_{it} + \alpha_8 CE_{it} + \alpha_9 FS_{it} + \text{Industry effects} + \text{Years effects} + \epsilon_{it} \quad (2)$$

Where i and t denote firms and the time horizon (year), α indicates a constant. Are intercept estimates. GI represents corporate green innovation. BGD (Board Gender Diversity) and ACE (Audit Committee Financial Expertise) are the primary independent variables. ACI, IBM, BS, NBM, FL, CR, CE, and FS are control variables. IBM, BS, and NBM refer to independent board members, board size, and number of board members, respectively. FL, CR, CE, and FS represent firm leverage, current ratio, capital expenditures, and total assets. The model accounts for industry and year effects. The tested data and facets are summarized in Table A1.

EMPIRICAL FINDINGS

Statistical Analysis and Correlation

Table 2 presents descriptive statistics of the tested variables, showing that the mean green innovation value is 10.07, with a standard-deviation of 23.57, suggesting some variation in the green innovation practices in the listed companies. The outcomes indicate that the mean of AC financial expertise members is 33.17, while the mean of AC independence members is 58.01. The summary also shows that the mean BGD in GCC countries is 3.9%, suggesting a very low female board share compared to economies like OECD countries (Farhan, Alqatamin, & Al-Hajaya, 2025). Furthermore, Table 3 indicates that all correlation coefficients for all the focused variables (BGD, ACI, ACE, IBM, BS, NBM, CR, CE, FL, and FS) with green innovation are lower than 0.9, suggesting the absence of strong correlation among the explanatory variables in our model. Further, Table 3 indicates that all the values of the variance inflation factor (VIF) of the tested variables are less than 10, suggesting that multicollinearity among the tested variables is not observed.

Table 2: Descriptive Statistics

Variables	Obs	Mean	Std-Dev.	Min.	Max.
GE	650	10.07	23.57	0	96.12
BGD	650	3.90	6.87	0	33.33
ACE	650	33.173	33.42	1.66	75.92
ACI	650	58.01	22.66	4.21	83.33
IBM	650	44.14	26.93	0	100
BS	650	8.76	2.27	1	25
NBM	650	6.37	2.49	1	30
FL	650	43.70	21.08	0	93
CR	650	2.09	2.82	.06	35.68
CE	650	17.90	2.63	5.24	24.64
FS	650	21.82	1.77	16.79	27.22

Table 3: Pairwise correlations

Variables	VIF	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1) EI		1.000										
(2) BGD	1.11	0.136*	1.000									
(3) ACE	1.07	0.089*	0.107*	1.000								
(4) ACI	1.06	0.025*	0.081*	0.081*	1.000							
(5) IBM	1.10	0.002	0.228*	0.077*	-0.036	1.000						
(6) BS	1.14	0.019	-0.078*	0.138*	-0.080*	-0.068	1.000					
(7) NBM	1.05	-0.024	0.023	0.000	0.040	-0.043	-0.009	1.000				
(8) FL	1.40	-0.042	0.004	0.008	-0.066	0.082*	0.066	0.110*	1.000			
(9) CR	1.37	0.095*	0.050	0.036	-0.029	-0.074	-0.162*	-0.059	-0.532*	1.000		
(10) CE	2.83	0.254*	0.044	0.116*	-0.075	-0.090*	0.250*	0.180*	0.300*	-0.208*	1.000	
(11) FS	2.67	0.298*	0.045	0.059	-0.135*	-0.060	0.237*	0.145*	0.239*	-0.141*	0.792*	1.000

Note: * indicate significance level at the 5% level.

