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Does board gender diversity affect renewable energy consumption?

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ABSTRACT

This paper examines the effect of board gender diversity on renewable energy consumption. Using a panel of 11,677 firm-year observations from the USA for 2008–2016, we find a positive relationship between board gender diversity and renewable energy consumption. Moreover, boards require two or more women for women to have a significant impact on renewable energy consumption, consistent with the critical mass theory. Further, we document that the positive impact of female directors on renewable energy consumption stems from female independent rather than female executive directors. Finally, we find a positive effect of the interaction between renewable energy consumption and board gender diversity on firm financial performance. Our findings are robust to different identification strategies and estimation techniques.

1. Introduction

Climate change, caused by the rapid rise in carbon dioxide (CO_2) emissions from fossil fuel combustion,[1] has emerged as one of the grand challenges for society (IPCC, 2007). To reduce such emissions, it is imperative to substitute clean or renewable energy for fossil energy (Lash and Wellington, 2007; Ben-Amar et al., 2017).[2] However, the increase in the share of renewable energy in the total energy mix largely depends on the efforts of firms, since they consume significant amounts of energy and generate a substantial percentage of

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[1] Since the industrial revolution, CO_2 emissions from fossil fuel combustion have increased rapidly from almost zero to 33 Giga tons (Gt) in 2017 (IEA, 2019). Specifically, the consumption of fossil energy, such as coal, oil, and natural gas, has been shown to account for 99.3% of global CO_2 emissions in 2017. Hence, the consumption of traditional energy represents an alarming environmental issue (Bang et al., 2000; Alam et al., 2019).

[2] Renewable energy sources include solar energy, wind, falling water, the heat of the earth (geothermal energy), plant materials (biomass), waves, ocean currents, temperature differences in the oceans, and the energy of the tides (Owusu and Asumadu-Sarkodie, 2016) that deliver low carbon energy (United Nations' 21st Conference of the Parties (COP21), 2015).

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total greenhouse gases emitted into the atmosphere.[3] The question that arises is whether there is a business case for firms playing a role in environmental activities, including tackling climate change. As it stands, the literature is as yet inconclusive as to the link between environmental performance and financial performance. Nevertheless, recent meta-analytical reviews of the literature (Horváthová, 2010; Endrikat et al., 2014; and Busch and Lewandowski, 2018) suggest that typically the link between the two is a positive one and our study contributes to this stream by identifying a context in which this link is more likely to be positive. Importantly, for businesses the decision to consume renewable energy hinges – at least to some extent – on the board of directors, i.e., the firm's main governance body (Hill and Jones, 1992; Prado-Lorenzo and Garcia-Sanchez, 2010; Borghesi et al., 2014). In turn, female directors have been shown to be more concerned about societal issues, including environmental concerns (e.g. Liu, 2018). Hence, female directors are more likely to advocate the use of renewable energy, which may then also improve financial performance.

Why would female directors be more concerned about global warming? Women have been shown to be more caring and ethically sensitive. This includes a greater emphasis on corporate social responsibility (CSR) (Shaukat et al., 2016) as well as the reduction in negative business practices (Boulouta, 2013; Cumming et al., 2015) and related lawsuits (Liu, 2018). Women are also more likely to support environmental protection and to adopt pro-environmental behaviors (McCright and Xiao, 2014; Kennedy and Dzialo, 2015). With direct relevance to our paper, perceptions of gender differences in energy choices are significant because women tend to favor 'soft' energies (i.e., renewables) and men 'hard' energies (i.e., fossil fuel and nuclear energy) (Longstreth et al., 1989). Importantly, recent research suggests that female leadership encourages tackling global warming as reflected by the move toward energy efficiency and green building, as well as the implementation of climate change policies. Hence, we expect that women play a key role on corporate boards in promoting renewable energy consumption. This paper contributes to the literature on board gender diversity and environmental CSR (e.g., Boulouta, 2013; Jia and Zhang, 2013; McGuinness et al., 2017; Liu, 2018) by examining a unique new angle of environmental CSR, i.e., renewable energy consumption, which has not been examined before.

To the best of our knowledge, this is the first study investigating the impact of board gender diversity on firms' renewable energy consumption. We investigate this issue by attempting to answer two important questions. Do women on the board affect the firm's renewable energy consumption? Does the interplay between renewable energy consumption and board gender diversity have an impact on firm financial performance? We proceed by investigating a panel of data consisting of 1491 firms for the period of 2008–2016, amounting to 11,677 firm-year observations from the USA. We find that renewable energy consumption is positively related to the percentage of women on the board as well as their number. Nevertheless, there needs to be a critical mass of women (Kristie, 2011) as the effect is only observed if there are at least two women on the board. The effect is more pronounced for female independent (outside) directors than for female executive (inside) directors. This result is intuitive given the monitoring and advisory roles of independent directors. Moreover, while both the literature on the performance effect of female directors and the literature on the link between environmental CSR and financial performance are still somewhat inconclusive, we find a positive effect of the *interaction* of board gender diversity and renewable energy consumption on firm financial performance. This suggests that the presence of female directors and the greater use of renewable energy jointly enhance firm value more than each of the two in isolation. Finally, our results are robust to the use of alternative econometric specifications, as well as alternative measures for renewable energy, firm financial performance, and the presence of women on the board.

Unsurprisingly, our study is subject to endogeneity concerns as omitted variables may drive the positive association between women on the board and renewable energy consumption. For example, male directors responsive to environmental concerns may also be more open to calls for greater board gender diversity. This would suggest correlation between female board representation and renewable energy consumption rather than causality. We employ three identification strategies to address endogeneity concerns. First, we implement the instrumental variable (IV) approach to extract the exogenous component from the percentage of women on the board. We confirm the positive association between women on the board and renewable energy consumption. Second, we employ propensity score matching (PSM) to identify firms with two or more female directors, which are indistinguishable from firms with less than two female directors. Post-matching, we still find that the presence of two or more women on the board is positively associated with renewable energy consumption. Third, we perform a difference-in-differences (DID) analysis to investigate the change in renewable energy consumption around female director appointments (the treatment group) compared with the equivalent change around male director appointments (the control group), with both types of appointments replacing an incumbent male director. Further, to ensure that we compare like with like, we match the observations for the treatment group with observations for the control group using propensity score matching. We find that renewable energy consumption is higher one year after the appointment of a female director than one year after the appointment of a male director. In a nutshell, our identification strategies indicate that board gender diversity has a positive causal effect on renewable energy consumption.

