Article:

Uyar, A., Gerged, A.M. orcid.org/0000-0001-6805-2737, Kuzey, C. et al. (1 more author) (2024) Renewable energy use, slack financial resources, and board attributes: does energy efficiency policy matter? Business Strategy and the Environment, 33 (5). pp. 4935-4957. ISSN 0964-4733

https://doi.org/10.1002/bse.3739

Renewable energy use, slack financial resources, and board attributes: Does energy efficiency policy matter?

Declarations of interest: none

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This paper is cited as follows:

Uyar, A., Gerged A. M., Kuzey, C., and Karaman A. (2024). Renewable energy use, slack financial resources, and board attributes: Does energy efficiency policy matter? *Business Strategy and the Environment*, DOI: 10.1002/bse.3739

Renewable energy use, slack financial resources, and board attributes: Does energy efficiency policy matter?

Abstract

This study examined the impact of slack financial resources, board characteristics (such as gender diversity, tenure, and skill/expertise), and energy efficiency policies on firms' consumption of renewable energy. Using a dataset of 17,753 observations from 2002 to 2019, we primarily utilized fixed-effects regression, among other methods, for robustness analysis. Our findings revealed that slack financial resources, board gender diversity, and energy efficiency policies positively correlate with increased renewable energy consumption. However, board skill negatively correlates with it. Interaction effects showed that firms with more female and tenured directors effectively utilize slack financial resources for increased renewable energy consumption, unlike firms with more expert directors. Energy efficiency policies enhanced the positive impact of female directors on renewable energy consumption but mitigated the influence of expert directors, weakening their association.

Keywords: Renewable energy; slack financial resources; board attributes; energy efficiency policy

1. Introduction

The rapid increase in energy consumption and the corresponding demand have negatively impacted the environment, posing challenges to human sustainability (Antunes et al., 2023; Allen et al., 2021; Zhang et al., 2018; Gerged et al., 2023). The primary cause of climate change is the escalating emission of greenhouse gases (GHGs) from the combustion of fossil fuels, representing a major global challenge (Li et al., 2024; Atif et al., 2021). In response, Ben-Amar et al. (2017) underscore the urgent necessity to transition from fossil fuels to renewable energy sources to diminish GHG emissions and mitigate the effects of global warming and climate change. This emphasizes the pivotal role of corporations in implementing effective energy efficiency policies and increasing green energy usage, given their substantial energy consumption and significant contributions to GHG emissions (Environmental Protection Agency, 2020; Liu et al., 2021; Igeland et al., 2024).

Acknowledging the critical role of corporations in combatting climate change, research has concentrated on examining the energy-saving behaviors of these entities. Firms' energy-saving behaviors encompass actions and strategies undertaken by businesses to lessen their energy consumption and improve energy efficiency (Delmas & Pekovic, 2013). These behaviors range from adopting energy-efficient technologies and practices to reengineering organizational processes and minimizing energy usage (Saqib et al., 2024; Testa et al., 2012; Bashir et al., 2024). Studies have explored the enablers and barriers to renewable energy adoption, including financial resources, organizational factors, and external influences such as customer demand, economic conditions, and environmental regulations (Cagno et al., 2015; Trianni et al., 2016; Verbeke & Hutzschenreuter, 2021; Yu & Tang, 2023; Steffen et al., 2022; Thollander et al., 2013; Zhang & Kong, 2022; Zhang et al., 2018; Brunke et al., 2014; Tan et al., 2022; Wang et al., 2022; Zhang et al., 2013; Li et al., 2023). Furthermore, top-level management support fosters energy-saving behavior, including renewable energy adoption (Liu et al., 2012; Liu et al., 2014; Suk et al., 2013). Directors' support can transform external pressures into energy-saving actions, such as adopting cleaner energy sources. Adequate organizational resources and energy efficiency policies can enhance the link between board characteristics and companies' adoption of renewable energy (Danneels, 2008; Joo and Kim, 2004; Wei and Gu, 2021; Zhao et al., 2021; Zhang & Kong, 2022; Fan & Wang, 2024).

Although these efforts have advanced our understanding of the factors influencing firms' renewable energy usage, most studies have relied on semi-structured interviews or case studies to investigate these factors (Brunke et al., 2014; Thollander et al., 2013; Zhang et al., 2013). Fewer studies have developed integrated theoretical models or empirically tested these factors' impact on firms' energy-saving performance (Cordroch et al., 2022; Opoku et al., 2021; Liu et al., 2012; Liu et al., 2014; Zhang & Kong, 2022). Additionally, there is a scarcity of theory-driven empirical evidence on companies' energy-saving attitudes (Suk et al., 2013; Zhang et al., 2015). Thus, further empirical research based on theoretical frameworks is necessary to deepen our understanding of this crucial environmental issue.

Moreover, while country-level studies have explored the drivers and outcomes of renewable energy consumption, firm-level studies are limited (Atif et al., 2021; Zhang et al., 2021). Although macro-level studies contribute to policies promoting renewable energy consumption, they offer limited direct implications for firm management and practices. Therefore, filling this empirical gap by examining the relationships between firms' financial slack, board characteristics, energy efficiency policy, and renewable energy consumption is imperative. Analyzing these aspects aims to elucidate firm-level factors predicting international renewable energy usage and provide comprehensive recommendations. A global study on corporate energy behaviors assesses how economic, cultural, regulatory, and technological factors worldwide influence corporations' investments in energy efficiency and renewable energy (Zhang et al., 2021). In this endeavor, we strive to generate broad, actionable insights for sustainability strategies, drawing on the diversity in financial resources, energy efficiency strategies, and environmental impacts of firms across different countries and regions (Gerged et al., 2023; Przychodzen & Przychodzen, 2020; Tariq et al., 2022).

Existing energy-saving studies exhibit two primary limitations. First, research on the moderating effect of board characteristics on the relationship between firms' financial resources and renewable energy adoption is scarce. Second, the literature lacks an exploration of energy efficiency policies as mechanisms through which board members can foster energy-saving attitudes. Our study, therefore, aims to bridge these gaps by investigating the potential moderating impact of board characteristics on the link between cash flow and renewable energy consumption and examining whether the relationship between board characteristics and renewable energy use depends on the presence of an energy efficiency policy.

Utilizing a sample of 17,753 data points from 2,647 unique firms across 39 countries, our study provides empirical evidence grounded in theoretical foundations. Our findings reveal a significant association between cash flow and firms' renewable energy usage. However, board characteristics display varied relationships with renewable energy consumption, with female directors promoting its adoption, while board skills impede it. Board tenure does not significantly affect firms' renewable energy consumption. Moreover, the implementation of an energy efficiency policy encourages renewable energy usage. Interaction effects show that female and tenured directors effectively leverage cash flow for greater renewable energy use, whereas expert directors do not support allocating firm financial resources to renewable energy. Additionally, while the energy efficiency policy itself does not directly influence the deployment of cash flow for renewable energy use, it encourages female directors (but not tenured and expert directors) to increase firms' use of renewable energy.

This study contributes to the literature by examining the influence of cash flow, board characteristics, and energy efficiency policy on firms' renewable energy consumption. Furthermore, we explore the interactions among these factors to identify which combinations yield the desired outcomes. We encourage firms to utilize their financial and board capital more effectively in adopting greener energy sources through relevant internal energy efficiency policies.

The paper is structured as follows: Section 2 presents the theoretical framework and hypothesis development. Section 3 describes the research methodology. Section 4 discusses the findings, while Sections 5 and 6 cover the conclusions and implications.

2. Theoretical framework and hypotheses

2.1. Operating cash flow and renewable energy consumption

Previous research indicates that businesses utilizing renewable energy sources are anticipated to experience a reduction in their energy consumption expenses (Joo & Kim, 2004). However, transitioning to renewable energy may entail additional costs, including the initial investment in renewable energy infrastructure and employee training to enhance awareness and utilization of green energy (Brunke et al., 2014; Dowell & Muthulingam, 2017). Consequently, sufficient organizational resources, especially financial flexibility, are essential for successfully adopting renewable energy (Danneels, 2008; Zhang et al., 2018; Sachan et al., 2023).