Results of Multiple Regression

Table 4 presents the results of the OLS analysis. In column 1, the outcomes show the impact of BGD and AC financial expertise on green innovation. The results indicate that AC financial expertise is positively associated with green innovation. Specifically, the coefficient for AC financial expertise in column 1 is 0.0603 and statistically significant, supporting the hypothesis that H1 AC financial expertise significantly influences corporate green innovation. These findings align with previous research, suggesting that increased financial expertise in AC promotes sustainable innovation within firms. For instance, Alkurdi et al. (2024) suggested that AC financial expertise positively promotes corporate sustainable performance in European firms. Conversely, the findings are not in line with Buallay and Al-Ajmi (2020), who suggested that AC financial expertise adversely affects ESG performance in GCC firms. However, the significant and positive linkage between ACE and green innovation affirms that more AC financial expertise guarantees a better understanding of activities on the part of the AC, via a balancing of the firm's profitability and sustainability practices. These outcomes align with stakeholder theory, which suggests that firms should strengthen their corporate governance mechanisms. Increasing AC financial expertise and independence will reduce conflicts between the firm and its shareholders, thereby maximizing alignment between shareholders' and management's interests, which in turn promotes corporate sustainability performance.

Table 4 reports a positive effect of BGD on green innovation. This finding suggests that H2 (Corporate gender diversity significantly promotes green innovation) is supported, indicating that an increase in the percentage of BGD plays a positive role in enhancing CSP in GCC firms. These outcomes align with stakeholder theory, which suggests that greater gender diversity in firms improves decision-making and promotes communication among board members. Subsequently, it leads to sustaining green innovation. Hence, these findings suggest that greater BGD in firms increases the adoption of green practices that mitigate harmful ecological effects, compared with their male counterparts. These outcomes support the conclusions of Dwekat et al. (2025), who confirmed the positive role of female board members in promoting corporate green innovation.

Table 4: Findings from OLS

Variables	(1)	(2)	(3)	(4)
BGD	0.493***	0.403***		0.382***
	(3.66)	(3.00)		(2.83)
ACE	0.0603**		0.0569**	0.0504*
	(2.26)		(2.11)	(1.87)
ACI		0.828**	0.882**	0.808**
		(2.36)	(2.51)	(2.31)
IBM		-0.00779	0.00807	-0.0130
		(-0.22)	(0.23)	(-0.37)
BS		-0.455	-0.640	-0.575
		(-1.10)	(-1.52)	(-1.37)
NBM		-0.515	-0.487	-0.505
		(-1.37)	(-1.30)	(-1.35)
FL		-0.0705	-0.0780	-0.0750
		(-1.37)	(-1.51)	(-1.46)
CR		1.269***	1.275***	1.245***
		(3.20)	(3.21)	(3.15)
CE		1.163**	1.103*	1.071*
		(2.06)	(1.94)	(1.90)

Variables	(1)	(2)	(3)	(4)
FS		3.263***	3.453***	3.358***
		(3.86)	(4.07)	(3.98)
C	8.603	-80.19***	-83.37***	-80.56***
	(1.56)	(-5.35)	(-5.55)	(-5.38)
N.	650	650	650	650
R^{Squared}	0.0625	0.186	0.180	0.191
Industry Effects	Yes	Yes	Yes	Yes
Years Effect	Yes	Yes	Yes	Yes

Note: *, **, *** means significance level at the 10,5 and 1, respectively. The figures in brackets represent (t-statistics).

Table 5: Moderating the role of BGD

Variables	(1) OLS	(2) GMM	(3) Lagged
GI_{t-1}		0.711***	
		(31.25)	
BGD* ACE	0.00579**	0.00278***	0.00539*
	(2.40)	(2.77)	(1.78)
ACI	0.891**	0.0813	0.993**
	(2.54)	(0.77)	(2.49)
IBM	-0.00236	0.0180	-0.00375
	(-0.07)	(1.47)	(-0.10)
BS	-0.552	0.0689	-0.570
	(-1.33)	(0.48)	(-1.30)
NBM	-0.558	-0.0733	-0.531
	(-1.48)	(-0.65)	(-1.37)
FL	-0.0662	0.000**	-0.112**
	(-1.28)	(2.53)	(-2.00)
CR	1.298***	0.879***	1.058**
	(3.27)	(4.36)	(2.35)
CE	1.083*	-0.267*	1.272**
	(1.91)	(-1.80)	(2.01)
FS	3.504***	1.285***	3.451***
	(4.13)	(3.52)	(3.69)
C	-83.26***	-22.72***	-83.40***
	(-5.55)	(-3.39)	(-5.17)
Observations	650	517	650
R^2	0.182	-	0.181
AR1	-	0.00	-
AR2	-	0.533	-
Hansen		0.894	
Industry Effect	Yes	Yes	Yes
Years Effect	Yes	Yes	Yes