Our paper makes four important contributions to the literature on board gender diversity and firms' environmental performance. First, to the best of our knowledge, this is the first study investigating the relationship between board gender diversity and renewable energy consumption. The findings of this study have important implications for both academic research and policy making. From an academic perspective, the study contributes to the literature on board gender diversity and environmental CSR (e.g., Boulouta, 2013; Jia and Zhang, 2013; McGuinness et al., 2017; Liu, 2018) by investigating the link between board gender diversity and renewable energy consumption. While extant literature tends to focus on the impact of female directors on environmental CSR ratings (e.g., Post

[3] The Environmental Protection Agency (EPA) estimates that in 2018 industry accounted for a total of 22% of greenhouse gas emissions (CO_2 emissions accounted for 81% of greenhouse gases) in the USA. Agriculture was responsible for 10%, whereas transportation (which includes cars run by households) caused 28% of emissions. The production of electricity generated 27% of the greenhouse gases whereas commercial property and residential homes accounted for the remainder, i.e., 12% (EPA, 2020).

et al., 2011) and environmental disclosure (e.g., Williams, 2003; Liao et al., 2015; Jizi, 2017), this paper investigates how female directors may directly contribute to combating climate change. This study offers new insights for policy makers into both the business case for board gender diversity and how to address climate change. More specifically, the positive effect of the interaction between board diversity and renewable energy consumption on firm performance strengthens the business case for female board representation. Given our finding that having women on the board increases renewable energy consumption, policy makers aiming at sustainability should encourage firms to have more female directors.

Second, we test the validity of the critical mass theory from a novel perspective. If this theory is valid, we should only observe a positive effect of women directors on renewable energy consumption for boards with two or more women. We provide such evidence, contributing to the strand of literature (e.g., Gul et al., 2011; Joecks et al., 2013; McGuinness et al., 2017; Owen and Temesvary, 2018), which finds that female directors only affect corporate policies once their number reaches a certain threshold.

Third, we examine the channel through which women directors influence the firm's renewable energy consumption. When we distinguish between female executives and female independent directors, we observe that the effect is stronger for the latter. Hence, our paper also contributes to an emerging literature, which suggests a differential effect of female independent directors on corporate decision making compared to female executives (e.g., Liu et al., 2014; Chen et al., 2017; García Lara et al., 2017; Li and Zhang, 2019).

Finally, we find that the interplay between board gender diversity and renewable energy consumption increases firm financial performance. This evidence adds new insights into the relationship between firm environmental and financial performance (for recent reviews of this literature, see Horváthová, 2010; Endrikat et al., 2014; and Busch and Lewandowski, 2018). While this literature has found mixed evidence on the link between firm environment and financial performance, we unveil a context within which this link is more likely to be positive.

The rest of the paper is structured as follows: Section 2 reviews the relevant literature and develops the hypotheses. Section 3 discusses the research design. Section 4 reports the empirical results. The next section carries out a battery of robustness checks, identification, and further analysis. Finally, Section 6 offers conclusions and policy implications.

2. Extant literature and hypothesis development

We begin this section by reviewing the literature that investigates the business case for board gender diversity. We then review gender socialization and ethicality theories, which provide reasons why females in general and female board directors in particular are more likely to make environmentally friendly decisions when compared to their male peers. Finally, we review extant literature on board gender diversity and environmental CSR, as well as on the relationship between firm environmental and financial performance. During the course of this discussion, we develop our research hypotheses.

2.1. The business case for board gender diversity

Diversity theory provides the theoretical basis for the business case for having a diverse group of decision-makers. Indeed, the theory predicts that diverse groups tend to consider a greater range of perspectives and hence improve the quality of decision making (Forbes and Milliken, 1999; Burgess and Tharenou, 2002; Singh and Vinnicombe, 2004; Kang et al., 2007). If director gender differences are the same as "typical" gender differences, then it is plausible that increasing board gender diversity will lead to improved board dynamics and decision making (Croson and Gneezy, 2009; Adams, 2016).

A fast-growing body of literature provides empirical support that board gender diversity creates such benefits (see e.g., Hill and Jones, 1992; Heugens et al., 2004; Adams and Ferreira, 2009; Gul et al., 2011; Levi et al., 2014; and Chen et al., 2019). Although there is still some disagreement as to the effects of board gender diversity on firm value, a consensus is nevertheless emerging that female directors at best add value and at worst neither add nor destroy value (Post and Byron, 2015).[4] The question arises as to how board gender diversity improves firm performance. The literature identifies at least two such channels. First, female directors tend to enhance corporate governance practices: Female directors put more emphasis on monitoring as reflected by more frequent board meetings, better attendance by both males and females at board meetings (Adams and Ferreira, 2009; Goergen and Renneboog, 2014), a higher dividend payout (Chen et al., 2017), and more short-term debt (Li and Zhang, 2019) for firms with otherwise weaker governance. Second, female directors improve the quality of decision making, such as decisions on mergers and acquisitions (Levi et al., 2014), as well as mitigating cognitive biases (e.g., overconfidence) in male CEOs (Chen et al., 2019). In turn, manifestations of such improved corporate governance practices and decision making include the following. First, female directors have been shown to reduce corporate misconduct and other malpractices that may be detrimental to the firm's reputation. For example, Cumming et al. (2015) find that female directors decrease the incidence of corporate fraud. In a similar vein, García Lara et al. (2017) find that earnings quality is improved while earnings management is reduced by the presence of female directors. Moreover, female directors also decrease corporate tax aggressiveness (Lanis et al., 2017). Second, female directors improve firm reputation (Hill and Jones, 1992; Heugens et al., 2004) through greater stakeholder orientation (Rindova, 1999; Carter, 2006; Adams et al., 2011; Adams and Funk, 2012). For example, firms with female directors are less likely to downsize their workforce (Matsa and Miller, 2013). Such firms also tend to have a stronger environmental CSR orientation (e.g., Hafsi and Turgut, 2013; Larrieta-Rubín de Celis et al., 2015; Al-Shaer and Zaman, 2016). Finally, firms with female directors also tend to provide a greater philanthropic response to victims of natural disasters

[4] See also, Erhardt et al. (2003), Smith et al. (2006), Campbell and Minguez-Vera (2008), Joecks et al. (2013), Ben-Amar et al. (2013), Ali et al. (2014), Owen and Temesvary (2018), and Atif et al. (2019b).

(Jia and Zhang, 2013).

To sum up, the above review of the literature suggests that female directors typically increase firm performance via improved corporate governance and decision making. Manifestations of the latter two include improved reputation and CSR. In what follows, we use gender socialization and ethicality theories to provide reasons why female board directors are more likely to make environmentally friendly decisions. We review the literature on board gender diversity and environmental CSR in detail in Section 2.3.