Some scholars define organizational slack as the excess resources available to achieve a company's objectives (Daniel et al., 2004). Bourgeois (1981) characterizes it as a buffer of resources that allows an organization to adapt effectively to internal and external pressures for change. Possessing slack resources enables companies to initiate and implement strategic changes in response to external pressures (Li & Umair, 2023; Zhang et al., 2018). Slack resources are categorized into four primary types: financial, operational, human, and customer relations (Voss et al., 2008). Of these, financial slack is the most versatile, permitting companies to direct it towards new projects, such as initiatives for renewable energy consumption, or to convert it into other forms of slack (Dollinger, 1999). Financial slack in firms is defined as the availability of liquid assets or resources that a company can efficiently allocate or utilize without adversely impacting its daily operations (Fazzari & Petersen, 1993; Núnez Chicharro et al., 2024). This concept is part of the broader notion of organizational slack, which refers to resources within an organization that exceeds the minimum required to produce a specified level of output (Cyert & March, 1963). Adequate financial resources enable a corporation to invest in equipment and expertise to enhance its capabilities and promote energy-saving behaviors (Danneels, 2008; Zhang et al., 2018). Financial slack encompasses not only a company's excess liquidity but also potential funding from external sources, such as banks and governmental entities (Wang & Cheung, 2004), thereby reflecting a company's financial capacity.

Drawing on the existing literature and the theoretical framework of financial slack, we posit that financial slack is positively associated with a company's propensity to adopt renewable energy sources. For example, Zhang et al. (2018) identified a positive relationship between operating cash flow as a measure of financial slack and energy-saving behavior among Chinese firms. Similarly, George (2005) argues that companies with financial slack are more capable of exploring and successfully implementing effective energy-saving practices, including the adoption of green energy. Thus, we hypothesize that financial slack is significantly related to a company's adoption of renewable energy sources. The first hypothesis examined in this study is as follows:

***H1**: Operating cash flow enhances renewable energy consumption.*

2.2. Board structure and renewable energy consumption

The support from board members for green energy consumption is anticipated to lead to effective energy-saving practices, as they possess access to resources and the capability to develop policies (Blass et al., 2014). Liang and Saraf et al. (2007) and Tan et al. (2022) contend that directors reconcile external pressures with proactive practices within companies. According to the upper echelons theory and institutional theory, top management plays a pivotal role in motivating firms to adopt green energy sources in response to external pressures from key stakeholders such as the government, professional bodies, or industry competitors (Liu et al., 2014; Zhang et al., 2015; Zhang et al., 2018). The decision by firms to employ renewable energy sources is primarily influenced by the attitudes and priorities of the board of directors, who act as the main governing body of the company (Borghesi et al., 2014; Prado-Lorenzo & Garcia-Sanchez, 2010).

Board skills include essential competencies for directors to effectively manage and steer organizations, mirroring strategic needs and challenges (Hermalin & Weisbach, 1991). These skills encompass financial acumen for overseeing fiscal health (Hermalin & Weisbach, 1991), industry knowledge for grasping market dynamics (Johnson, Daily, & Ellstrand, 1996), strategic thinking for long-term planning (Zahra & Pearce, 1989), leadership for decision-making (Finkelstein & Mooney, 2003), risk management in complex environments (Tihanyi, Graffin, & George, 2014), legal compliance to uphold ethical standards, embracing diversity for broader perspectives (Adams & Ferreira, 2009), and technological insight for fostering innovation (Huse, 2007). These skills are fundamental to effective governance, strategy, and organizational success.

Previous research indicates that board characteristics such as gender diversity (Liu, 2018; Zhang et al., 2021), board tenure (Paolone et al., 2023), and board skills (Aliani, 2023) contribute to a heightened concern for environmental issues and are likely to encourage the adoption of renewable energy. Furthermore, Atif et al. (2021) suggest that female directors have a more significant impact on renewable energy consumption, especially when considering board tenure and skills in the context of the USA. These findings affirm that board characteristics, including gender diversity, tenure, and skills, are significant factors affecting firms' propensity to utilize renewable energy sources. Therefore, the second hypothesis to be examined in this study is as follows:

> ***H2****: Board gender diversity (a), board tenure (b), and board skills (c) foster renewable energy consumption.*

2.3. The moderating role of board characteristics

The involvement of companies in green energy consumption is hindered by limited financial resources unless supported by top-level management (Zhang et al., 2018). Previous studies (Berrone et al., 2013; Daniel et al., 2004; Trianni et al., 2013; Zona, 2012) have demonstrated that a firm's decision to adopt renewable energy sources requires not only sufficient financial resources but also depends on the capabilities of top managers. These managers are tasked with balancing long-term energy conservation against short-term profits. In essence, a company's ability to allocate financial resources toward promoting green energy investments is significantly influenced by the priorities and strategic vision of its top management (George, 2005). For example, if a company has ample financial resources, its directors will not be preoccupied with short-term expenses and return on investment. This attitude supports the company's investments in renewable energy consumption (Zhang et al., 2018). Therefore, we hypothesize that a company's capacity to invest its financial resources (operating cash flow) in green energy is dependent on various characteristics of the board of directors, such as gender diversity, tenure, and expertise (Liu, 2018; Atif et al., 2021). Consequently, we aim to test the following hypothesis:

> ***H3**: Cash flow stimulates more renewable energy use in firms with greater female directors (a), tenured directors (b), and expert directors (c) on the board.*

2.4. The moderating role of energy efficiency policy

The existing research body demonstrates that the energy efficiency policies implemented by companies significantly impact their overall performance and economic growth. Numerous studies, including those by Inglesi-Lotz (2016), Trotter & Brophy (2022), Wei and Gu (2021), and Zhao et al. (2021), have established this relationship. Furthermore, Yang and Song (2023) and Zhang and Kong (2022) argue that a well-designed energy efficiency policy significantly influences a company's propensity to use renewable energy sources. This perspective is supported by Liu et al. (2021), who suggest that companies are more inclined to invest their surplus funds in renewable energy sources if they have an energy efficiency policy in place. Recent findings from Chang et al. (2023) also indicate that financial flexibility enhances the adoption of renewable energy among companies with energy efficiency policies. Drawing on previous empirical evidence and the theoretical framework of financial flexibility, we posit that the relationship between cash flow and the use of renewable energy depends on the existence of an effective energy efficiency policy. Therefore, we aim to test the following hypothesis:

> ***H4**: Operating cash flow stimulates more renewable energy use in firms with energy efficiency policies.*

Furthermore, a body of previous research suggests that the extent to which top management promotes the use of renewable energy sources in their companies is greatly influenced by the implementation of energy-efficiency policies (Blass et al., 2014; Liu et al., 2014; Solnørdal & Foss, 2018; Suk et al., 2013). While it is theoretically important for top management to support the utilization of renewable energy, the successful execution of such initiatives also hinges on the adoption of energy efficiency policies (Zhang et al., 2018). These policies can encourage greater consumption of clean energy by establishing specific measures and setting short- and long-term targets (Mulholland et al., 2017). Although it is evident that the support of directors plays a significant role in the adoption of cleaner energy, we contend that the effectiveness of such support in promoting energy-saving behavior largely depends on a company's implementation of energy efficiency policies. In other words, we posit that an energy efficiency policy acts as a prerequisite for board characteristics, such as gender diversity, tenure, and expertise, to stimulate a company's consumption of renewable energy. Therefore, the fifth hypothesis we examine in this study is as follows:

> ***H5**: Board gender diversity (a), board tenure (b), and board skills (c) stimulate more renewable energy use in firms with energy efficiency policies.*

3. Research methodology

In this section, we initially explain the variables, then describe the research sample, and finally clarify the research methodology.

3.1. Variables

The extent of renewable energy use is evaluated using two indicators: the renewable energy use ratio out of total energy consumption (RERATIO)[1] and the natural logarithm of renewable energy consumption (LNRE)[2] (Atif et al., 2021; Zhang et al., 2021). These measures are commonly used in research to capture both the proportion and amount of renewable energy use. Slack financial

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[1] Following earlier studies, if a firm discloses total energy consumption but does not disclose renewable energy use, we take the latter zero (Atif et al., 2021). However, we also run a robustness test with observations having positive renewable energy data (please see the robustness tests section).
[2] We use RERATIO in the baseline analyses, and LNRE in the robustness tests.

resources are measured using the cash flow from operations scaled by total assets. This measure reflects a firm's ability to generate internal cash from its core operations (Velury & Jenkins, 2006; Wasiuzzaman et al., 2022). Board attributes are assessed using three indicators: board gender diversity (BDIVERSITY), board tenure (BTENURE), and board skills (BSKILLS). These characteristics influence corporate strategies, with board gender diversity indicating the representation of women on the board, board tenure representing the average duration of board service, and board skills reflecting directors' financial and/or sector-specific expertise (Amorelli & García-Sánchez, 2020; Vafaei et al., 2020). The presence of an energy efficiency policy is represented by a binary variable, taking the value of one if the policy exists and zero if not (Gómez-Bolaños et al., 2020; Aslam et al., 2021).

