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12. Dynamic relationship between board gender diversity and renewable energy

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Abstract This chapter investigates whether board gender diversity affects firms' renewable energy use. Employing a sample of U.S. environmentally responsible firms, I find support for the hypothesis that board gender diversity significantly affects the renewable energy use of U.S. firms. Specifically, I find that the previous year's board gender diversity positively affects the current year's renewable energy use. In contrast, concurrent board gender diversity does not lead to an increase in renewable energy use. The study findings are robust to endogeneity issues with the application of dynamic estimation models such as the generalized method of moments (GMM). The study contributes to a rare strand of literature and provides valuable insight into firms in the context of increasing pressure to embrace sustainability practices.

Keywords board gender diversity | renewable energy | environmental performance | corporate governance | sustainability

12.1 INTRODUCTION

The International Renewable Energy Agency (IRENA) believes that effective energy decarbonization in the context of reaching zero carbon dioxide (CO_2) in all sectors of the economy by the 2050s is crucial[1]. Zhang et al. (2021) argue that renewable energy is one of the most critical steps to cope with climate change and achieve sustainable goals. Renewable energy refers to the total energy sources from bioenergy, geothermal, hydropower, ocean, solar, and wind. However, renewable energy is not necessarily employed due to several barriers and challenges (Painuly, 2001).

Agency cost or principal-agent problem is one reason that leads to corporate environmental negligence resulting from the conflicting interests of principal

1 International renewable energy agency, https://www.irena.org/.

and agent (Fakoya & Nakeng, 2019). As a result, corporate environmental performance and corporate governance have become important issues in recent literature (Fakoya & Nakeng, 2019; García Martín & Herrero, 2019). The corporate board is an important mechanism within the framework of internal corporate governance (Chen & Lin, 2016) since it works as a bridge between shareholders and management and as a watchdog on behalf of all stakeholders. So, the corporate board is also associated with important decisions regarding a firm's sustainability or environmental performance. Still, there is no clarity on which board characteristics influence environmental performance (Fakoya & Nakeng, 2019).

Board gender diversity is a little-studied characteristic of the corporate board. But the growing pressure from policymakers is further accelerating the importance of gender diversity. Several countries have legislated boardroom quotas for their largest publicly listed companies, while other countries have set voluntary targets to foster an increase in the number of women on boards, and thus reap the rewards of gender diversity[2]. Some of the countries introducing compulsory quotas are Norway, Germany, and France. In contrast, Australia, the U.K., South Africa, etc., have enacted voluntary measures so far. U.S. firms are also under ever-increasing pressure to increase board gender diversity. For instance, in the U.S., State Street's policy initiative required at least one female director on every board in 2017[3]. The new regulation in California mandated that all the companies headquartered in the state should have at least one woman on their boards in 2019, and at least three women directors are required by 2021 for boards with six members or more. Other U.S. states also enacted or are considering board diversity legislation related to the minimum number of females on boards as a percentage, with deadlines and penalties for failure to file and comply[4]. Furthermore, recently, NASDAQ's proposal for board gender diversity was approved by the Securities and Exchange Commission (SEC). The policy will require the almost 3,000 companies on NASDAQ to hire at least one woman on their boards[5]. This policy debate is

2 International Labour Organization (ILO) report 2019 on Women in Business and Management, https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/briefing-note/wcms_754631.pdf.

3 On its *policy initiative*, State Street Global Advisors (SSGA) announced a call for 3,500 global companies, representing $30 trillion in market capitalization, to increase the number of women on boards. https://corpgov.law.harvard.edu/2019/06/18/u-s-board-diversity-trends-in-2019/

4 Center for Corporate Governance, Harvard University, https://corpgov.law.harvard.edu/2020/05/12/states-are-leading-the-charge-to-corporate-boards-diversify/.

5 Forbes (2021), https://www.forbes.com/sites/jackkelly/2021/08/11/new-policy-requires-diversity-on-corporate-boards-for-nasdaq-listed-companies/.

ongoing throughout the U.S., which substantially raised its board gender diversity in recent years[6].

Studies show that firms could improve their environmental performance if they have a gender-diverse board (Atif et al., 2021; Li et al., 2017; Liu, 2018; Lu & Herremans, 2019). Liu (2018) studied the relationship between board gender diversity and environmental violations and found that firms with greater board gender diversity are less often sued for environmental infringements. Lu and Herremans (2019) find a positive effect of gender diversity on environmental performance scores primarily in the more environmentally impactful industry sector. Similarly, Li et al. (2017) found a direct and significant relationship between board gender diversity and firms' environmental policies. However, the aspect of renewable energy use is overlooked as an environmental performance measure, so it is a unique new angle to measure environmental corporate social responsibility (CSR) (Atif et al., 2021).

There is a dearth of literature on the interaction between board gender diversity and renewable energy use. A recent study by Atif et al. (2021) claims to be the first study to look into renewable energy consumption in connection with board gender diversity. Following Atif et al. (2020), this chapter attempts to extend the study by focusing only on environmentally responsible firms, while the earlier study considered a sample of diverse firms. In this chapter, the sample of environmentally responsible firms is derived from the *Asset4* at the Refinitiv (formerly Thomson Reuters) database. *Asset4* is a leading provider of environmental, social and governance (ESG) information, so the current study assumes that firms listed or having an ESG rating at *Asset4* are more environmentally responsible. The main focus of this study is then whether these firms employed renewable energy for their use.