2.2. Women, morality and ethics

While the above discussion suggests that female directors are more likely to adopt a stakeholder orientation and to pursue CSR-related issues than their male peers, one could argue that they might not be proactive in the promotion of renewable energy consumption to mitigate global warming. Indeed, such promotion might go against addressing the concerns of their immediate stakeholders and tackling wider societal challenges. Hence, why would female directors be more inclined to use renewable energy?

Gender socialization and ethicality theories suggest at least two reasons why female directors might be more concerned about wider societal issues than their male counterparts. First, women define morality and ethics differently from men. For women morality is about responsibilities. Such responsibilities include the duty to care for others as well as – more generally – a duty to alleviate the "'real and recognizable trouble' of this world" (Gilligan, 1977, p. 511). In contrast, for men morality is about the right to life and self-fulfillment as well as the non-interference with the rights of others. Hence, women are more sensitive to wider societal challenges than men. Second, the type of helping behavior also differs across gender (Eagly and Crowley, 1986). While men tend to focus on heroic and more short-term actions, the helping behavior of women is typically of a caring and nurturing nature and for the long term. As tackling climate change requires long-term measures, we would expect women to be more inclined to take such measures.

The question arises whether, like women in general, female managers and directors care more about society at large than their male counterparts. A number of studies confirm that this is indeed the case (Ameen et al., 1996; Cohen et al., 1998; Sundén and Surette, 1998; Oumlil and Balloun, 2009; Adams and Funk, 2012; Tormo-Carbó et al., 2019). For example, women find it more difficult to justify unethical business practices, such as tax evasion and bribery, compared to their male counterparts (Chen et al., 2016). Further, Cohen et al. (1998) argue that women are more sensitive to ethical dilemmas (e.g., a credit manager approving a bank loan to a friend). Finally, female directors have also been found to have a more positive attitude toward codes of ethics, believing that such codes can make a positive difference to their organization (Ibrahim et al., 2009).

To sum up, female directors are more likely to care about long-term societal challenges, such as global warming, and should therefore be more likely to promote renewable energy consumption than their male counterparts. In the next section, we review the literature on board gender diversity and environmental CSR.

2.3. Board gender diversity and environmental CSR

Confirming the predictions of gender socialization and ethicality theories, female leaders and directors have been shown to be more concerned about ethical practices and socially responsible behavior (Johnson and Greening, 1999; Bear et al., 2010; Hafsi and Turgut, 2013; McGuinness et al., 2017). Boulouta (2013) provides evidence in support of women's more caring nature as female directors tend to reduce negative business practices, i.e., business practices that the CSR rating agency Kinder, Lydenberg and Domini (KLD) considers to be areas of concern. They are also more inclined to take actions to reduce perceived risks (Schubert et al., 1999; Carter et al., 2003; Adams and Ferreira, 2009). Similarly, Bear et al. (2010) and McGuinness et al. (2017) find that female directors increase CSR ratings, thereby improving the firm's reputation. Finally, firms with female directors are also more likely to make voluntary disclosures about CSR,[5] which in turn are more valued by the market than voluntary disclosures by firms without female directors (Nekhili et al., 2017).

While the above-mentioned literature suggests that female directors care more about CSR than their male counterparts, the question arises whether female directors are also more concerned about one specific facet of CSR, i.e., their firm's environmental impact. This is a highly relevant question as Pearl-Martinez and Stephens (2016) argue that increased gender diversity in the workforce is a necessary condition for the transition toward a more sustainable society. Evidence by Post et al. (2011), Hafsi and Turgut (2013), Larrieta-Rubín de Celis et al. (2015), and Al-Shaer and Zaman (2016) suggests that the answer to this question is affirmative as firms with female directors have better environmental CSR ratings. Further, Liu (2018) reports that firms with female directors are less likely to be subject to environmental lawsuits.

We conclude that female directors have a greater propensity to pursue environmental issues, including climate change, one of society's long-term grand challenges. As global warming is one of the major challenges that society faces, we expect firms with female directors to be more likely to play their part in addressing this challenge by substituting renewable energy for fossil energy. This leads us to our first hypothesis:

[5] However, we do not find that firms with female directors are more likely to disclose their consumption of renewable energy. Indeed, for the subsample of firm-year observations where renewable energy consumption equals zero, we find that 26.69% of such firm-year observations are without female directors and 73.29% are with female directors, suggesting that disclosure of renewable energy is not directly associated with female directors. For information, for the entire sample the percentage of firm-year observations without female directors is 30.5% (see Table 2 where this percentage can be obtained by summing up the values for *W1*, *W2*, and *W3*).

H1a. Having women on the board increases the firm's renewable energy consumption.

Although the literature implies that women have a significant impact on CSR and environmental policies, it also suggests that having a single female director on the board is not sufficient to affect corporate decision making. Kanter (1977a) argues that dominantly male observers tend to distort women's image by molding women into a gender-role stereotype (Block, 1973; Sherrick et al., 2014) rather than valuing their individual leadership qualities. Such a distorted image creates difficulties for women directors to be heard and, importantly, listened to on an equal footing to male board members (Terjesen et al., 2009). Hence, Kanter (1977a) concludes that a single woman on the board is a "token", i.e., an individual whose role is to be the sole representative of a specific group (e.g., women). This token status of women in top management reinforces the stereotypes that women have weaker attributes for serving in such positions (Lee and James, 2007).

Given this token status of women, there is a need for a critical mass of women on the board of directors to ensure their influence on decision making. Kristie (2011) summarizes the critical mass theory as follows: The presence of one female director is a token, while two is a presence but three helps to raise their voice. Hence, real change only occurs when there are enough women on the board (Konrad et al., 2008; Joecks et al., 2013; Jia and Zhang, 2013; Owen and Temesvary, 2018; Atif et al., 2019b) since women feel more comfortable, and less constrained (Terjesen et al., 2009). Critical mass theory predicts that only once their number has reached two or more, women become influential in decision making. This prediction is validated by Post et al. (2011) who find that firms with three or more female directors have higher KLD scores for environmental CSR than other firms.[6] Therefore, we posit our second hypothesis as follows:

H1b. Two or more women on the board have a significant effect on renewable energy consumption whereas a single woman on the board does not result in significantly more renewable energy consumption.