Additionally, we control various firm characteristics. These include the existence of energy efficiency policies (EEFFICIENCY), the size of the board of directors (BSIZE), the independence of the board (BINDEPEND), whether the CEO holds dual roles (CEODUALITY), the intensity of research and development activities (RD), the size of the company (FSIZE), the return on assets (ROA), the level of financial leverage (LEVERAGE), and the percentage of shares available for trading (FFLOAT) as an indicator of the ownership structure (Atif et al., 2021; Zhang et al., 2021; Uyar et al., 2022). The size of the board (BSIZE) may have an impact on the board's effectiveness in decision-making, while the independence of the board (BINDEPEND) is crucial for its ability to monitor the company's activities. The presence of CEO duality (CEODUALITY) reflects the CEO's power and influence in shaping the company's decisions. Moreover, the level of research and development activities (RD) demonstrates the company's capacity for innovation and investment in renewable energy and other ecological solutions. The size of the company (FSIZE) indicates a firm’s ability to benefit from economies of scale, while the return on assets (ROA) is an important measure of financial performance that could incentivize companies to adopt renewable energy practices. Financial leverage (LEVERAGE) refers to the use of external funds that can facilitate the procurement and utilization of equipment for renewable energy production and use. Additionally, the percentage of shares available for trading (FFLOAT) reflects the ownership structure and the influence of shareholders in decision-making, including decisions related to renewable energy consumption. Lastly, we account for the institutional environment by considering the Worldwide Governance Indicators (WGI), a comprehensive measure of public governance quality, which comprises six metrics. The quality of the institutional environment can encourage companies to prioritize renewable energy sources over fossil fuels and promote ecological transformations. We obtained all company-level data from Thomson Reuters Eikon, while WGI data was obtained from the World Bank (2021). Detailed definitions of the research variables can be found in Table 1.

INSERT TABLE 1 HERE

3.3. Sampling process

The research period selected for this study was from 2002 to 2019 because data on renewable energy consumption were only available starting from the early 2000s in the Thomson Reuters Eikon database. The data were capped in 2019 as it was the latest year for which the data were accessible at the time of designing the study. The research sample excluded the financial sector, cases where energy use data were unavailable, and countries with less than ten firms. To ensure data quality, several preprocessing steps were undertaken after initially cleaning and refining the sample, which were necessary before testing the research hypotheses (Hair et al., 2019).

To address issues of skewness and high variability, five variables (CFLOW, BSIZE, RD, ROA, and LEVERAGE) were adjusted through winsorization at the one percent level of the two tails (Cox, 2006) based on the initial descriptive statistics. Additionally, potential significant outliers were identified and removed using the Minimum Covariance Determinant method (Verardi & Dehon, 2010), removing 21 outliers from the research sample. Furthermore, a missing value analysis was conducted, revealing that some variables had missing values of less than five percent, which were considered inconsequential (Schafer, 1999) and were not expected to introduce any estimation bias in the analysis (Bennett, 2001)[3]. In the last stage of the data screening process, we address the issue of missing observations in the mentioned variables by employing the Markov Chain Monte Carlo technique for imputation.

The initial research sample consisted of 59,194 observations. However, specific observations were excluded from the analysis, including the financial sector (13,333 records), non-available energy use data (27,902 records), countries with fewer than ten firms (185 records), and significant multivariate outliers (21 records). After these exclusions, the final sample comprised 17,753 records, as shown in Table 2, Panel A.

To examine the distribution of the sample, the researchers analyzed it at different levels: sector level, year level, and country level. At the sector level (Table 2, Panel B), the ratios varied from 4.21% (Telecommunications services) to 22.43% (Industrials). At the year level, covering the period from 2002 to 2019, the ratios ranged from 0.29% in 2002 to 12.89% in 2019 (Table 2, Panel B). Finally, at the country level (Table 2, Panel C), the research sample consisted of 39 countries, with 2,647 unique firms and 17,753 data points. The majority of firms were from the USA (18.10%), Hong Kong (6.31%), and the UK (6.27%). Regarding data points, 17.20% were from the USA, 16% were from Japan, and 7.58% were from the UK.

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[3] The missing value analysis reveals that BTENURE had 2.95%, BDIVERSITY had 1.12%, BSIZE had 0.24%, BSKILLS had 2.23%, FFLOAT had 0.76%, LEVERAGE had 0.13%, FSIZE had 0.13%, BINDEPEND had 1.99%, RD had 0.20%, ROA had 0.45%, and WGI had 0.21% missing observations.

INSERT TABLE 2 HERE

3.4. Research models

The proposed research models utilize a regression approach incorporating fixed-effects (FE) for county, industry, and year. Employing a country, industry, and year FE approach can yield various benefits. First, our sample encompasses observations with country-, industry-, and year-specific levels. In addition, this approach addresses the potential problem of time-invariant endogeneity, which can arise due to omitted variable bias (Schons & Steinmeier, 2016; Rjiba et al., 2020). By employing the FE regression model approach, there is a potential reduction in the risk of multicollinearity (Baltagi, 2005), estimation bias (Baltagi, 2005), and omitted variable bias (Wooldridge, 2010). Equation (1) presents the formulation of the proposed research models. Furthermore, we account for heterogeneity by controlling for country, industry, and year-based heterogeneity (Gujarati, 2014), wherein each entity has its intercept. To capture the country, industry, and year FE, we introduced country, industry, and year variables as dummy variables, as illustrated in Equation (1), using the Least Squares Dummy Variable (LSDV) method (Gujarati, 2014). This method effectively captures the data's time series and cross-sectional dimensions while addressing country, industry, and year-specific heterogeneity.

$$(Y)_{i,t,c} = \beta_0 + \beta_1(X)_{i,t,c} + \beta_2(Controls)_{i,t,c} + \beta_3\sum(Country)_c + \beta_4\sum(Industry)_i + \beta_5\sum(Year)_t + \varepsilon_{i,t,c} \quad (1)$$

Equation (1) introduces a framework where we propose a dependent variable, as well as testing variables and control variables. The dependent variable, labelled as RERATIO or the "Y" term, is of particular interest. We also consider the testing variables CFLOW (to test H1) and three board characteristics (BDIVERSITY, BTENURE, and BSKILLS) (to test H2), referred to as the "X" term. Additionally, there are several control variables to account for potential influences, namely EEFFICIENCY, BSIZE, BINDEPEND, CEODUALITY, RD, FSIZE, ROA, LEVERAGE, FFLOAT, WGI, and EEFFICIENCY[4].

Moderation effects: Moreover, the proposed research models examine the moderating models, which are specified in Equation (2) as follows:

$$(Y)_{i,t,c} = \beta_0 + \beta_1(X)_{i,t,c} + \beta_2(M)_{i,t,c} + \beta_3(X*M)_{i,t,c} + \beta_4(Controls)_{i,t,c} + \beta_5\sum(Country)_c + \beta_6\sum(Industry)_i + \beta_7\sum(Year)_t + \varepsilon_{i,t,c} \quad (2)$$

Equation (2) investigates the relationship between the dependent variable RERATIO (represented as "Y") and the testing variables of interest (referred to as "X") as well as the moderators (referred to as "M"). The study examines the moderating effects of three board characteristics (BDIVERSITY, BTENURE, and BSKILLS) on the relationship between CFLOW and RERATIO to test hypothesis H3. Additionally, the moderating effect of EEFFICIENCY on the relationship between CFLOW and RERATIO is analyzed to test hypothesis H4. Moreover, hypothesis H5 examines the moderating effect of EEFFICIENCY on the relationship between the three board attributes (BDIVERSITY, BTENURE, and BSKILLS) and RERATIO. The study also includes several control variables: BSIZE, BINDEPEND, CEODUALITY, RD, FSIZE, ROA, LEVERAGE, FFLOAT, and WGI. To address concerns regarding heteroscedasticity, robust standard errors are reported using country clustering in the regression models analysis, following the approach outlined by Wooldridge (2020).

[4] EEFFICIENCY is also used as a control variable when CFLOW, BDIVERSITY, BTENURE, and BSKILLS are incorporated as the testing variables of interest.