The current chapter contributes to the rare literature on board gender diversity and firms' renewable energy use with a few significant contributions. First, this is one of the earliest papers investigating the relationship between these two issues. It extends the findings from Atif et al. (2021) and Zhang et al. (2021) by focusing on the dynamic[7] relationship between environmentally pronounced firms' board gender diversity and renewable energy use. Second, this chapter studies the vital issue of sustainability – renewable energy use – at the micro level. The previous literature looked at energy consumption at the macro level and how it interacts with gross domestic product (GDP), economic growth, financial development, etc.

6 Boardex (2021), https://www.boardex.com/2020-global-gender-diversity-analysis-women-on-boards/.

7 The ignorance of the dynamic relationship between structure performance relationship in existing empirical works presents significant concerns related to endogeneity (Wintoki et al., 2012).

However, studies in recent years have examined it from the perspective of the micro level (Chang et al., 2017), which is necessary because of the energy demand growth from industrial firms. Further, previous studies focused only on traditional energy consumption, such as energy efficiency or energy intensity (Chang, 2015; Mukherjee, 2008), paying no attention to renewable energy consumption. Finally, the findings of the study have important implications for both academics and policymakers.

The following section discusses the literature and builds the hypothesis. Section 12.3 discusses the method and data. Section 12.4 presents the results and analysis, and finally section 12.5 discusses the findings, including the conclusion.

12.2 THEORETICAL FRAMEWORK AND HYPOTHESIS

The literature shows that the strand on firms' energy performance has been previously studied from two aspects. First, researchers have been interested in looking at the financial outcome of energy performance such as return on assets, return on equity, return on investment, profitability, etc. (Fan et al., 2017; Sahu & Narayanan, 2015). Second, an increased amount of literature examines how corporate governance characteristics shape improved energy performance (Atif et al., 2021; Fakoya & Nakeng, 2019; Min, 2014; Zhang et al., 2021). This chapter takes the latter position to examine the causal relationship between the board characteristic of gender diversity and renewable energy use. Board diversity in terms of culture, background, internationalization, gender, and so on is commonly studied in several interdisciplinary research fields such as leadership, management, and international business. However, this chapter intends to focus specifically on board gender diversity, which refers to female representation on the corporate board of directors. This body of research continues to attract considerable attention (Reddy et al., 2019) due to both policy pressure and empirically dubious outcomes.

The board is regarded as a mechanism for resolving agency problems (Campbell & Mínguez-Vera, 2007; Carter et al., 2003). Jensen and Meckling's (1976) agency theory argues that the agency problem is a result of conflicts of interests between a firm's agent and principal. In this line, and according to the overinvestment hypothesis, the management may have an interest in overinvesting in CSR if it is conducive to its private benefits or reputation building, but that is detrimental to shareholders' value maximization (Barnea & Rubin, 2010). In this context, there is an inverse relationship between board structure and CSR investment due to increased internal and external board monitoring on CSR overinvestment (Jo & Harjoto, 2012). However, agency theory does not provide a more direct relation between board structure and firm performance. This issue or link becomes an empirical question (Carter et al., 2003) and a controversial one at that (Joecks et al., 2012). So, this chapter also attempts to assess the clear link between board gender diversity and renewable energy use in the context of agency theory. In addition, I develop the hypothesis by drawing insights from the gender socialization theory and upper echelons theory.

Gender socialization theory argues that women are more concerned with social and environmental issues and consider the welfare of stakeholders due to their communal values, ethics, and traits (Krishnan & Parsons, 2007; Nielsen & Huse, 2010). Women are perceived to be less likely to engage in corporate misconduct and unethical behavior that could harm a firm's reputation (Liu, 2018). According to Hofstede (2001)[8], the gender role expectation in society is reflected at the level of masculinity, where men are expected to be assertive, tough, and achievement-oriented, while women are expected to show modesty and be focused on quality of life. Thus, the theory suggests that women care more about environmental and sustainability issues than their male peers. Drawing on the gender socialization theory, Liu (2018) showed that firms with greater board gender diversity are less often sued for environmental regulation violations, probably due to ethical performance shown by female directors. Furthermore, Nadeem et al. (2020) found a significant positive relationship between board gender diversity and environmental innovation. Similarly, Ben-Amar et al. (2015) also found evidence that the likelihood of voluntary climate change disclosure increases with the percentage of women on boards. These studies ascribe better environmental performance to female directors' values and concerns for stakeholders.