In turn, the board's influence on renewable energy consumption is facilitated by its monitoring and advisory roles (Hillman and Dalziel, 2003; García Lara et al., 2017). Hence, we expect that female *independent directors* are more likely to affect the consumption of renewable energy than female executives. In support of our argument, the literature on female board representation suggests that female independent directors have a more significant impact on corporate decision making than female executives (e.g., Liu et al., 2014; Chen et al., 2017; García Lara et al., 2017; Li and Zhang, 2019). For example, Chen et al. (2017) find that female independent directors increase the dividends paid to the shareholders rather than female executives. Further, Li and Zhang (2019) find that firms with a greater percentage of female independent directors have relatively more short-term debt. They do not find such a link for female executive directors.[7] Hence, we expect that female independent directors, rather than female executive directors, increase renewable energy consumption. Therefore, we posit the following hypothesis:

H1c. The presence of female independent directors rather than female executive directors increases renewable energy consumption.

2.4. Relationship between firm environmental and financial performance

Several empirical studies investigate the relationship between environmental responsibility and financial performance. One group of these studies, such as Walley and Whitehead (1994), Klassen and Whybark (1999), and Telle (2006), find a negative relationship between firm environmental management and financial performance. They justify this result by arguing that, by investing in environmental protection, firms deploy their scarce assets and resources away from the central areas of the business, resulting in lower financial performance.

In contrast, another group of these studies, such as Porter and Van der Linde (1995), Hart (1995), Gallego-Álvarez et al. (2015), and Lee et al. (2015), report that firms can be both environmentally and financially competitive. These studies indicate that firms can reduce global warming through various environmental initiatives (e.g., renewable energy consumption) while generating new business opportunities, and ultimately achieving both greater environmental and financial performance. Still, a few other studies – including Graves and Waddock (1999) and Qiu et al. (2016) – find no evidence that environmentally responsible firms have significantly better or worse financial performance.

Given this inconclusive empirical evidence, Horváthová (2010), Endrikat et al. (2014), and Busch and Lewandowski (2018) perform a meta-analytic review to draw overall conclusions about the relationship between firm environmental and financial performance. Summarising 64 empirical studies conducted between 1978 and 2008, Horváthová (2010) concludes that 55% of the studies found a positive, 15% a negative, and the remainder an insignificant effect of environmental improvements on financial performance. In the same vein, reviewing the findings of 149 studies, Endrikat et al. (2014) report a generally positive relationship between firm environmental and financial performance. Finally, Busch and Lewandowski (2018), using 101,775 observations from 32 empirical studies, conclude that better carbon performance is positively linked to greater financial performance. Hence, the evidence suggests that typically there is a positive relationship between firm environment performance and financial performance.

Similarly, while the literature on the impact of female directors on firm performance and firm value is somewhat inconclusive, a recent meta-analysis review by Hoobler et al. (2018) suggests that the effect on firm performance of more women on the board is

[6] As afore-mentioned, Owen and Temesvary (2018) find that female directors have a positive effect on firm performance once a certain threshold of female board representation has been reached.

[7] Similar to Chen et al. (2017) who conclude that female directors consider dividends to play a monitoring role; Li and Zhang (2019) also consider short-term debt to be a monitoring device.

typically positive. We argue that the interplay of female board representation and renewable energy consumption is more likely to have a positive effect on firm value and firm performance than female board representation or greater renewable energy *on its own*. In support of this argument, Nekhili et al. (2017) find that the market values voluntary CSR reporting by firms with female directors more than by firms without female directors. Further, Isidro and Sobral (2015) find that, while the percentage of female directors does not directly affect financial performance, it has an indirect effect on firm performance via improved ethical and social compliance. This discussion leads to our final hypothesis:

H2. Firms with both women on the board and higher renewable energy consumption have better financial performance.

3. Research design

3.1. Sample

Our data consists of an unbalanced panel of annual data on US firms in the Standard & Poor's (S&P) 1500 index for the period of 2008–2016.[8] Our data is sourced from Bloomberg, BoardEx, and Factset. Bloomberg reports data on firms' total annual energy consumption in thousands of megawatt hours (MWh), including renewable energy consumption, and total energy consumption within the USA. Renewable energy data, which is largely consistent with the United Nations (UN) definition of renewable energy, includes annual aggregated energy from wind, solar, biomass, small-scale hydro, and waste sources. Total energy consumption includes all sources of energy including traditional (fossil fuel) energy as the main contributor. Our data on board and firm characteristics (e.g., the percentage of women directors on the board, board independence, and return on assets) is from Bloomberg. We collect the data on director tenure, age, and qualifications from BoardEx. Factset provides information on institutional shareholdings. Consistent with previous studies, we require firm-years to have the necessary data on board gender diversity and accounting numbers to be part of the sample. Our final sample consists of 1491 firms or 11,677 firm-year observations.[9]

3.2. Empirical model and variables

To examine the impact of board gender diversity on renewable energy consumption and firm performance, we estimate the following two baseline models:

$$renewable\ energy\ consumption_{i,t} = \alpha + \beta_1(board\ gender\ diversity)_{i,t} + \beta_2(Z)_{i,t} + \beta_3\sum(industry\ effects)_i + \beta_4\sum(year\ effects)_t + \varepsilon_{it} \quad (1)$$

$$firm\ perf_{i,t} = \alpha + \beta_1(renewable\ energy\ consumption)_{i,t} + \beta_2(board\ gender\ diversity)_{i,t} + \beta_3(board\ gender\ diversity \times renewable\ energy\ consumption)_{i,t} + \beta_4(Z)_{i,t} + \beta_5\sum(industry\ effects)_i + \beta_6\sum(year\ effects)_t + \varepsilon_{i,t} \quad (2)$$

We measure our dependent variable in model 1, i.e., renewable energy consumption, as the percentage of renewable energy in the firm's total energy consumption *(REN/TC)* during year *t*. We also employ alternative measures of renewable energy consumption, including renewable energy consumption over sales; renewable energy consumption over industry-mean-adjusted sales; the natural logarithm of total renewable energy consumption; a dummy variable equaling one, if the firm uses renewable energy, and zero otherwise; and renewable energy consumption scaled by industry mean and median-adjusted energy consumption. We measure our dependent variable in model 2, i.e., *firm_perf*, as the return on sales (*ROS*) and the return on assets (*ROA*). In the robustness section, we use the return on equity (*ROE*) and *Tobin's q* as alternative measures of firm performance.

The variable of interest in this study is board gender diversity. We measure board gender diversity by the percentage of women directors on the board (*WOBP*), and alternatively by the number of women directors on the board (*WOBN*), following extant literature (e.g., Adams and Ferreira, 2009; Liu et al., 2014; Chen et al., 2017). We also employ the dummy variables *W0, W1, W2,* and *W3* to measure board gender diversity, more specifically when testing the validity of H1b. Dummy variable *W0* equals one if the board has no female director, and zero otherwise; dummy variable *W1* equals one if the board has one female director, and zero otherwise; dummy variable *W2* equals one if the board has two female directors, and zero otherwise; and dummy variable *W3* equals one if the board has three or more female directors, and zero otherwise. We also use the number of female independent directors (*WOB_independence*) and the number of female executive directors on the board (*WOB_insider*) as a measure of board gender diversity when testing the validity

[8] To avoid sample selection bias, we select large, medium, and small firms, i.e., members of the S&P 1500 index, which consist of the S&P 500, S&P MidCap 400, and S&P SmallCap 600 members.