4. Findings

4.1. Summary statistics

Table 3 presents the descriptive statistics for the research variables. The findings indicate that the average value for RERATIO is 0.03 (with a range between 0 and 1), and the average value for LNRE is 2.39 (with a range between 0 and 19.23). Concerning the variables of interest in the study, the estimated average for CFLOW is 0.09. Additionally, the average values for the three board attributes are as follows: BDIVERSITY has an average of 15.04, BTENURE has an average of 50.46, and BSKILLS has an average of 49.72. Finally, it is worth noting that 88% of the observations have an established EEFFICIENCY.

INSERT TABLE 3 HERE

4.2. Correlation coefficients

Table 4 presents the correlation coefficients obtained using Pearson's method, which assesses the relationship between two variables. The results indicate that CFLOW, BDIVERSITY, and EEFICIENCY are positively correlated with both RERATIO and LNRE, and these correlations are statistically significant. On the other hand, BSKILLS is negatively correlated with both RERATIO and LNRE, and these correlations are also statistically significant. In contrast, there is no significant linear correlation between BTENURE and RERATIO, as well as LNRE.

INSERT TABLE 4 HERE

Multicollinearity: We additionally examine whether there is any multicollinearity among the independent variables used in our research models. To determine this, we calculate the Variance Inflation Factor (VIF) values. Our findings indicate that the VIF values range from 1.03 to 1.51, considerably lower than the recommended threshold of 10 (Neter et al., 1996; Kennedy, 2008;

Hair et al., 2019). Thus, the results affirm that there is no significant concern about multicollinearity.

4.3. Baseline analysis

The findings are presented in Table 5, where we analyze the direct connections using a regression analysis that incorporates country, industry, and year FE. The outcomes demonstrate that CFLOW, BDIVERSITY, and EEFFICIENCY positively and significantly correlate with RERATIO. On the other hand, BSKILLS displays a negative and significant relationship with RERATIO, while BTENURE does not show any significant association with RERATIO. Consequently, our results support hypotheses H1 (cash flow and renewable energy use) and H2a (board gender diversity and renewable energy use). Still, they refute hypotheses H2b and H2c (board tenure and skills and renewable energy use, respectively).

INSERT TABLE 5 HERE

Moderation analysis: the study explores two different sets of moderating effects by conducting a regression analysis incorporating country, industry, and year FE (Table 6). Firstly, we investigate the influence of three board characteristics (BDIVERSITY, BTENURE, and BSKILLS) on the relationship between CFLOW and RERATIO. The findings indicate that the coefficients of the interaction terms, specifically CFLOW*BDIVERSITY and CFLOW*BTENURE, are significantly positive. However, the coefficient of the interaction term CFLOW*BSKILLS is significantly negative. This means that cash flow promotes the use of renewable energy in firms with a higher proportion of female directors and directors with longer tenures. However, it does not stimulate the adoption of renewable energy in firms with directors who possess more expertise.

Secondly, the study examines the moderating effect of EEFFICIENCY on the relationship between CFLOW and three board structures (BDIVERSITY, BTENURE, and BSKILLS) about RERATIO. The results indicate that the coefficient of the interaction term BDIVERSITY*EEFFICIENCY is significantly positive, while the coefficient of the interaction term BSKILLS*EEFFICIENCY is significantly negative. However, the interaction terms CFLOW*EEFFICIENCY and BTENUR*EEEFFICIENCY are not statistically significant. Therefore, the findings support hypothesis H5a but do not support hypotheses H4, H5b, and H5c. In other words, while having a diverse gender composition on the board encourages the use of renewable energy in firms with energy efficiency policies, board tenure, board skills, and cash flow do not significantly impact renewable energy adoption in firms with energy efficiency policies.

INSERT TABLE 6 HERE

4.4. Robustness checks

We assess the robustness and reliability of the initial analysis findings through a series of rigorous tests. These tests involve trying alternative dependent variable, addressing potential issues of endogeneity, and examining an alternative data set to ensure consistency.

Alternative dependent variable: The researchers have thoroughly re-evaluated the linear associations and moderating models using the LNRE as the alternative dependent variable (Table 7 and Table 8). Their findings indicate that even with this change in the dependent variable, the results regarding the linear associations and moderating effects remain consistent and valid. This demonstrates the robustness and stability of the initial findings.

INSERT TABLE 7 HERE

INSERT TABLE 8 HERE

Endogeneity: To address the problem of endogeneity, various methodologies have been employed, namely the Two-Stage Least Squares (2SLS) regression analysis, Entropy balancing approach, Propensity score matching (PSM), Two-Step Generalized Method of Moments (GMM)-based Dynamic Panel regression method, and inclusion of the one-year lag of testing variables of interest. These approaches aim to mitigate potential endogeneity issues such as omitted variable bias and reverse causality (Wooldridge, 2010; Godos-Díez et al., 2018; Wooldridge, 2020).

Initially, we utilized the 2SLS regression analysis, which is commonly employed in accounting research, to minimize the possibility of inconsistent parameter estimation resulting from endogeneity (Larcker and Rusticus, 2010). Table 9 presents the results of the first stage, second stage, Wu-Hausman test of endogeneity, overidentifying restriction test, and weak instrument test. In the first stage, we evaluated the relationship between the instrumental and endogenous variables. To this end, we employed the one-year lag of testing variables of interest and the industry average of testing variables of interest, excluding the focal firms as instrumental variables. Prior literature posits that the lag of testing variables as instruments meets the relevancy and exclusion criteria since while the correlation between the lag of testing variables and contemporaneous testing variables should be high, the correlation between lag of testing variables and contemporaneous renewable energy variables should be weak (Schreck, 2011 Gupta, 2018). The industry average of testing variables as instrumental variables is also likely to meet both relevancy and exclusion criteria (Cai et al., 2011; Oikonomou et al., 2020; Banerjee et al., 2022). A firm's cash flow, board structure, and energy efficiency policy in a specific industry might be influenced by other firms' cash flow, board structure, and energy efficiency policy in the same industry (relevancy condition). The industry average of testing variables is also unlikely to be endogenous to the firm's renewable energy use (the exclusion restriction). Hence, we used the following instrumental variables: CFLOW(t-1), CFLOW-IndAve, BDIVERSITY(t-1), BDIVERSITY-IndAve, BTENURE(t-1), BTENURE-IndAve, BSKILLS(t-1), BSKILLS-IndAve, EEFFICIENCY(t-1), and EEFFICIENCY-IndAve.

We formulated the first stage using Equation (3), where "X" represents the endogenous variables, while "Z" denotes the instrumental variables.

$$(X)_{i,t,c} = \beta_0 + \beta_1(Z)_{i,t,c} + \beta_2(Controls)_{i,t,c} + \beta_3\sum(Country)_c + \beta_4\sum(Industry)_i + \beta_5\sum(Year)_t + \varepsilon_{i,t,c}$$

(3)

The results of the first stage indicate that the instrumental variables are significantly associated with the endogenous variables (CFLOW, BDIVERSITY, BTENURE, BSKILLS, and EEFFICIENCY), even after controlling for all other relevant variables. This suggests that the relevance of the instrumental variables is satisfied.

In the second stage, the predicted values from the first stage serve as the independent variable in the main regression equation. We conduct the second stage using the country, industry, and year FE regression for the renewable energy use ratio out of total energy consumption (RERATIO) as the dependent variable, incorporating the predicted values alongside other exogenous variables. We formulated the second stage using Equation (4), where "$X_{predicted}$" represents the predicted values obtained from the first stage. The dependent variable "Y" and the control variables remain consistent across both stages."

$$(Y)_{i,t,c} = \beta_0 + \beta_1(X_{predicted})_{i,t,c} + \beta_2(Controls)_{i,t,c} + \beta_3\sum(Country)_c + \beta_4\sum(Industry)_i + \beta_5\sum(Year)_t + \varepsilon_{i,t,c}$$

(4)

Furthermore, we present the results of the post-estimation tests. Specifically, the findings of the Durbin-Wu-Hausman test for endogeneity suggest that CFLOW(t-1), CFLOW-IndAve, BDIVERSITY(t-1), BDIVERSITY-IndAve, BTENURE(t-1), BTENURE-IndAve, BSKILLS(t-1), BSKILLS-IndAve, EEFFICIENCY(t-1), and EEFFICIENCY-IndAve are endogenous regressors. Secondly, the results of the overidentifying restrictions test indicate the validity of the employed instruments. Additionally, the weak instrument test results demonstrate that the instruments are not weak, as the test statistics values significantly exceed the suggested threshold of 10.