On the other hand, upper echelons theory argues that a board or top management team's cognitive and values differences result in performance differences since their traits and psychological processes characterize women and men differently, and that this substantially impacts their decision-making processes (Li et al., 2017; Nadeem et al., 2020). Li et al. (2017) believe that information sharing, joint decision-making, and collaboration between women and men collectively lead to good strategies because of these differences. So, the theory suggests that the more gender-diverse corporate boards are, the more sensitive towards ethical behavior and environmental issues they will be. Within the framework of upper echelons theory, Li et al. (2017) attributed the better environmental policy in a more gender-diverse board of directors to the increased sense of social responsibility at the firm level and women directors' personal characters. In this vein, Nadeem et al. (2020) also endorse this theory with the findings that female

8 Hofstede, G. (2001), *Culture's Consequences: Comparing Values, Behaviors, Institutions, and Organizations Across Nations*, 2nd ed. Sage, Thousand Oaks, CA.

directors' concerns for the environment can be instrumental for environmental innovation in modern firms.

12.2.1 Board gender diversity and renewable energy use

In the context of agency theory, gender socialization theory, and upper echelons theory, this chapter intends to examine the effect of board gender diversity on renewable energy use. At this intersection, a constant search of the literature found a couple of recent indistinct studies (Atif et al., 2021; Fakoya & Nakeng, 2019; Zhang et al., 2021), with positive, negative, and insignificant results.

Atif et al. (2021) closely examined the relationship between board gender diversity and renewable energy consumption, while the other studies used board gender diversity as one of the board characteristics among other variables when investigating the relationship between corporate board characteristics and energy use/renewable energy use. For instance, Atif et al. (2021) studied board gender diversity in 1,491 listed U.S. firms. They used different proxies of board gender diversity and renewable energy and found that boards with two or more women positively impact renewable energy consumption. However, their sample includes diverse U.S. firms. Building on that, this chapter emphasizes only the environmentally pronounced firms that also use and/or report renewable energy. In addition, I categorize the samples into high renewable energy use and low renewable energy use to check the robustness of results. This subsample study is essential due to the significant emphasis given to renewable energy consumption by this chapter. There can be a higher effect of board gender diversity on firms with high renewable energy use.

Zhang et al. (2021) studied 1,027 firms from 47 countries to investigate the role of internal and external corporate governance on renewable energy use. They found that board characteristics, including a strong female presence on boards, can positively influence firms' renewable energy behavior in civil law countries but not in common law countries. However, their study lacks a specific focus on gender diversity and renewable energy use. Zhang et al. (2021) argue that future studies should focus in more detail and provide the fundamental mechanisms of how the variables interact. The current chapter closely concentrates only on the link between board gender diversity and renewable energy use based on a single country sample, followed by an understanding of intrinsic theoretical insights.

On the other hand, Fakoya and Nakeng (2019) studied 28 retail and banking firms listed on the Johannesburg Stock Exchange from 2007 to 2017 and indicated that the number of female board members has an insignificant influence on sustainable energy performance. However, their limited sample and failure to mitigate endogeneity issues position the results skeptically.

Since these existing studies overlooked the endogeneity related to dynamic effects (Wintoki et al., 2012), the current chapter uses a dynamic approach to examine the relationship between board gender diversity and firms' renewable energy use. Furthermore, more research should be carried out to add to this new area of study. Rare and preliminary studies earlier at this intersection do not provide us with any confidence to conclude the significant relationship between board gender diversity and renewable energy use. So, based on prior studies and theoretical insights, in this chapter, I investigate the following hypothesis:

Board gender diversity significantly affects renewable energy use.

12.3 DATA AND METHOD

12.3.1 Sample and data

The study employs a sample of *Asset4* U.S. firms from the Refinitiv database. The Refinitiv derives a wide range of ESG dimensions of firms' corporate social performance data using public sources such as annual reports, sustainability reports, and news. Several recent studies focusing on board gender diversity and firms' environmental performance used the same database (Gallego-Sosa et al., 2020; Nadeem et al., 2020). Its use is growing because of data-driven, transparent, objective measurements of ESG components.

Similarly, this chapter uses the U.S. as a sample country, widely studied in terms of sustainability. There are three reasons for the significance of the U.S. study. First, the U.S. is the second-largest economy generating carbon emissions[9]. So, it has a significant responsibility and mounting pressure for the green transition. Second, the issue of board gender diversity in the U.S. is equally growing. For instance, California enacted the subnational board gender diversity quota, and other states across the country are also undergoing similar legislation.[10] Similarly, NASDAQ's proposal for board gender diversity was approved by SEC recently. The policy will require the almost 3,000 companies on NASDAQ to hire at least one woman on

9 United States Environmental Protection Agency, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data.

10 International Labour Organization (ILO) report 2019 on Women in Business and Management, https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---act_emp/documents/briefing-note/wcms_754631.pdf.

their boards[11]. S&P 500 companies also reached the point of having at least one female director for the first time in 2020[12]. Due to these reasons, the study of green transition and board gender diversity in the U.S. has important policy relevancy. Finally, choosing the U.S. as a country sample is also warranted to account for the country-specific governance. For instance, Zhang et al. (2021) found that board gender diversity is not positively related to green energy in common law countries. Their worldwide study finding motivates us to look into a specific country.