[9] Reporting on renewable energy consumption is not exhaustive as it is voluntary for firms. However, firms, which are part of the S&P 1500, report such data on a regular basis. Twenty-one percent of firms in our sample report data and we consider renewable energy consumption to be zero if not reported. As firms in intensive carbon emission industries are riskier to the climate, they are expected to have a greater propensity to disclose information about their climate strategies than those in low carbon emission industries. We find a greater propensity to disclose renewable energy data by firms from the *Energy* (11%), *Materials* (11.5%), *Industrial* (16%), and *Consumer Discretionary* (12%) industry sectors compared to firms from the *Communication* (1.65%), and *Financials* (8%) industry sectors, which is consistent with prior studies (e.g., Ben-Amar et al., 2017). Bloomberg collects renewable energy consumption data from sustainability reports, annual reports, websites, public sources, and through direct contact with companies.

Table 1
Definitions of variables.

Notation	Variable name	Measure
Panel A: Renewable energy		
REN/TC	Renewable energy consumption	Total renewable energy consumption as a percentage of total energy use
REN/Sales	Renewable energy consumption	Total renewable energy consumption as a percentage of sales turnover
REN/Sales (industry adjusted)	Renewable energy consumption	Total renewable energy consumption as a percentage of industry adjusted sales turnover. The industry sectors are based on the two-digit GICS codes
Ln_REN	Renewable energy consumption	Log of total renewable energy consumption
REN_D	Renewable energy consumption	A dummy variable equaling one if the firm uses renewable energy, and zero otherwise
REN/TC (industry mean/ median)	Renewable energy consumption	Total renewable energy consumption as a percentage of the firm's industry mean/median energy consumption. The industry sectors are based on the two-digit GICS codes
Panel B: Gender diversity		
WOBP	Percentage of women on the board	The number of women directors on the board expressed as a percentage of total board size
WOBN	Number of women on the board	The number of women directors on the board
W0	Women dummy 0	A dummy variable equaling one if the firm has no woman director on the board, and zero otherwise
W1	Women dummy 1	A dummy variable equaling one if the firm has one woman director on the board, and zero otherwise
W2	Women dummy 2	A dummy variable equaling one if the firm has two women directors on the board, and zero otherwise
W3	Women dummy 3	A dummy variable equaling one if the firm has three or more women directors on the board, and zero otherwise
WOB_independence	Women independent directors	The number of independent women directors divided by board size
WOB_insider	Women executive directors	The number of executive (insider) women directors divided by board size
WOBP-adjusted	Percentage of women on the board	The percentage of women on the board adjusted by the industry average. The industry sectors are based on the two-digit GICS codes
Panel C: Corporate governance		
WCEO	Women CEO	A dummy variable equaling one if the CEO is female, and zero otherwise
Board size	Board size	The total number of directors on the board
Duality	CEO duality	A dummy variable equaling one if the CEO is also the chairman of the board, and zero otherwise
%_Board independence	Board independence	The number of independent directors as a percentage of board size
B_meeting	Board meetings	The number of board meetings held in a year
Panel D: Firm characteristics		
ROE	Return on equity	Net income as a percentage of total equity
Tobin's q	Growth opportunities	Market value of equity plus total assets minus the book value of equity, all divided by total assets
ROS	Return on sales	Net income as a percentage of total sales
ROA	Return on assets	Net income and interest as a percentage of total assets
Cash/net assets	Cash reserves	Cash and cash equivalents divided by net assets
Leverage	Leverage	The sum of short-term and long-term debt divided by total assets
IO	Institutional ownership	The percentage of shares held by institutional shareholders
%_Insider owner	Insider ownership	The percentage of common shares held by insiders
Firm size	Size of firm	Log of total assets
Panel E: Instrument		
Female_male_ratio	Female-to-male workforce participation	Female participation ratio divided by male participation ratio for the state of the firm's head office. The female (male) participation ratio is computed as the percentage of the non-institutional population of females (males) in the civilian workforce

of *H1c*. We interact renewable energy and *WOBP* to form our variable of interest when testing the validity of *H2*.

Z (in both models) represents the vector of control variables as defined in Table 1. We use two types of control variables: corporate governance characteristics and firm characteristics. Our selection of control variables is based on previous studies (e.g., Harford et al., 2008; Liu et al., 2014; Chen et al., 2017). For example, Chen et al. (2017) argue that board characteristics, including board gender diversity, are important determinants of corporate policies (e.g., the dividend payout). Therefore, we include a variety of board-specific variables to capture the quality of corporate governance, such as a female CEO (*WCEO*) (a dummy variable equal to one if the CEO is a woman, and zero otherwise); board size (*Board size*) (measured by the total number of directors on the board); CEO duality (*Duality*) (a dummy variable equal to one if the CEO is also the chairman of the board, and zero otherwise); board independence (*%_Board independence*) (measured by the number of independent directors expressed as a percentage of board size); and board meetings (*B_meeting*), a proxy for monitoring intensity (Rutherford and Buchholtz, 2007) (measured by the total number of board meetings held during the year).

Based on extant literature (e.g., Liu et al., 2014), we also control for firm characteristics, which may influence renewable energy consumption. These firm characteristics are as follows. *Tobin's q*, a proxy for growth opportunities, is measured as market value of equity plus total assets minus the book value of equity, all divided by total assets. *ROA*, the return on assets, is a measure of profitability. It is computed as net income and interest scaled by total assets. *Cash/net assets,* is a proxy for cash reserves, and it is measured as cash and cash equivalents divided by net assets (total assets minus cash and cash equivalents). *Leverage* is measured by the ratio of total debt (short-term and long-term debt) to total assets. Institutional ownership *(IO)* is measured by the percentage of shares held by institutional owners. *%_Insider owner*, measuring insider ownership, is measured by the number of shares held by insiders expressed as a percentage of total shares outstanding. Finally, the size of the firm *(Firm size)* is measured by the natural logarithm of total assets. These variables, as well as all others, are defined in Table 1.