The findings of the second stage support the initial baseline analysis findings. More specifically, the results for instrumented cash flow, board attributes, and energy efficiency policies are qualitatively in line with the baseline findings.

INSERT TABLE 9 HERE

Second, we employ Entropy balancing to reduce variations among variables in the treatment and control groups (Hainmueller & Xu, 2013). This technique involves adjusting the dataset weights to create a more balanced sample (Hainmueller, 2012). Considering recent scholarly works, we utilize Entropy balancing to tackle the potential endogeneity issue arising from omitted variable bias (Garcia, de Villiers, & Li, 2021). To form the treatment groups, we assign a value of one to the top quartile observations of the relevant testing variables (CFLOW, BDIVERSITY, BTENURE, BSKILLS, & EEFFICIENCY). Similarly, the control groups are created by assigning a value of zero to the remaining observations of these variables. We then rerun the linear baseline research models using the Entropy balancing method (Table 10). The results obtained align with those of the initial analysis.

INSERT TABLE 10 HERE

Third, we utilize the PSM methodology (Leuven and Sianesi, 2003) to tackle the endogeneity issue. Similarly, we create control and treatment groups by selecting individuals from the upper quartiles of the variables we are examining for the PSM analysis. Furthermore, we re-evaluate the initial research models using the PSM approach (Table 11). The findings obtained from the baseline models remain consistent even after incorporating the PSM approach.

INSERT TABLE 11 HERE

Fourth, we analyze the initial research models using a methodology called Two-Step GMM-based dynamic panel regression analysis (Table 12). The findings mostly align with the original baseline analysis results, with one notable exception: BTENURE exhibits a significant positive effect in this robustness test, whereas it did not show such significance in the initial analysis.

INSERT TABLE 12 HERE

Fifty, to address the issue of reverse causality and minimize the potential impact of endogeneity, we address a one-year lag in the testing variables of interest in our research models. This approach aims to prevent a decrease in the correlation between the predictors and the error term. The findings in Table 13 align with the initial results obtained from the contemporary models used as a baseline.

INSERT TABLE 13 HERE

Alternative sample: For the final robustness check, we constructed an alternative sample consisting of observations characterized by positive RERATIO. We then revisited and analyzed our original research models using this alternative sample (Table 14). The results obtained from this analysis partially align with the initial baseline analysis. The coefficients for CFLOW and

BDIVERSITY remain significantly positive, consistent with the baseline findings. However, in the robustness check, the coefficients for BSKILLS and EEFFICIENCY no longer exhibit statistical significance, whereas, in the baseline analysis, they were found to be negatively and positively significant, respectively.

INSERT TABLE 14 HERE

Overall, the findings survive after several robustness tests incorporating alternative dependent variables, endogeneity concerns, and alternative samples.

5. Conclusions and policy implications

While several studies have examined the drivers and consequences of renewable energy use at the country level (Doytch and Narayan, 2016; Inglesi-Lotz, 2016; Fan and Hao, 2020), there is a lack of research focusing on firm-level analysis (Atif et al., 2021; Zhang et al., 2021). Although these macro studies can provide valuable insights for developing policies to promote renewable energy consumption, they do not directly address the implications for firms' management and practices. Therefore, our objective is to bridge this gap by investigating the influence of cash flow, board characteristics, and energy efficiency policies on firms' adoption of renewable energy. Additionally, we explore how these factors interact to identify the specific combinations that lead to increased usage of greener energy sources.

5.1. Conclusions

Our findings highlight the critical role of operating cash flow in facilitating firms' renewable energy use. However, the impact of board characteristics on renewable energy use varies. While board gender diversity encourages the use of renewable energy, board skills have a discouraging effect. On the other hand, board tenure does not significantly influence renewable energy use. Moreover, the presence of an energy efficiency policy stimulates the utilization of renewable energy sources. When considering the interaction effects, we find that female directors and those with longer tenures are instrumental in leveraging firm cash flow to promote greater renewable energy use. However, expert directors do not contribute to deploying firm financial resources for renewable energy use. Furthermore, while the energy efficiency policy does not directly drive the allocation of firm financial resources, it does stimulate female directors. Still, not tenured or expert directors embrace renewable energy sources.

Our findings reinforce the importance of having sufficient financial resources to support renewable energy use (Danneels, 2008; Zhang et al., 2018). Furthermore, the positive influence of board gender diversity on renewable energy use aligns with previous research (Liu, 2018; Atif et al., 2021; Zhang et al., 2021). In contrast, the insignificant role of board tenure in renewable energy adoption is consistent with Aliani (2023) but contradicts Paolone et al. (2023). However, it should be noted that Aliani (2023) and Paolone et al. (2023) focused on carbon emissions and environmental performance rather than exclusively examining renewable energy use. Consequently, further investigations are required to clarify the role of tenured directors in environmental practices. Additionally, the negative association between board skills and renewable energy use aligns with Galletta et al. (2022) but conflicts with Aliani (2023). This discrepancy may be attributed to skilled and expert directors' more significant emphasis on financial performance, as Galletta et al. (2022) suggested. Moreover, our findings underscore that the decision to adopt greener energy sources not only necessitates ample financial resources but also relies on the capabilities and commitments of top managers (Berrone et al., 2013; Daniel et al., 2004; Trianni et al., 2013; Zona, 2012) as well as the development of energy efficiency policies (Mulholland et al., 2017).

5.2. Theoretical, managerial, and policymaking implications

The findings of this study have theoretical implications. Firstly, they provide support for the slack financial resources theory and highlight the synergetic effects of combining slack financial resources with upper-echelon theories (Wasiuzzaman et al., 2022). However, the upper echelons theory alone only partially explains renewable energy use (Atif et al., 2021). Moreover, while the presence of female directors supports renewable energy use, it does not hold for tenured and expert directors. Interestingly, as an internal policy instrument, energy efficiency policy stimulates female directors but not tenured and expert directors. This difference could be attributed to the ethical and rule-compliant nature often associated with women (Zalata et al., 2019). Thus, our findings indicate the utility and necessity of interplay between financial slack, monitoring mechanisms, and internal policymaking for cleaner energy transition.

The findings also suggest several managerial implications for better use of cash resources, mobilizing board capital, and formulating essential policies for renewable energy transition. First, as renewable energy production and use may necessitate changing the firms' operations, it may require an investment and cash outlay. Considering our financial slack proxy, our findings highlight the importance of the cash flow-generating ability of firms out of their core operating activities for greater energy use. Second, as corporate boards are the main decision-making body, their composition matters for renewable energy use. Hence, we suggest firms shape their corporate boards accordingly. It is evident that female directors are of paramount importance for cleaner energy use; on the contrary, expert (i.e., financial or sector) directors are, in any case, against the transition to renewable energy. Tenured directors are beneficial in supporting renewable energy use with the existence of an energy efficiency policy. Third, formulating an internal energy efficiency policy is undoubtedly helpful in mobilizing board capital for energy transition.

Eventually, managers might develop their genuine roadmap for greater renewable energy use by considering the interplay of three pillars on which we focus.

Policymaking implications are that financial sustainability (i.e., generating cash), female directors, and energy efficiency policy are critical for the transition to cleaner energy resources. Thus, policymakers might devise regulations reinforcing firms' financial stability and supervise the market with essential organisms. Second, corporate governance codes and market regulations might suggest companies reshape their corporate boards with more female directors as they are helpful in energy transition. Third, as energy efficiency policy is applicable in better mobilizing board capital for greater energy use, policymakers might encourage firms to formulate policies that detail clean energy production and consumption, considering firms' availabilities and operational processes.

5.3. Limitations and future research avenues

It is essential to exercise caution when generalizing the results of this study to specific sectors or countries since sectoral tendencies and country-specific regulations may influence firms' renewable energy use. The binary nature of our renewable energy policy proxy limits its assessment of policy depth. Future firm-level studies could explore additional factors that positively or negatively influence firms' renewable energy use. For instance, examining firm-level corporate social responsibility practices, environmental mechanisms, and the influence of national cultures, such as long-term orientation and masculinity, may shed further light on firms' renewable energy use. Furthermore, additional research is necessary to validate our findings in environments with distinct institutional characteristics. This includes economies abundant in natural resources yet facing financial constraints, exemplified by the context of Sub-Saharan Africa. Such research would further elucidate the relationship between financial slack, energy efficiency strategies, and renewable energy consumption in corporations. Finally, it would also be insightful to perform a case study to highlight the practicality of the research model and help firms understand how slack financial resources, board attributes, and energy efficiency policy may help more renewable energy use in firms.