12.3.2 Environmentally responsible "green" firms

The point of departure for the sample in this study was the 1,060 U.S. firms listed in the *Asset4* Refinitiv database. These firms can be regarded as environmentally pronounced firms due to their decent environmental rating by Refinitiv. However, this chapter applies more screening to focus on highly environmentally responsible firms. First, I looked into whether the firms used renewable energy since this is a significant step for a sustainable future. I found 3,732 firm-year observations for the firms that used renewable energy. Then, considering the firms that reported renewable energy as a portion of their total energy use, the sample firms reduced to 723 firm-year observations. Furthermore, after the restriction to a minimum of three years of panel data on the variable of interest – renewable energy use ratio – I ended up with 102 firms and 622 firm-year observations from 2004 to 2019.

In Figure 12.1 below, I show the initial data on sampled firms' board gender diversity and renewable energy use percentage trends from 2004 to 2019 using a locally weighted scatterplot smoothing line. The graph shows that board gender diversity percentage is growing at an increasing rate lately while renewable energy use percentage is increasing at a somewhat constant rate during the same period. This noticeable increase in board gender diversity provides the significance of this study.

11 Forbes (2021), https://www.forbes.com/sites/jackkelly/2021/08/11/new-policy-requires-diversity-on-corporate-boards-for-nasdaq-listed-companies/.

12 CNBC (2021), https://www.cnbc.com/2020/12/15/all-sp-500-boards-have-at-least-1-woman-first-time-in-over-20-years.html.

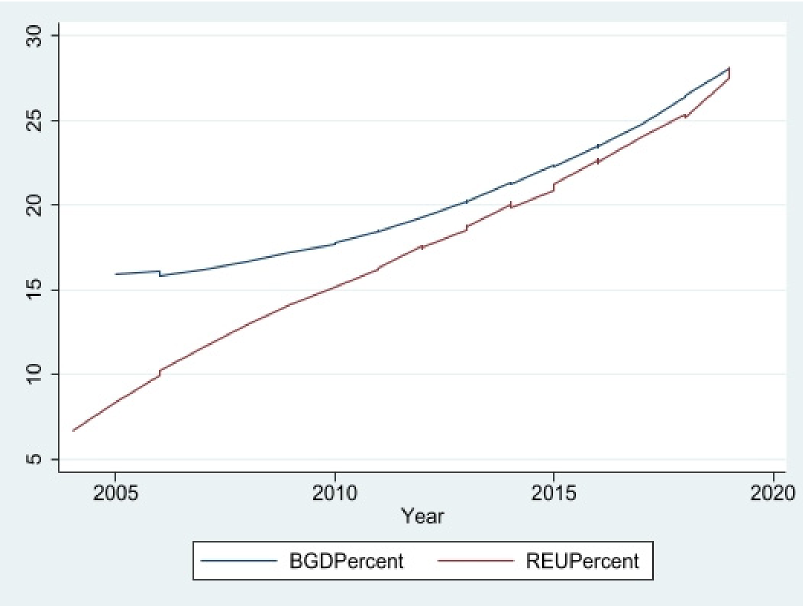

Figure 12.1: Board gender diversity and renewable energy data.

12.3.3 Empirical measures

The dependent variable, renewable energy use, is measured by the renewable energy use percent (REUPercent). The independent variable, board gender diversity percent (BGDPercent), is measured as the percent of female board members. This study also uses lagged dependent and independent variables as explanatory variables to consider the dynamic effect. Furthermore, the ESG score is also a lagged control variable. The ESG score variable accounts for environmental, social, and governance factors related to the REUPercent and BGDPercent aspects of environmental and governance, respectively. The ESG score can drive firms to keep up the positive environmental and governance performance due to their concern for legitimacy in society. In this context, legitimacy theory explains that firms with low ESG scores should perform better in ESG factors to legitimate themselves in the eyes of stakeholders. Thus, I use the lagged period ESG score to account for the lagged effect of the ESG score.

Similarly, the study employs other control variables for firm characteristics, such as leverage, capital intensity (CI), firm size, return on sales (ROS), and capital expenditure (Capex). The description of all variables used is given in Table 12.1.

I also cite existing studies that used the same control variable measures in the body of gender diversity and environmental performance literature.

Table 12.1: Variables description

Variable ID	Variable name	Definition
Dependent variable:		
REUPercent	Renewable energy use percent	Total renewable energy generated (produced/purchased) for use as a percentage of total energy (Atif et al., 2021; Zhang et al., 2021).
Independent variable:		
BGDPercent	Board gender diversity percent	Percentage of female directors on the board (Atif et al., 2021; Zhang et al., 2021).
Control variables:		
ESGScore	ESG	The weighted average rating of firms' environmental, social and governance performance.
Leverage	Leverage	The ratio of the firm's total debt to total equity (Ben-Amar et al., 2015; Nadeem et al., 2020).
CI	Capital intensity	The ratio of total net fixed assets to total assets (García Martín & Herrero, 2019; Lu & Herremans, 2019).
FirmSize	Firm size	The natural logarithm of the net sales revenue (Cordeiro et al., 2020).
ROS	Return on Sales	Firm's income divided by its net sales (Atif et al., 2021).
Capex	Capital expenditure	The ratio of capital expenditures divided by total assets (Nadeem et al., 2020).