To estimate our empirical models, we use ordinary least squares (OLS) as the baseline method while controlling for industry (based on two-digit GICS industry sector codes) and year effects. The standard errors are corrected for clustering at the firm level to control for heteroscedasticity and within-firm correlation in the residuals (Petersen, 2009). We also use one-year (*t*-1, Table B in the Appendix), two-year (*t*-2), and three-year lagged (*t*-3) independent variables by replacing the contemporaneous variables to mitigate the endogeneity concerns in all the regressions (Harford et al., 2008). The underlying rationale is that female directors and board characteristics require time to influence firm policies, including the use of renewable energy. In the robustness section, we use Tobit, firm-fixed effects, four-digit GICS industry codes, alternative dependent variables, and additional director characteristics. We also exclude firm-year observations with a female CEO[10] as well as firm-year observations for the *Consumer Discretionary* and *Industrial* sectors, the two industry sectors with the highest numbers of observations (*Consumer Discretionary* and *Industrial*). We still find a positive effect of female directors on renewable energy consumption.

3.3. Descriptive statistics

Table 2 presents summary statistics. Panel A suggests that the sample's average usage of renewable energy as a percentage of total energy consumption is 28.77%. When comparing the sub-sample of firm-year observations with female directors with the sub-sample of firm-year observations without female directors, the former sub-sample has higher renewable energy consumption on average (31.18% versus 20.96%). This difference is significant at the 1% level. Panel B shows that 13.50% of all directors on the board are women and there are on average 1.24 women on the boards of our sample firms. About 32%, 24%, and 13% of observations have one woman, two women, and three or more women on the board, respectively. The remaining 31% of firm-year observations have no women on their boards. Finally, our sample firms have on average 11% of women that are independent directors and 0.9% of women that are inside directors.

As to the corporate governance characteristics, Panel C of Table 2 shows that the percentage of female CEOs is only 0.31 on average, average board size is 9.61, 63% of firms have CEO duality, the percentage of independent directors is 81, and the average number of board meetings per year is 8.65. A comparison of the firm-year observations with female directors with those without shows that the former sub-sample tends to have a significantly larger board (10.15 versus 7.87), greater board independence (82.09% versus 76.27%), and more board meetings (8.71 versus 8.48). Chen et al. (2017, 2019) find similar differences between firms with and without female directors. Further, a comparison of the firm-year observations with renewable energy data with those without reveals significant differences (except for *Duality*) in the corporate governance characteristics between the two sub-samples.

Finally, Panel D of Table 2 focuses on the firm-specific variables that may have an impact on renewable energy. *Tobin's q* is on average 1.90, and *ROS* and *ROA* have an average of 9.07% and 5.08%, respectively. *Cash/net assets* is on average 0.25, *Leverage* has an average of 0.24, *IO* has an average of 0.77, and *%_Insider owner is* on average 3.44. The size of the firm *(Firm size)* has an average value of 8.68. The sub-sample of firm-year observations with renewable energy data is largely different from that without renewable energy data in terms of firm characteristics.

Table A in the Appendix reports the use of renewable energy and raw energy across various sectors of industry. On average, the *Real Estate* sector uses the most renewable energy as a percentage of total energy consumption (56.92%), followed by the *Materials* (51.85%) and *Information Technology* industry sectors (28.28%).

Fig. 1 depicts the evolution of board gender diversity over the period of 2008–2016. The percentage of women on the board *(WOBP)* increased from 12% in 2008 to 18% in 2016 and the average number of women on the board *(WOBN)* also increased during the same period, from 0.36 to 1.80. Fig. 2 shows the percentages of firms with one female director, two female directors and three or more female directors on the board. The percentage of firms with one female director on the board increased from 25% to 38%, the percentage of firms with two female directors increased from 15% to 32%, and the percentage of firms with three or more directors increased from 7.5% to 22%. This suggests that over the period not only more boards appointed their first female director, but that the number and percentage of female directors on boards also increased over the period. These patterns are in line with those reported by Chen et al. (2017, 2019). Fig. 3 compares the annual renewable energy consumption (as a percentage of total energy consumption) of the sub-sample of firm-year observations with female directors with the sub-sample of firm-year observations without female directors. For each year, the renewable energy consumption of firm-year observations with female directors exceeds that of firm-year observations without female directors.[11]

[10] The reason why we exclude such observations is that the positive effect of female directors may be driven by female CEOs rather than female independent directors.

[11] The annual difference is calculated as the difference between renewable energy consumption of the sub-samples with and without female directors scaled by the renewable energy consumption of the sub-sample with female directors.

Table 2
Descriptive statistics.

Variable	Full Sample		With female		Without female				Firms with REN		Firms without REN			
	N = 11,677		N = 8926		N = 2751									
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean Diff	*t*-stat	Mean	Std. Dev.	Mean	Std. Dev.	Mean Diff	*t*-stat
Panel A: Renewable energy														
REN/TC	28.766	3341.769	31.175	3822.092	20.963	1164.279	10.212***	10.989	33.154	4216.033	0.000	0.000	33.154***	5.126
Panel B: Gender diversity														
WOBP	13.503	10.303	17.665	8.084	0.000	0.000	17.665***	110.023	17.239	10.286	12.418	8.525	4.821***	3.231
WOBN	1.242	1.122	1.624	1.013	0.000	0.000	1.624***	84.116	1.245	1.081	1.241	1.222	0.004***	4.332
W1	0.323	0.468	0.459	0.493	0.000	0.000	0.459***	44.866	0.332	0.472	0.321	0.467	0.011	1.198
W2	0.244	0.429	0.349	0.468	0.000	0.000	0.349***	35.873	0.241	0.420	0.245	0.429	−0.004***	−2.891
W3	0.128	0.335	0.189	0.374	0.000	0.000	0.189***	23.561	0.124	0.310	0.129	0.334	−0.005***	−6.134
WOB_independence	0.112	0.081	0.158	0.067	0.000	0.000	0.158***	105.432	0.113	0.083	0.112	0.082	0.001***	2.882
WOB_insider	0.009	0.310	0.011	0.039	0.000	0.000	0.011***	29.872	0.012	0.029	0.008	0.033	0.004***	2.458
Panel C: Corporate governance														
CEO	0.031	0.174	0.041	0.199	0.000	0.000	0.041***	10.861	0.033	0.169	0.030	0.154	0.003***	4.123
Board size	9.614	2.398	10.153	2.290	7.865	1.842	2.287***	47.842	7.837	2.010	10.104	1.692	−2.267***	−6.132
Duality	0.632	0.367	0.674	0.398	0.559	0.513	0.115***	15.372	0.465	0.428	0.673	0.591	−0.208	−1.162
%_Board independence	80.724	11.440	82.098	10.771	76.265	12.375	5.833***	23.949	76.112	8.184	81.985	13.125	−5.873***	−13.911
B_meeting	8.651	1.763	8.714	1.732	8.486	1.863	0.228***	6.024	8.551	1.723	8.712	0.186	−0.161***	−4.112
Panel D: Firm characteristics														
Tobin's q	1.903	1.312	1.884	1.278	1.965	1.416	−0.081***	−4.832	1.956	1.391	1.879	1.286	0.077***	3.122
ROS	9.070	1.330	11.400	0.375	1.614	2.620	9.876***	4.143	5.167	1.645	10.114	2.732	−4.947***	3.323
ROA	5.081	9.025	5.129	7.938	4.926	11.893	0.203	1.031	5.221	9.757	5.051	10.193	0.170	1.711
Cash/net assets	0.249	0.441	0.190	0.396	0.318	0.514	0.128***	−12.14	0.301	0.506	0.232	0.348	0.069***	8.133
Leverage	0.235	0.204	0.243	0.202	0.209	0.208	0.033***	7.511	0.211	0.210	0.239	0.205	−0.028***	−4.263
IO	0.767	0.210	0.773	0.192	0.746	0.260	0.027	1.811	0.748	0.249	0.771	0.199	−0.023	−1.362
%_Insider owner	3.439	6.344	2.840	5.584	5.382	8.047	−2.541***	−18.641	5.321	7.998	2.968	5.505	2.353***	7.121
Firm size	8.675	0.753	8.713	0.741	7.094	0.575	1.618***	56.221	7.883	0.550	8.855	0.725	−0.972***	−5.154