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Table 1: Variables

Variable	
RERATIO	Total renewable energy consumption as a ratio of total energy consumption.
LNRE	Natural logarithm of the total renewable energy use in gigajoules.
CFLOW	Cash flow from operations scaled by total assets.
BDIVERSITY	Percentage of women directors on boards.
BTENURE	Average number of years each board member has been on the board.
BSKILLS	Percentage of board members with either an industry-specific or financially solid background.
EEFFICIENCY	An indicator variable showing the existence of a company's energy efficiency policy, including various processes/mechanisms/procedures to improve energy use efficiently. It is an indicator variable.
BSIZE	Number of members the company has on board.
BINDEPEND	Percentage of non-executive directors on boards.
CEODUALITY	CEO duality takes 1 if the chairperson and CEO are the same person and 0 if not.
RD	Research and development expenditure scaled by total assets.
FSIZE	Total assets' natural logarithm.
ROA	Earnings before interest and tax scaled by total assets.
LEVERAGE	Total assets scale total debt.
FFLOAT	Free float percentage of shares tradeable by shareholders.
WGI	The mean of six Worldwide Governance Indicators includes government effectiveness, control of corruption, rule of law, voice and accountability, political stability and absence of violence/terrorism, and regulatory quality (All indicators' values range between -2.5 and 2.5).

This table presents the variable definitions.

Table 2: Sample distributions

Panel A:

Initial sample	59,194
(-) Financial sector	13,333
(-) Observations with missing energy use data	27,902
(-) Countries with less than ten firms	185
(-) Multivariate outliers	21
Final Sample	*17,753*

Panel B:

Variable	Category	Freq.	Percent
	Basic Materials	3,133	17.65
	Consumer Cyclicals	2,857	16.09
	Consumer Non-Cyclicals	1,728	9.73
	Energy	1,420	8.00
	Healthcare	1,242	7.00
	Industrials	3,982	22.43
	Technology	1,678	9.45
	Telecommunications Services	748	4.21
	Utilities	965	5.44
	Total	*17,753*	*100.00*
Year	2002	51	0.29
	2003	75	0.42
	2004	127	0.72
	2005	213	1.20
	2006	272	1.53
	2007	485	2.73
	2008	635	3.58
	2009	786	4.43
	2010	941	5.30
	2011	1,083	6.10
	2012	1,207	6.80
	2013	1,287	7.25
	2014	1,356	7.64
	2015	1,427	8.04
	2016	1,579	8.89
	2017	1,837	10.35
	2018	2,103	11.85
	2019	2,289	12.89
	Total	*17,753*	*100.00*

Panel C:

	Country	Unique firms	Percent	Data points	Percent
1	Argentina	12	0.45	27	0.15
2	Australia	106	4.00	691	3.89
3	Austria	22	0.83	120	0.68
4	Belgium	21	0.79	154	0.87
5	Brazil	55	2.08	361	2.03
6	Canada	100	3.78	683	3.85
7	Chile	19	0.72	109	0.61
8	China	102	3.85	317	1.79
9	Colombia	13	0.49	61	0.34
10	Denmark	30	1.13	203	1.14
11	Finland	31	1.17	277	1.56
12	France	111	4.19	935	5.27
13	Germany	98	3.70	686	3.86
14	Greece	12	0.45	70	0.39
15	Hong Kong	167	6.31	571	3.22
16	India	64	2.42	396	2.23
17	Indonesia	19	0.72	121	0.68
18	Italy	67	2.53	336	1.89
19	Japan	282	10.65	2,840	16.00
20	Korea; Republic (S. Korea)	64	2.42	507	2.86
21	Malaysia	37	1.40	170	0.96

22	Mexico	25	0.94	169	0.95
23	Netherlands	33	1.25	285	1.61
24	New Zealand	13	0.49	58	0.33
25	Norway	35	1.32	207	1.17
26	Philippines	12	0.45	47	0.26
27	Poland	20	0.76	82	0.46
28	Portugal	14	0.53	74	0.42
29	Russia	30	1.13	219	1.23
30	Singapore	23	0.87	113	0.64
31	South Africa	73	2.76	525	2.96
32	Spain	47	1.78	373	2.10
33	Sweden	61	2.30	435	2.45
34	Switzerland	57	2.15	424	2.39
35	Taiwan	75	2.83	434	2.44
36	Thailand	25	0.94	167	0.94
37	Turkey	27	1.02	107	0.60
38	United Kingdom	166	6.27	1,346	7.58
39	United States of America	479	18.10	3,053	17.20
	Total	*2,647*	*100.00*	*17,753*	*100.00*

This table presents sample construction and distribution across sectors, periods, and countries.

.

Table 3: Descriptive statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
RERATIO	17,753	0.03	0.12	0.00	1.00
LNRE	17,753	2.39	5.07	0.00	19.23
CFLOW	17,753	0.09	0.05	-0.37	0.35
BDIVERSITY	17,753	15.04	13.20	0.00	85.71
BTENURE	17,753	50.46	26.32	0.09	99.89
BSKILLS	17,753	49.72	22.67	0.00	100.00
EEFFICIENCY	17,753	0.88	0.32	0.00	1.00
BSIZE	17,753	11.02	3.44	4.00	21.00
BINDEPEND	17,753	73.08	24.07	0.00	100.00
CEODUALITY	17,753	0.37	0.48	0.00	1.00
RD	17,753	0.01	0.03	0.00	0.27
FSIZE	17,753	22.82	1.40	15.98	27.41
ROA	17,753	0.08	0.07	-0.37	0.36
LEVERAGE	17,753	0.26	0.16	0.00	0.83
FFLOAT	17,753	75.33	25.74	0.00	100.00
WGI	17,753	1.08	0.63	-0.83	1.97

This table presents the descriptive statistics.

Table 4: Correlation

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	RERATIO	1															
2	LNRE	0.635*	1														
3	CFLOW	0.062*	0.038*	1													
4	BDIVERSITY	0.167*	0.187*	0.094*	1												
5	BTENURE	0.005	0.001	0.057*	-0.035*	1											
6	BSKILLS	-0.093*	-0.119*	0.003	-0.216*	0.045*	1										
7	EEFFICIENCY	0.057*	0.107*	0.036*	0.092*	0.01	-0.056*	1									
8	BSIZE	0.017*	0.099*	-0.060*	-0.015*	-0.017*	-0.098*	0.098*	1								
9	BINDEPEND	0.094*	0.139*	0.073*	0.414*	-0.031*	-0.466*	0.008	-0.022*	1							
10	CEODUALITY	-0.040*	-0.002	0.013	-0.031*	0.106*	0.091*	0.016*	0.090*	-0.063*	1						
11	RD	0.040*	0.050*	0.041*	-0.020*	0.027*	0.077*	-0.004	-0.058*	-0.015*	0.109*	1					
12	FSIZE	0.042*	0.173*	-0.080*	-0.015	-0.038*	-0.034*	0.152*	0.417*	0.012	0.149*	-0.016*	1				
13	ROA	0.036*	0.033*	0.550*	0.106*	0.095*	-0.017*	0.013	-0.067*	0.136*	0.014	0.040*	-0.108*	1			
14	LEVERAGE	0.043*	0.052*	-0.091*	0.035*	-0.066*	-0.066*	0.022*	0.105*	0.072*	0.019*	-0.186*	0.195*	-0.174*	1		
15	FFLOAT	-0.015*	0.036*	-0.031*	0.087*	0.021*	0.163*	-0.054*	-0.029*	-0.041*	0.110*	0.167*	0.082*	-0.001	0.002	1	
16	WGI	0.029*	0.044*	-0.050*	0.178*	0.005	0.080*	-0.063*	-0.085*	0.031*	0.011	0.139*	0.01	-0.060*	-0.071*	0.448*	1