12.3.4 Model specification

$$Y_{it} = \propto + \gamma_s Y_{it\text{-}1} + \beta X_{it} + \phi X_{it\text{-}1} + \delta Z_{it} + \text{YearDummies} + \text{IndustryDummies} + \varepsilon_{it}$$

In the model, *i* is firm, *t* is time, and Y is the dependent variable *REUPercent*. The coefficient symbols γ, β, ϕ, and δ are vectors of coefficients on the lagged dependent variable Y, the independent variable X (*BGDPercent*), lagged X, and control variables Z. YearDummies and IndustryDummies are the time and industry effects control variables. ε_{it} represents a random error term.

Thus, this chapter employs the autoregressive distributed lags model ARDL (1, 1) as the baseline model. The rationale is that a change in the level of board gender diversity may have behavioral implications beyond the time period in which it occurred. So, the lagged values of both renewable energy use and board gender diversity are included to account for the sluggish adjustment. The use of the ARDL model provides an appealing separation of short- and long-run effects (Bentzen & Engsted, 2001) accounting dynamic effects of explanatory variables. Furthermore, in existing literature, endogeneity issues are the primary concern as studies are not free from the potential endogeneity of corporate governance and performance (Adams & Ferreira, 2009). This relationship is commonly studied using the fixed-effects (FE) approach and/or the instrumental variable (IV) approach to mitigate endogeneity issues (Nguyen et al., 2015). I backed my findings with a rigorous research design and robustness tests such as dynamic pooled OLS, fixed effects, random effects, and the Hausman-Taylor model. In addition, the application of the generalize method of moments (GMM) estimation system accounts for endogeneity issues.

12.4 RESULTS AND ANALYSIS

12.4.1 Descriptive statistics

Table 12.2: Descriptive summary

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
REUPercent	622	20.346	24.556	0	100
BGDPercent	620	21.945	9.228	0	54.545
ESGScore	622	69.459	14.13	23.574	93.112
Leverage	622	.08	15.178	-235.636	80.983
CI	564	.422	.215	.059	.949
FirmSize	550	23.179	1.361	13.816	26.909
ROS	568	.163	.151	-1.062	.846
Capex	622	.033	.034	0	.502

Note: Accounting variables are winsorized at the 1% and 99% levels to mitigate the influence of outliers. All variables are defined in Table 12.1.

Table 12.2 shows the summary statistics for the variables of interest. The dependent variable, REUPercent, is the total portion of renewable energy use to total energy use, has a mean value of 20.346, and is between 0 and 100%. The mean BGDPercent of 21.945 suggests that the sampled firms have around 22% of board gender diversity on average, and a maximum of 54.545%. The control variable, ESGScore, shows that sample firms' ESG score is about 70% on average. This score also suggests that the sample firms are noticeably socially-environmentally responsible. The leverage is between -235.636 and 80.983, the average being 0.08.

The mean firm size is 23.179, which is the log of net sales revenue and ranges between 13.816 and 26.909. CI, a ratio of total fixed assets (net) to total assets, has a mean of 0.422. Further, ROS has a mean value of 0.163 and ranges from -1.062 to 0.846. Finally, the Capex has a mean of 0.33 and ranges between 0 and 0.502.

Table 12.3: Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) REUPercent	1.000									
(2) L1REUPercent	0.915*	1.000								
(3) BGDPercent	0.040	0.050	1.000							
(4) L1BGDPercent	0.016	0.033	0.871*	1.000						
(5) L1ESGScore	-0.048	-0.071	0.318*	0.359*	1.000					
(6) Leverage	-0.046	-0.055	0.061	0.018	-0.102*	1.000				
(7) CI	-0.051	-0.027	0.014	0.001	-0.092	0.279*	1.000			
(8) FirmSize	0.170*	0.186*	0.168*	0.198*	0.259*	-0.036	0.132*	1.000		
(9) ROS	0.063	0.061	-0.019	0.006	0.004	0.117*	-0.025	0.089*	1.000	
(10) Capex	-0.079*	-0.062	0.006	-0.002	0.064	0.074	0.377*	-0.271*	-0.081	1.000

Note: *L1REUPercent*, *L1BGDPercent*, and *L1ESGScore* refer to the one-year lagged period *REUPercent*, *BGDPercent*, and *ESGScore*, respectively. Asterisks with correlation coefficients indicate significance levels at 0.05.

Table 12.3 presents the pairwise correlation between dependent, independent, and control variables. The correlation of REUPercent with BGDPercent and L1BGDPercent is 0.040 and 0.016, respectively. This preliminary positive but insignificant relationship between variables of interest warrants investigating the proper relationship between BGDPercent and REUPercent. The correlation matrix shows that correlation coefficients are below 0.50 except the correlation between variables with their lagged values. Since the ARDL model may include multicollinearity among the regressors (Baltagi, 2008), I tested it with the variance inflation factor (VIF). The VIF for the variables in the model is below 5 with a mean of 2.04. So, there is no concern with multicollinearity.