Table 2 presents descriptive statistics for the full sample and the sub-samples with women and without women as well as the sub-samples with reported renewable energy and without. For each variable, the differences in means between the sub-samples are reported along with *t*-statistics based on the two-sample *t*-test. ***Denotes statistical significance at the 1% level. Refer to Table 1 for the definitions of the variables.

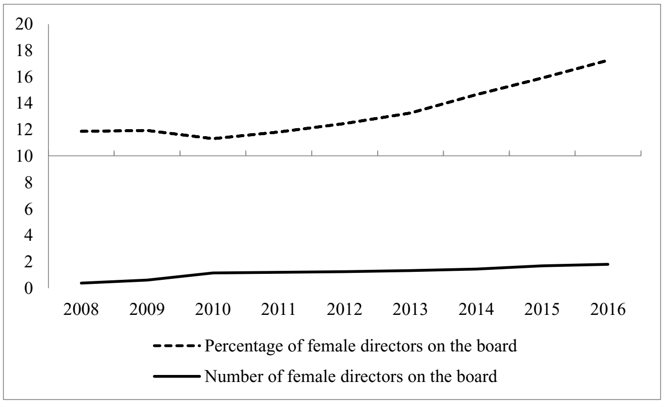

Fig. 1. Average percentage of female directors on the board by year. The Y-axis shows the percentage and number and the X-axis represents the years. The figure shows the average percentage (dashed line) and number of female directors (bold line) on the board over the period of 2008–2016, and is based on 1491 S&P 1500 firms.

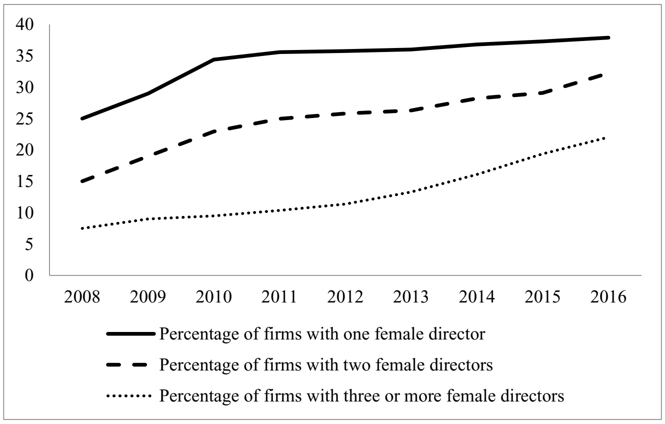

Fig. 2. Percentage of firms with one, two and more female directors on the board by year. The Y-axis shows the percentage and the X-axis represents the years. The figure shows the percentage of firms with one (bold line), two (dashed line) and three or more female directors (dotted line) on the board over the period of 2008–2016 and is based on 1491 S&P 1500 firms.

Table 3 shows the correlations among the variables used in the regression analysis. As expected, the highest correlations are between *WOBP* and *WOBN*, *W3* and *WOBP,* and *W3* and *WOBN*, highlighted in bold (0.83, 0.61, and 0.72, respectively). As a rule of thumb, a correlation coefficient higher than 0.5 may indicate a multicollinearity issue. Hence, we use the highly correlated variables in separate regressions rather than jointly in the same regression. The correlation coefficients for the remaining variables do not exceed 0.5. In addition, all the variables have a variance inflation factor (VIF) of less than 1.24 and the overall mean VIF value is 1.23.[12] This suggests that multicollinearity is not an issue.

4. Results and discussion

4.1. Percentage of women on the board and renewable energy consumption

First, we examine the impact of the percentage of women on the board *(WOBP)* on renewable energy consumption. Table 4 presents the results of the baseline regressions using OLS. We start our analysis by regressing the renewable energy consumption (measured by the firm's renewable energy consumption as a percentage of its total energy consumption) on the percentage of female directors.[13] The regression in Column 1 includes only the variable of interest (i.e., renewable energy consumption) as well as the industry and year effects. The regression in Column 2 includes the contemporaneous governance and firm characteristics, while the regressions in

[12] Lardaro (1993) suggests that multicollinearity is an issue if the VIF exceeds 10.
[13] We consider the firm's renewable consumption usage rather than production.