This table presents the correlation analysis. *p<0.05

Table 5: Cash flow, board attributes, and renewable energy use

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
CFLOW	0.083***				
	(3.94)				
BDIVERSITY		0.00081***			
		(8.46)			
BTENURE			0.000019		
			(0.55)		
BSKILLS				-0.00015***	
				(-2.98)	
EEFFICIENCY	0.0054*	0.0043	0.0054*	0.0053*	0.0054*
	(1.80)	(1.43)	(1.80)	(1.77)	(1.80)
BSIZE	0.00067**	0.00058*	0.00069**	0.00062*	0.00069**
	(2.04)	(1.77)	(2.09)	(1.87)	(2.09)
BINDEPEND	-0.00034***	-0.00039***	-0.00034***	-0.00040***	-0.00034***
	(-4.94)	(-5.62)	(-4.88)	(-5.62)	(-4.96)
CEODUALITY	-0.0043**	-0.0047**	-0.0042*	-0.0039*	-0.0041*
	(-2.04)	(-2.20)	(-1.95)	(-1.85)	(-1.91)
RD	0.25***	0.26***	0.26***	0.26***	0.26***
	(6.64)	(7.00)	(6.83)	(6.97)	(6.83)
FSIZE	0.0055***	0.0050***	0.0055***	0.0055***	0.0055***
	(6.83)	(6.22)	(6.78)	(6.80)	(6.78)
ROA	0.0071	0.035**	0.042***	0.042***	0.043***
	(0.43)	(2.55)	(3.04)	(3.07)	(3.08)
LEVERAGE	0.0089	0.0096	0.0090	0.0088	0.0089
	(1.48)	(1.59)	(1.49)	(1.47)	(1.48)
FFLOAT	-0.000038	-0.000061	-0.000042	-0.000044	-0.000041
	(-0.81)	(-1.31)	(-0.90)	(-0.94)	(-0.88)
WGI	0.0060	0.0072*	0.0057	0.0062	0.0057
	(1.40)	(1.67)	(1.31)	(1.43)	(1.32)
Constant	-0.17***	-0.14***	-0.17***	-0.16***	-0.17***
	(-5.29)	(-4.25)	(-5.17)	(-4.81)	(-5.15)
Country, industry, & year FE	Y	Y	Y	Y	Y
N	17753	17753	17753	17753	17753
R^2	0.12	0.12	0.12	0.12	0.12
Adj. R^2	0.118	0.121	0.117	0.118	0.117
F-stat.	33.15***	34.01***	32.92***	33.05***	33.37***

This table presents the association between cash flow and board attributes and renewable energy use based on country, industry, & year FE. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Moderation analysis

Table 6: Moderation effects of BDIVERSITY, BTENURE, BSKILLS, & EFFICIENCY

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO	(6) RERATIO	(7) RERATIO
CFLOW	-0.076**	-0.044	0.20***	0.011			
	(-2.55)	(-1.16)	(4.63)	(0.23)			
BDIVERSITY	-0.000049				0.000022		
	(-0.33)				(0.09)		
EEFFICIENCY	0.0042	0.0054*	0.0053*	-0.0016	-0.0063	0.011*	0.020***
	(1.42)	(1.82)	(1.79)	(-0.29)	(-1.51)	(1.90)	(2.79)
BTENURE		-0.00021***				0.00013	
		(-3.16)				(1.28)	
BSKILLS			0.000060				0.000089
			(0.71)				(0.76)
CFLOW*BDIVERSITY	0.0092***						
	(7.35)						
CFLOW*BTENURE		0.0025***					
		(4.03)					
CFLOW*BSKILLS			-0.0024***				
			(-3.08)				
CFLOW*EEFFICIENCY				0.081			
				(1.54)			
BDIVERSITY*EEFFICIENCY					0.00087***		
					(3.64)		
BTENURE*EEFFICIENCY						-0.00012	
						(-1.16)	
BSKILLS*EEFFICIENCY							-0.00028**
							(-2.25)
BSIZE	0.00053	0.00064*	0.00061*	0.00068**	0.00057*	0.00068**	0.00061*
	(1.62)	(1.94)	(1.84)	(2.06)	(1.75)	(2.08)	(1.84)
BINDEPEND	-0.00037***	-0.00034***	-0.00040***	-0.00034***	-0.00039***	-0.00034***	-0.00041***
	(-5.41)	(-4.91)	(-5.54)	(-4.95)	(-5.64)	(-4.91)	(-5.69)
CEODUALITY	-0.0048**	-0.0044**	-0.0042**	-0.0043**	-0.0047**	-0.0042*	-0.0039*
	(-2.28)	(-2.08)	(-1.97)	(-2.02)	(-2.20)	(-1.94)	(-1.85)
RD	0.25***	0.24***	0.26***	0.25***	0.26***	0.26***	0.26***
	(6.59)	(6.46)	(6.86)	(6.62)	(7.02)	(6.84)	(6.99)
FSIZE	0.0051***	0.0056***	0.0055***	0.0055***	0.0050***	0.0055***	0.0055***
	(6.31)	(6.93)	(6.82)	(6.80)	(6.17)	(6.79)	(6.80)
ROA	-0.0059	0.0060	0.0052	0.0070	0.035**	0.042***	0.043***
	(-0.36)	(0.36)	(0.32)	(0.43)	(2.52)	(3.00)	(3.11)
LEVERAGE	0.0080	0.0093	0.0086	0.0087	0.0098	0.0089	0.0088
	(1.33)	(1.55)	(1.43)	(1.44)	(1.63)	(1.48)	(1.47)
FFLOAT	-0.000062	-0.000040	-0.000040	-0.000035	-0.000061	-0.000042	-0.000045
	(-1.34)	(-0.85)	(-0.86)	(-0.76)	(-1.31)	(-0.90)	(-0.97)

WGI	0.0072*	0.0061	0.0060	0.0062	0.0074*	0.0058	0.0063
	(1.67)	(1.42)	(1.39)	(1.43)	(1.72)	(1.34)	(1.45)
Constant	-0.13***	-0.16***	-0.17***	-0.17***	-0.13***	-0.17***	-0.17***
	(-3.98)	(-4.96)	(-5.23)	(-5.06)	(-3.93)	(-5.28)	(-5.09)
Country, industry, & year FE	Y	Y	Y	Y	Y	Y	Y
N	17753	17753	17753	17753	17753	17753	17753
R^2	0.13	0.12	0.12	0.12	0.13	0.12	0.12
Adj. R^2	0.124	0.119	0.119	0.118	0.122	0.117	0.118
F-stat.	34.15***	32.52***	32.56***	32.74***	33.76***	32.50***	32.68***

This table presents the moderating effect of the three board characteristics between CFLOW and RERATIO, the moderating effect of EEFFICIENCY on the relationship of CFLOW and RERATIO, and the moderating effect of EEFFICIENCY on the relationship of the three board attributes and RERATIO. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Robustness checks

Table 7: Alternative dependent variable - LNRE

Independent variables	(1) LNRE	(2) LNRE	(3) LNRE	(4) LNRE	(5) LNRE
CFLOW	1.24*				
	(1.69)				
BDIVERSITY		0.032***			
		(8.51)			
BTENURE			-0.00074		
			(-0.54)		
BSKILLS				-0.0041**	
				(-2.11)	
EEFFICIENCY	0.40***	0.35***	0.40***	0.40***	0.40***
	(3.38)	(3.00)	(3.38)	(3.35)	(3.38)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y
N	17753	17753	17753	17753	17753
R^2	0.17	0.17	0.17	0.17	0.17
Adj. R^2	0.167	0.171	0.167	0.167	0.167
F-stat.	49.22***	50.37***	49.19***	49.26***	49.87***

This table presents the association between cash flow and board attributes and renewable energy use based on an alternative renewable energy proxy (LNRE). LNRE refers to the natural logarithm of the total renewable energy use in gigajoules. CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Alternative dependent variable – Moderation effects

Independent variables	(1) LNRE	(2) LNRE	(3) LNRE	(4) LNRE	(5) LNRE	(6) LNRE	(7) LNRE
CFLOW	-1.42	-1.77	4.85***	0.40			
	(-1.19)	(-1.18)	(2.82)	(0.20)			
BDIVERSITY	0.018***				-0.0084		
	(3.04)				(-0.90)		
EEFFICIENCY	0.35***	0.40***	0.40***	0.32	-0.19	0.58**	1.06***
	(3.00)	(3.39)	(3.37)	(1.48)	(-1.16)	(2.45)	(3.75)
BTENURE		-0.0061**				0.0025	
		(-2.35)				(0.64)	
BSKILLS			0.0023				0.0066
			(0.68)				(1.44)
CFLOW*BDIVERSITY	0.15***						
	(3.05)						
CFLOW*BTENURE		0.061**					
		(2.42)					
CFLOW*BSKILLS			-0.073**				
			(-2.38)				
CFLOW*EEFFICIENCY				0.96			
				(0.46)			
BDIVERSITY*EEFFICIENCY					0.045***		
					(4.74)		
BTENURE*EEFFICIENCY						-0.0037	
						(-0.89)	
BSKILLS*EEFFICIENCY							-0.013***
							(-2.58)
Controls	Included	Included	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y	Y	Y
N	17753	17753	17753	17753	17753	17753	17753
R^2	0.17	0.17	0.17	0.17	0.18	0.17	0.17
Adj. R^2	0.171	0.168	0.168	0.167	0.172	0.167	0.168
F-stat.	49.22***	48.02***	48.09***	48.57***	50.06***	48.55***	48.71***