12.4.2 Regression analysis

Table 12.4: Pooled OLS, fixed-effects, and random-effects models

VARIABLES	(OLS) Model1 REUPercent	(FE) Model2 REUPercent	(RE) Model3 REUPercent
L1REUPercent	0.8848***	0.5020***	0.8733***
	(0.0561)	(0.1097)	(0.0586)
BGDPercent	-0.1908**	-0.2456**	-0.1911**
	(0.0938)	(0.1201)	(0.0945)
L1BGDPercent	0.1390*	0.2624**	0.1408*
	(0.0779)	(0.1111)	(0.0783)
L1ESGScore	0.0036	-0.0702	0.0004
	(0.0411)	(0.0561)	(0.0415)
Leverage	0.0184**	0.0205*	0.0180**
	(0.0080)	(0.0105)	(0.0078)
CI	-4.8812*	-21.6134*	-4.8627*
	(2.5610)	(12.3675)	(2.5879)
FirmSize	0.2611	6.7988**	0.2656
	(0.2984)	(2.6032)	(0.3035)
ROS	8.8960***	3.4912	8.8846***
	(3.0323)	(5.2617)	(3.0338)
Capex	45.6463	1.6709	44.7258
	(27.9016)	(33.3917)	(28.0756)
Constant	-1.4021	-135.3208**	-1.4818
	(6.1216)	(60.5110)	(6.2567)
Firm	No	Yes	No
Time	Yes	Yes	Yes
Industry	Yes	No	Yes
Observations	433	433	433
R-squared	0.861	0.537	
Number of id		92	92

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: Standard errors are clustered to account for heteroscedasticity across individual clusters of observations.

Table 12.4 shows the results for the study model employing pooled OLS, FE, and random-effects (RE) models to examine the relationship between BGDPercent and REUPercent. As can be seen in the table, all three models consistently report the significantly negative effect of BGDPercent on REUPercent at a 5% level of significance. However, L1BGDPercent affects the outcome variable positively at a 5%–10% significance level, also shown by all three models. This result shows that contemporaneous BGDPercent does not contribute to higher renewable energy use. Instead, one-year lagged BGDPercent positively affects the renewable energy use, indicating the lagged or long-run effects of board gender diversity, which is understandable due to the delayed board policy effects.

The dynamic pooled OLS and panel models, accounting for the lagged dependent variable as an explanatory variable, show that lagged REUPercent positively affects the REUPercent at a 1% significance level. Furthermore, the control variables leverage, CI, firm size, and ROS seem to affect the REUPercent significantly.

Table 12.4 reports three regression models. Since the OLS estimates are not consistent if lagged variable is correlated to error term (Baltagi, 2008), I also used panel regression models, FE and RE. The appropriate model for this chapter is the FE model. The Hausman test below rejects the null hypothesis that the difference in coefficients is not systematic, so FE is a consistent estimator.

Test: Ho: difference in coefficients not systematic

Hausman (1978) specification test

	Coef.
Chi-square test value	100.356
P-value	0

According to the FE model, L1BGDPercent positively affects the REUPercent at a 5% significance level. However, the current BGDPercent does not increase the REUPercent; instead, it decreases considerably at the same significance level. I argue that this negative effect does not necessarily refer to a decrease in renewable energy use, but is either due to the increase in board gender diversity being greater than renewable energy use or vice versa, driven by several legislation enactments in the U.S. lately. Notably, it is noticeable in Figure 12.1 above that board gender diversity has recently been increasing at a higher rate while renewable energy use has been increasing constantly.

Table 12.5: Subsample analysis with fixed-effect (FE) and Hausman-Taylor (HT) models

	High renewable energy use subsample (highREU)		Low renewable energy use subsample (lowREU)	
VARIABLES	FE Model1 REUPercent	HT Model2 REUPercent	FE Model3 REUPercent	HT Model4 REUPercent
L1REUPercent	0.4000***	0.4984***	0.0412	0.0560**
	(0.1133)	(0.0490)	(0.0330)	(0.0243)
BGDPercent	-0.1387	-0.1776	0.0099	0.0147
	(0.1399)	(0.1631)	(0.0490)	(0.0277)
L1BGDPercent	0.4874***	0.3671**	0.0007	-0.0114
	(0.1804)	(0.1691)	(0.0281)	(0.0273)
L1ESGScore	-0.0658	-0.0241	-0.0058	0.0029
	(0.1193)	(0.1276)	(0.0144)	(0.0150)
Leverage	0.1887	0.2864	0.0058*	0.0064
	(0.1656)	(0.2163)	(0.0030)	(0.0043)
FirmSize	9.6626*	1.6054	0.8861	0.0902
	(4.8614)	(1.7423)	(1.0703)	(0.4183)
ROS	-0.5225	14.5341**	1.5092*	1.2179
	(11.1305)	(6.6338)	(0.7793)	(0.9060)
Capex	94.4114	91.7315*	-15.6434**	-16.1537**
	(68.4495)	(55.1091)	(7.4620)	(7.5467)
Constant	-198.4183*	-2.3663	-17.0110	-0.0505
	(109.0970)	(39.5014)	(24.9137)	(10.1912)
Firm effects	Yes	No	Yes	No
Time effects	Yes	Yes	Yes	Yes
Industry effects	No	Yes	No	Yes
Observations	218	218	215	215
R-squared	0.601		0.467	
Number of id	58	58	62	62

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Note: The FE model, appropriate for this study, employs firm and time-fixed effects for time-variant variables, while the HT model, referred to as the hybrid model, also incorporates time-invariant variables. So, the HT model in the subsample analysis controls for industry in addition to time effects.