Note: *, **, *** means significance level at the 10,5 and 1, respectively. The figures in brackets represent (t-statistics).

Table 6: Findings of GMM

Variables	(1)	(2)	(3)	(4)
ENV_{t-1}	0.930***	0.916***	0.913***	0.905***
	(13.50)	(18.92)	(13.86)	(15.54)
BGD	0.0693**	0.0853**		0.0782**
	(2.43)	(2.53)		(2.24)
ACE	0.0322***		0.0318***	0.0335***
	(5.09)		(5.19)	(5.52)
ACI		0.0279***	0.0364***	0.0385***
		(5.12)	(6.15)	(6.56)
IBM		-0.0359***	-0.0340***	-0.0416***
		(-3.10)	(-3.10)	(-3.42)
BS		0.269***	0.201***	0.132*
		(3.37)	(2.74)	(1.68)
NBM		0.181***	0.251***	0.271***
		(3.36)	(4.18)	(4.57)
FL		0.0693***	0.0746***	0.0723***
		(4.98)	(5.30)	(4.87)
CR		1.082***	1.071***	1.058***
		(13.07)	(13.84)	(12.06)
CE		-0.167	-0.246**	-0.187
		(-1.48)	(-2.18)	(-1.60)
FS		1.170***	1.293***	1.249***
		(5.74)	(6.12)	(5.81)
C	-2.183***	-23.75***	-26.61***	-27.05***
	(-4.22)	(-6.13)	(-6.72)	(-6.51)
Observations	517	517	517	517
AR1	0	0	0	0
AR2	0.073	0.132	0.129	0.106
Hansen Test	0.473	0.205	0.37	0.374
Industry Effect	Yes	Yes	Yes	Yes
Years Effect	Yes	Yes	Yes	Yes

Note: *, **, *** means significance level at the 10,5 and 1, respectively. The figures in brackets represent (t-statistics).

Table 7: Findings of Lagged Model

Variables	(1)	(2)	(3)	(4)
BGD	0.540***	0.401**		0.383**
	(3.37)	(2.53)		(2.42)
ACE	0.0579**		0.0582**	0.0539*
	(2.01)		(2.00)	(1.86)
ACI		0.941**	0.965**	0.902**
		(2.36)	(2.42)	(2.26)
IBM		-0.00731	0.000622	-0.0123
		(-0.20)	(0.02)	(-0.33)
BS		-0.503	-0.683	-0.629

Variables	(1)	(2)	(3)	(4)
		(-1.15)	(-1.54)	(-1.43)
NBM		-0.496	-0.465	-0.469
		(-1.29)	(-1.21)	(-1.22)
FL		-0.116**	-0.121**	-0.120**
		(-2.09)	(-2.17)	(-2.16)
CR		0.994**	1.022**	0.991**
		(2.22)	(2.28)	(2.22)
CE		1.279**	1.283**	1.178*
		(2.04)	(2.04)	(1.87)
FS		3.297***	3.412***	3.392***
		(3.55)	(3.66)	(3.66)
C	8.678	-80.54***	-83.22***	-80.93***
	(1.60)	(-5.00)	(-5.16)	(-5.03)
Observations	520	520	520	520
R^2	0.0617	0.186	0.183	0.192
Industry Effect	Yes	Yes	Yes	Yes
Years Effect	Yes	Yes	Yes	Yes

Note: *, **, *** means significance level at the 10,5 and 1, respectively. The figures in brackets represent (t-statistics).