Based on an alternative renewable energy proxy (LNRE), this table presents the moderating effect of the three board characteristics between CFLOW and RERATIO, the moderating effect of EEFFICIENCY on the relationship of CFLOW and RERATIO, and the moderating effect of EEFFICIENCY on the relationship of the three board attributes and RERATIO. While LNRE refers to the natural logarithm of the total renewable energy use in gigajoules, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Two-stage least squares (2SLS) regression analysis

Independent variables	(1) CFLOW	(2) RERATIO	(3) BDIVERSITY	(4) RERATIO	(5) BTENURE	(6) RERATIO	(7) BSKILLS	(8) RERATIO	(9) EEFFICIENCY	(10) RERATIO
	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage	1st Stage	2nd Stage
CFLOW(t-1)	0.55***									
	(86.45)									
CFLOW-IndAve	0.089***									
	(4.55)									
BDIVERSITY(t-1)			0.83***							
			(192.13)							
BDIVERSITY-IndAve			0.0022							
			(0.03)							
BTENURE(t-1)					0.87***					
					(233.36)					
BTENURE-IndAve					-0.016					
					(-0.28)					
BSKILLS(t-1)							0.55***			
							(91.23)			
BSKILLS-IndAve							-0.028			
							(-0.39)			
EEFFICIENCY(t-1)									0.62***	
									(128.16)	
EEFFICIENCY-IndAve									0.024	
									(0.55)	
Instrumented CFLOW		0.11***								
		(2.90)								
Instrumented BDIVERSITY				0.0010***						
				(8.63)						
Instrumented BTENURE						0.000027				
						(0.67)				
Instrumented BSKILLS								-0.00029***		
								(-3.23)		
Instrumented EEFFICIENCY	-0.00040	0.0073**	0.27**	0.0056*	0.34	0.0072**	-0.54	0.0070**		0.0073*
	(-0.43)	(2.30)	(2.01)	(1.77)	(1.02)	(2.28)	(-1.39)	(2.22)		(1.67)
Controls	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
WHTE		3.51*		10.82***		3.058*		3.79*		3.651*
OVRET		0.689		0.039		0.903		0.413		2.191
WEINST		3762.85		18457.1		27259.6		4161.53		8215.11
N	16655	16655	16655	16655	16655	16655	16655	16655	16655	16655
R^2	0.57	0.13	0.85	0.13	0.78	0.12	0.60	0.12	0.57	0.12
Adj. R^2	0.571	0.121	0.853	0.124	0.781	0.121	0.597	0.121	0.569	0.121
F-stat.	300.80***		1306.79***		804.00***		335.00***		301.63***	
χ^2-stat.		2383.06***		2456.94***		2374.04***		2384.67***		2370.97***

This table presents the association between cash flow, board attributes, and renewable energy use based on 2SLS regression analysis. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Instrumental variables: IV1 Lag of testing variables & IV2: Ind-Ave of testing variables excluding focal firms.
WHTE: Wu-Hausman test of endogeneity. OVRET: Overidentifying restriction test (Sargan test). WEINST: Weak instrument test (F-value)

Table 10: Entropy balancing

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
CFLOW	0.018*				
	(1.68)				
BDIVERSITY		0.0012***			
		(7.06)			
BTENURE			0.000020		
			(0.52)		
BSKILLS				-0.000063*	
				(-1.79)	
EEFFICIENCY	0.00045	0.0069	0.0033	0.0038	0.016***
	(0.06)	(1.31)	(1.14)	(1.26)	(4.28)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y
N	17753	17753	17753	17753	17753
R^2	0.16	0.12	0.13	0.10	0.11
Adj. R^2	0.160	0.119	0.127	0.098	0.109
F-stat.	9.09***	11.04***	16.40***	10.21***	16.95***

This table presents the association between cash flow, board attributes, and renewable energy use based on Entropy balancing. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 11: Propensity Score Matching

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
CFLOW	0.13***				
	(3.37)				
BDIVERSITY		0.00082***			
		(4.81)			
BTENURE			0.000018		
			(0.37)		
BSKILLS				-0.00014**	
				(-2.00)	
EEFFICIENCY	0.0062	0.0062	0.00064	0.0041	0.0080**
	(0.91)	(0.88)	(0.14)	(1.04)	(2.49)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y
N	6145	6835	7830	6107	17305
R^2	0.17	0.15	0.13	0.13	0.12
Adj. R^2	0.156	0.140	0.124	0.121	0.119
F-stat.	18.78***	16.25***	15.92***	12.70***	33.07***

This table presents the association between cash flow, board attributes, and renewable energy use based on propensity score matching. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 12: Two-Step GMM-based dynamic panel regression analysis

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
RERATIO(t-1)	0.32***	0.33***	0.32***	0.32***	0.32***
	(292.17)	(199.53)	(221.58)	(219.51)	(379.40)
CFLOW	0.038***				
	(13.39)				
BDIVERSITY		0.00056***			
		(9.33)			
BTENURE			0.000027***		
			(2.62)		
BSKILLS				-0.000024*	
				(-1.69)	
EEFFICIENCY	0.0030*	0.0033*	0.0028	0.0025	0.0024*
	(1.71)	(1.80)	(1.60)	(1.44)	(1.68)
Controls	Included	Included	Included	Included	Included
N	12223	12223	12223	12223	12223
χ^2-stat.	2.12e+09***	1.32e+09***	1.78e+09***	2.05e+09***	1.93e+09***

This table presents the association between cash flow, board attributes, and renewable energy use using a two-step GMM-based dynamic panel regression analysis. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 13: One-year lag of testing variables of interest

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
CFLOW(t-1)	0.063***				
	(2.93)				
BDIVERSITY(t-1)		0.00086***			
		(8.62)			
BTENURE(t-1)			0.000024		
			(0.67)		
BSKILLS(t-1)				-0.00016***	
				(-3.23)	
EEFFICIENCY(t-1)					0.0045*
					(1.67)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y
N	16655	16655	16655	16655	16655
R^2	0.13	0.13	0.12	0.13	0.12
Adj. R^2	0.121	0.125	0.121	0.121	0.121
F-stat.	32.50***	33.53***	32.38***	32.53***	32.78***

This table presents the association between cash flow and board attributes and renewable energy use based on a One-year lag of testing variables of interest. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 14: Alternative sample based on positive RERATIO

Independent variables	(1) RERATIO	(2) RERATIO	(3) RERATIO	(4) RERATIO	(5) RERATIO
CFLOW	0.34***				
	(3.69)				
BDIVERSITY		0.0013***			
		(3.14)			
BTENURE			0.000078		
			(0.52)		
BSKILLS				-0.00028	
				(-1.32)	
EEFFICIENCY	-0.017	-0.018	-0.015	-0.016	-0.015
	(-0.93)	(-0.96)	(-0.84)	(-0.86)	(-0.84)
Controls	Included	Included	Included	Included	Included
Country, industry, & year FE	Y	Y	Y	Y	Y
N	3392	3392	3392	3392	3392
R^2	0.24	0.24	0.24	0.24	0.24
Adj. R^2	0.223	0.222	0.220	0.220	0.220
F-stat.	14.14***	14.07***	13.90***	13.93***	14.09***

This table presents the association between cash flow, board attributes, and renewable energy use based on an alternative sample, including the observations with positive renewable energy values. While RERATIO refers to total renewable energy consumption as a ratio of total energy consumption, CFLOW refers to cash flow from operations scaled by total assets. BDIVERSITY shows the percentage of women directors on boards, BTENURE is the average number of years each board member has been on the board, and BSKILLS is the percentage of board members with either an industry-specific background or a strong financial background. EEFFICIENCY is an indicator variable showing the existence of a company's energy efficiency policy's existence, including various processes/mechanisms/procedures to improve energy use efficiently. All variables are described in Table 1. *Statistics are* in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.