Table 12.5 reports dynamic panel regression analysis for REU subsamples. The idea is to examine whether the highly environmentally responsible/sustainable firms are positively affected by the higher gender diversity in their boards. First, I categorized the total sample into two groups (highREU and lowREU) based on the median REU. Since 50% of sample firms have used 10.28% of renewable energy as a percentage of total energy use, firms with a usage percent over and including 10.28 are termed as highREU subsamples while firms below 10.28 are in the lowREU subsample. Then, the panel regression analysis employing FE and HT models consistently shows that L1BGDPercent positively benefits (at a 1% to 5% significance level) highREU subsample firms to increase their use of renewable energy, while there is no effect of board gender diversity on the lowREU subsample. The subsamples analysis results also indicate that the previous year's board gender diversity is beneficial to increasing the current year's renewable energy consumption.

12.4.3 Endogeneity

Table 12.6: System GMM for endogeneity

VARIABLES	(One-step) Model1 REUPercent	(Two-step) Model2 REUPercent
L1REUPercent	0.3423***	0.7388***
	(0.1089)	(0.1374)
BGDPercent	-2.4120***	-1.1890**
	(0.9115)	(0.5461)
L1BGDPercent	2.0342***	1.0287**
	(0.7663)	(0.4557)
L1ESGScore	-0.0410	-0.0445
	(0.1168)	(0.0874)
Leverage	0.0386	0.0314
	(0.0428)	(0.0290)
CI	-8.9031	-6.7673
	(7.2064)	(5.8027)
FirmSize	1.6312	0.4925
	(1.1070)	(0.6580)
ROS	22.9901*	6.5119
	(13.1609)	(8.3875)
Capex	164.1571*	101.9135*
	(97.9162)	(59.7544)

VARIABLES	(One-step) Model1 REUPercent	(Two-step) Model2 REUPercent
Constant	-10.7331	4.1701
	(26.4287)	(13.9732)
Time effects	Yes	Yes
Industry effects	Yes	Yes
AR(1)	0.013	0.032
AR(2)	0.257	0.506
Hansen test	0.08	0.25
Instruments	49	45
Observations	332	332
Number of id	84	84

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 12.6 presents one of the widely applied techniques concerning endogeneity – system GMM (Lu & Herremans, 2019; Nguyen et al., 2015; Wintoki et al., 2012). The lagged dependent variable as an independent variable is significant at a 1% level and positively related to the dependent variable RECPercent. Thus, it supports the application of system GMM with the lagged dependent variable. The one-step and two-step system GMM[13] use several instruments related to control variables. Time and industry effects are also controlled. So, the output in Table 12.6 shows the endogeneity-adjusted effects of BGDPercent on REUPercent. Both models show a similar relationship between these two variables, which is also consistent with the main results above. For instance, Model1 exhibits a significantly positive effect of L1BGDPercent on REUPercent while BGDPercent affects both negatively at a 1% significance level. Similarly, Model2 reports a constant effect but at a 5% significance level.

Furthermore, sample selection bias is likely to be an issue in the current study due to the inclusion of only those firms that used and reported renewable energy data. So, I employed the Heckman sample selection model. Similar accounting variables were used to predict the selection variable. The Heckman selection

13 According to Hwang & Sun (2018), under the conventional asymptotic theory, the two-step GMM estimator has a smaller asymptotic variance. Statistical tests based on the two-step estimators are also asymptotically more powerful than those based on the one-step estimator. Hwang, J., & Sun, Y. (2018). Should we go one step further? An accurate comparison of one-step and two-step procedures in a generalized method of moments framework. *Journal of Econometrics*, *207*(2), 381–405. https://doi.org/10.1016/j.jeconom.2018.07.006

model showed a consistent and significant (at a 10% level) dynamic relationship between board gender diversity and renewable energy use in an unreported result.

Therefore, this study provides evidence that the previous year's board gender diversity is positively related to renewable energy consumption. However, the result needs to be interpreted with caution due to the negative effect of current year board gender diversity. I interpret these results as suggesting that though the board gender diversity effect is not visible immediately, it has a lagged effect on firms' environmental performance.

12.5 DISCUSSION AND CONCLUSION

The current study examined the relationship between board gender diversity and the firm's renewable energy consumption. The study of large "green" U.S. firms using unbalanced panel data provides evidence for the significant effect of board gender diversity on renewable energy use. This result also supports the hypothesis that *board gender diversity significantly affects renewable energy use.* Along the same lines, Atif et al. (2021) found a significant increase in renewable energy consumption due to contemporaneous and lagged board gender diversity. Zhang et al. (2021) also found a consistent effect of concurrent board gender diversity in civil law countries, but a negative effect in common law countries. In contrast, Fakoya and Nakeng (2019) found no significant relationship between female board members and sustainable energy use.

This study produced two significant findings: First, the previous year's board gender diversity leads to a concurrent increase in renewable energy use. Second, contemporaneous board gender diversity does not improve renewable energy use.