Focusing on control variables, our analysis indicates that AC independence positively influences corporate green innovation. Conversely, the impact of independent board members and board size on green innovation appears limited. Firm leverage shows an insignificant effect. Additionally, current ratios, capital expenditures, and firm size contribute to improved corporate sustainability performance by fostering green innovation.

We utilize OLS, system GMM, and lagged models to evaluate the effect of BGD on the relationship between AC financial expertise and green innovation. The results, presented in Table 5, indicate that the combined influence of BGD and AC financial expertise is positive and statistically significant. These findings suggest that BGD positively impacts the relationship between AC expertise and green innovation, supporting H3 (Corporate gender diversity drives audit committee expertise-green innovation) within GC firms. This effect may be due to the presence of women on the board, which encourages the AC to maintain its role in strengthening the link between the firm and stakeholders' interests. This can be achieved by increasing disclosures related to sustainable practices in corporate reports. The results confirm that corporate sustainable practices are not solely focused on green performance but also on the synergistic relationship between financial performance and sustainability initiatives. Consequently, green innovation is viewed through the auditor's role, demonstrating a positive impact on a company's economic advantage (Fosu, Fosu, Akyina, & Asiedu, 2024). Hence, the study suggests that female on board members pay significant attention and effort to align all governance mechanisms and committees with sustainable practices. Hence, we suggest that the interaction between AC financial expertise and BGD plays a positive role in addressing sustainability challenges, which, in turn, leads to increased adoption of green innovation.

Robustness Checks and Alternative Measurements

To address endogeneity, we use the system GMM method, which handles this issue by taking first differences, resulting in unbiased estimated outcomes (Yu, Farooq, Alam, & Dai, 2024). In this context, the method uses lagged variable values as instruments by employing their past values. The study utilizes the lagged dependent variable (t-1) as an instrument (Khatib, 2025). To assess the validity of the employed instruments, we used Hansen and Arellano Bond tests for first-order (AR1) and second-order autocorrelation (AR2). The findings from Table 6 show that the p-values of AR2 and the Hansen tests are insignificant, suggesting that the instruments are exogenous and the tested models are valid. The S-GMM findings (Table 6) show that the dependent

variable lag is significant, indicating that they satisfy the condition of a dynamic variable that depends on its past record (Okoyeuzu, Ujunwa, Ujunwa, & Onah, 2021).

Table 8: Alternative measurement of BGD

Variables	(1)	(2)	(3)
BLUA	0.315***	0.266***	0.252***
	(3.81)	(3.24)	(3.06)
ACE	0.0597**		0.0516*
	(2.24)		(1.93)
ACI		0.858**	0.828**
		(2.48)	(2.40)
IBM		-0.0103	-0.0157
		(-0.29)	(-0.45)
BS		-0.486	-0.615
		(-1.19)	(-1.49)
NBM		-0.598*	-0.591*
		(-1.70)	(-1.69)
FL		-0.0835*	-0.0872*
		(-1.66)	(-1.73)
CR		1.252***	1.226***
		(3.17)	(3.11)
CE		1.212**	1.113**
		(2.16)	(1.98)
FS		3.479***	3.546***
		(4.24)	(4.33)
C	8.536	-84.63***	-84.14***
	(1.55)	(-6.00)	(-5.98)
Observations	650	650	650
R^2	0.0644	0.186	0.191
Industry Effect	Yes	Yes	Yes
Years Effect	Yes	Yes	Yes

Note: *, **, *** means significance level at the 10,5 and 1, respectively. The figures in brackets represent (t-statistics).

In addition, we used the lagged (t-1) for all the study variables. The outcomes of lagged variables are displayed in Table 7. The findings from Tables 6 and 7 show that the coefficients for BGD and ACE remain positive and significant, confirming their positive role in driving green innovation. On the other hand, the percentage of BGD may indicate a high degree of gender homogeneity. To address this issue, we use the BLAU index as an alternative measurement of BGD (Kılıç & Kuzey, 2016). The Blau index assumes the maximum value when the share of each category is at its maximum. This index ranges from 0 to 0.5. The findings reported in Table 8 indicate that the BLAU coefficients across models are positive and significant, confirming the positive role of BGD in reinforcing green innovation.