The first finding is consistent with Atif et al.'s (2021) finding of a positive effect of several lagged board gender diversity variables on renewable energy consumption. In this vein, Liu (2018) stated that the lagged female board members percentage is beneficial for reducing environmental lawsuits. I assume that firms with sustainability practices are less prone to environmental violations, being less likely to be charged with environmental lawsuits. This is due to specific female attributes, as argued by gender socialization theory. As a result, a balanced gender-diverse board leads to the formulation of environmental and sustainability-focused policies (Li et al., 2017) and strategic behavior such as the formation of renewable energy alliances (Post et al., 2015), consistent with insights from the upper echelons theory. In the context of the gender socialization theory and upper echelons theory, this finding thus explains that higher female representation on the board is advantageous for firms' environmental performance.

The explanation of the lagged or dynamic effect can be the nature of the board functions. For instance, a board is mainly responsible for guiding and monitoring the firm, integrating the interests of both principal and agents (Nielsen & Huse, 2010). The process of providing guidance and monitoring the management activities is not a one-step process. The board has to contend with multiple board meetings, consensus, and decision-making to provide guidance, suggestions, and monitoring to the management, which justify that the concurrent environmental policies made by the gender-diverse board can take time to implement and can result in a lag in the outcomes. Jo and Harjoto (2012) also documented the positive effect of lag corporate governance variables such as institutional holdings, independent directors, and CEO duality on CSR engagement. So, ignoring the dynamic nature of the structure performance relationship presents serious concern for inference (Wintoki et al., 2012).

The second finding that the concurrent board gender diversity reduces the renewable energy use is consistent with Zhang et al. (2021), who found a negative effect of the female board director percentage on the renewable energy share in common law countries. The authors believe that the negative effect in common law countries such as the U.S. is due to weak incentives to adopt sustainability practices. In contrast, Atif et al. (2021) and García Martín and Herrero (2019) found a significantly positive effect of contemporaneous women board directors and renewable energy use. However, Wintoki et al. (2009) documented no causal relation between board structure and current firm performance when they controlled for past performance. So, the positive link between board gender diversity and renewable energy use shown by a couple of past studies is likely to be biased. Nevertheless, the negative effect of board gender diversity on renewable energy found by this chapter is consistent with the agency theory overinvestment hypothesis. The hypothesis states that various corporate governance mechanisms improve the internal and external monitoring that controls the insiders' incentives and opportunities for CSR overinvestment (Jo & Harjoto, 2012). Since female directors are more likely to join monitoring committees (Adams & Ferreira, 2009), a gender-diverse board can monitor and control the CEO's CSR overinvestment for private opportunities. Within this theoretical framework, the second finding that board gender diversity reduces renewable energy use is plausible, as the gender-diverse board's monitoring concurrently controls or reduces renewable energy use driven by the overinvestment hypothesis.

In addition, some other country-specific characteristics support the second finding. The U.S. is under increasing pressure to improve gender diversity on corporate boards due to its relaxation in mandating the board gender diversity quota earlier. Recently, California mandated the quota system, and the issue is similarly under the process of change throughout the nation. The data shows a recent sharp increase in female representation on boards. On the other hand, renewable energy use by U.S. firms seems to follow a constant increment. Zhang et al. (2021) also argued that the common law governance systems should incentivize firms to adopt renewable energy. This inconsistent board gender diversity and renewable energy use increment could explain the adverse effect or low level of renewable energy use concurrently. Furthermore, board gender diversity has a lagged effect responsible for not contributing to the increased renewable energy use concurrently. Since this study is robust to endogeneity issues with the application of system GMM, I confirm that board gender diversity has a dynamic effect on renewable energy use.

Hence, in the context of increased pressure on U.S. firms, the study provides insight through which U.S. firms can pivot their activities to adopt sustainability policies and practices. Board gender diversity serves as a channel to reach firms' stakeholders due to the female directors' consideration of social and environmental concerns. Such female directors' behaviors, ethics, and values are explained by gender socialization theory. Female directors bring their values and ethics with them when female representation on the corporate board increases. In this context, upper echelons theory argues that a gender-diverse board improves the firm's performance, including environmental performance such as renewable energy use. Thus, the study findings can be empirically implied for policy decisions. First, firms' board gender diversity significantly affects environmental performance. So, it is imperative to improve board gender diversity when addressing current climate change and sustainability issues. Second, this study suggests that although board gender diversity may not contribute to the environmental performance concurrently, it is instrumental in enhancing the future environmental performance due to the lagged effect. So, shareholders and stakeholders should excercise patience to see the concrete benefits from gender-diverse boards. Policymakers should also consider this lag effect when formulating policies for the future.

However, the study has some limitations. First, this study assumes *Asset4* firms as environmentally responsible "green", which excludes firms not included in the *Asset4* database but that are nonetheless environmentally high performers. Second, I have a small sample because of the insufficient availability of renewable energy data. Third, this study considers the publicly listed firms only, so the inclusion of small and other not listed environmentally responsible firms can showcase the overall and distinct effects of board gender diversity on renewable energy use. Besides, future studies with a large sample could investigate if the same findings occur in different institutional and governance settings, including assessing additional board characteristics.

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