CONCLUSION

This research examines the influence of board gender diversity (BGD) and audit committee (AC) financial expertise on corporate green innovation within GCC countries from 2015 to 2024. It addresses a gap in existing

literature by analyzing how BGD and AC financial expertise interact to promote sustainable practices in these economies. The study employs various methodologies, including fixed effects, system GMM, lagged models, and Blau's Index, to ensure robustness. Results indicate that increased BGD positively impacts corporate green innovation, with female board members more likely to adopt environmentally friendly practices than their male counterparts. Additionally, AC financial expertise shows a significant positive effect on green innovation, emphasizing the importance of knowledgeable audit committees. The findings also reveal that BGD enhances the relationship between AC financial expertise and sustainable corporate practices, suggesting that diverse boards and audit committees are more committed to aligning corporate strategies with sustainability goals. The study highlights that BGD encourages green innovation by fostering structures within boards and audit committees that prioritize sustainability. Based on these outcomes, the research proposes recommendations aimed at strengthening corporate green innovation, emphasizing the need for increased gender diversity and financial expertise in governance structures to support sustainable development initiatives.

Supporting stakeholder theory, this research provides empirical evidence that AC financial expertise encourages green innovation. Policymakers should establish strong ACs by considering members' backgrounds and experience to improve green governance. These committees can enhance the quality and quantity of corporate sustainable disclosures.

The study indicates that increased female representation encourages green innovation. Firms should strengthen governance by promoting board diversity and including women in sustainability initiatives. Prioritizing diversity enhances decision-making and supports environmental goals, emphasizing the importance of gender inclusion in corporate governance and sustainability efforts.

Third, women on the board play a crucial role in fostering the relationship between the audit committee and green innovation. The study recommends that GCC firms align their governance structures such as gender diversity and audit committees, with sustainability objectives by developing strategies that include adopting eco-technologies and sustainable sourcing. Additionally, female directors should implement more evaluation systems for corporate green innovation and incorporate green disclosures into final audit reports. These measures can strengthen their positive influence on corporate green transition.

This paper emphasizes the significance of AC financial expertise and BGD in promoting green innovations within GCC countries. It acknowledges limitations that suggest avenues for future research. Firstly, the study relied on the green innovation score from the Refinitiv database; subsequent research could explore other metrics to evaluate the impact of AC and BGD on corporate green innovation. Secondly, the focus was on AC financial expertise; future studies might consider alternative proxies for AC characteristics, such as the size of the AC, which can be examined through different indicators. Thirdly, the research concentrated on BGD's role in green innovation, but other aspects like board cultural diversity could be explored in future work. Lastly, the study's context is limited to GCC economies, which affects the broader applicability of the findings. Future research could extend this analysis to other regions, such as MENA economies, to validate and expand upon these results.

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Table A1: Appendix: Variable Construction

Abb.	Indicator	Measurement
GI	Green innovation	Environmental Innovation (EI) score, which captures the level of green products and activities and level of eco-friendly technologies and the processes or eco-designed products
BGD	Board gender diversity	Share of female on board to the total board members
ACE	Audit committee financial expertise	AC has at least three members, including one financial expert per the Sarbanes-Oxley
ACI	Audit committee independent	The share of AC independents to the total number of AC members
IBM	Independent board member	Share of Independent board members to the total board members
BS	Board size	Total number of board members (both insider and outsider)
FL	Firm Leverage	Total debt / Total equity.
CR	Current ratio	Total current liabilities / Total current assets.
CE	Capital expenditures	Natural logarithm of capital expenditures
FS	Firm Size	Natural logarithm of firm total assets (in thousands)