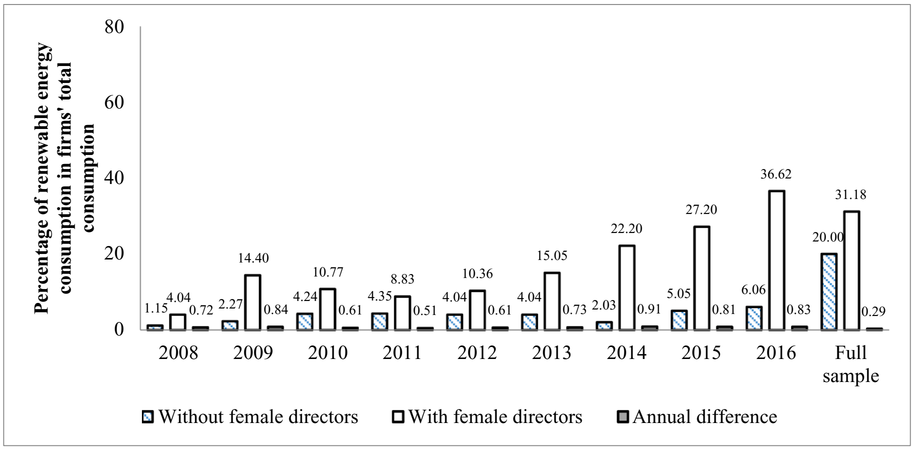

Fig. 3. Renewable energy consumption as a percentage of total energy consumption per year. The Y-axis shows the percentage of renewable energy consumption and the X-axis represents the years. The figure shows the annual difference, which is calculated as the difference between renewable energy consumption of the sub-samples with and without female directors scaled by the renewable energy consumption of the sub-sample with female directors over the period of 2008–2016, and is based on 1491 S&P 1500 firms.

Columns 3 and 4 include the two-year and three-year lagged corporate governance and firm characteristics, respectively.[14]

All of the above specifications suggest that female directors have a significantly positive impact (at the 1% level) on the use of renewable energy. For instance, a one-percentage-point increase in the percentage of female directors leads to an increase in renewable energy consumption of between 1.03 and 1.58 percentage points. Hence, the economic significance is also high. In a nutshell, there is consistent and statistically strong evidence that women on the board have a significantly positive impact on the use of renewable energy.[15] Overall, these findings support *H1a*. In addition to women on the board *(WOBP)*, *Board size*, *%_Board independence*, *Firm size,* and *ROA* also have a significantly positive relationship with the use of renewable energy. In contrast, *Duality* and *%_Insider owner* have a significantly negative relationship.

4.2. Number of female directors and renewable energy consumption

Our analysis in the previous section indicates that women on the board have a significantly positive impact on the firm's renewable energy consumption. We now test whether the impact of the number of female directors on renewable energy consumption is consistent with critical mass theory, using the following variables: the number of women on the board *(WOBN),* and the four dummy variables *W0*, *W1*, *W2*, and *W3*. We report the regression results in Table 5. The number of women on the board *(WOBN*) has a statistically significant and positive effect on the use of renewable energy in Columns 1 to 3. In addition, the dummy variables *W2* and *W3* have a statistically significant and positive effect on the use of renewable energy across Columns 4–6, whereas *W0* has no effect.

The results suggest that one woman on the board *(W1)* has at best a marginally significant impact on renewable energy consumption. However, this relationship improves in terms of statistical significance with two as well as three or more women on the board. These findings indicate that there need to be at least two women on the board for them to have a positive impact on renewable energy consumption. This is consistent with critical mass theory. The difference in coefficients test (Wald test) indicates that the coefficient on *W1* is significantly different from that on *W2*, and the coefficient on *W2* is significantly different from that on *W3*. The at best weakly significant impact of just one woman on renewable energy use is consistent with "tokenism" of women. Overall, the evidence is consistent with "presence and voice" (Kanter, 1977b). Therefore, the empirical evidence is in support of *H1b*. As to the control variables, *Board size*, *%_Board independence*, *ROA*, and *Firm size* also have a positive impact on the use of renewable energy. Similarly, if a woman holds the CEO position, the impact is positive.

[14] The results based on the one-year lagged levels are consistent with the main findings and are presented in Table B (Appendix).

[15] It may be the case that renewable energy usage and board gender diversity have risen at the same time. This would suggest correlation rather than causation. We use two strategies to address this concern. First, we focus on the earlier sample period of 2008–2012, corresponding to the period preceding the board gender diversity recommendations by the National Association of Corporate Directors (NACD) Blue Ribbon Commission in 2012. This recommendation would have increased (at least to some extent) the pressure to increase board gender diversity (Atif et al., 2019b). NACD is the only non-profit organization in the country devoted to improving board performance. It provides guidance on an array of board governance issues and practices. We then investigate the relationship between board gender diversity and renewable energy consumption. The results (see Table C in the Appendix) are consistent with our main findings. Second, we de-trend both variables, i.e., renewable energy consumption and the percentage of female directors on the board. We regress each of the variables on the year dummies (2008–2016) and then use the residuals (rather than the raw variables) from each regression to estimate the relationship between the two variables. Our results suggest a positive relationship. We report the analysis in the Appendix (Table F).

Table 3
Correlation matrix.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	REN/TC	1.000																					
2	WOBP	0.009	1.000																				
3	WOBN	0.016	**0.830**	1.000																			
4	W0	0.011	0.106	0.042	1.000																		
5	W1	−0.012	−0.147	−0.152	0.134	1.000																	
6	W2	0.014	0.358	0.382	0.161	−0.364	1.000																
7	W3	0.014	**0.611**	**0.721**	0.214	−0.266	−0.213	1.000															
8	WOB_ independence	0.023	0.216	0.133	0.001	0.041	0.104	0.108	1.000														
9	WOB_insider	−0.050	0.381	0.321	0.002	0.008	0.042	0.075	0.026	1.000													
10	WCEO	−0.003	0.262	0.242	0.005	−0.075	0.025	0.223	0.274	0.023	1.000												
11	Board size	0.024	0.274	0.419	−0.111	−0.131	0.190	0.317	0.078	0.184	0.042	1.000											
12	Duality	−0.003	0.208	0.192	0.005	−0.055	0.002	0.195	0.123	0.035	0.545	0.039	1.000										
13	%_Board independence	0.017	0.220	0.224	0.001	−0.041	0.134	0.133	0.112	0.101	0.047	0.193	0.068	1.000									
14	B_meeting	0.006	0.068	0.061	0.003	−0.023	0.007	0.062	0.019	0.047	0.029	0.107	0.057	0.147	1.000								
15	Tobin's q	−0.001	0.005	0.013	0.031	0.034	−0.015	0.010	0.036	−0.002	−0.018	−0.110	−0.030	−0.053	−0.145	1.000							
16	ROS	0.002	0.001	0.004	0.010	0.011	0.035	0.022	0.034	0.021	−0.014	−0.035	−0.015	0.024	0.133	0.544	1.000						
17	ROA	0.001	0.013	0.001	0.002	0.010	−0.023	0.014	0.033	0.013	−0.016	−0.080	−0.017	−0.032	−0.135	0.513	0.113	1.000					
18	Cash/net assets	0.030	−0.302	−0.355	−0.100	−0.132	−0.181	−0.264	−0.068	−0.246	0.048	0.553	0.058	0.174	0.100	−0.013	−0.133	0.142	1.000				
19	Leverage	−0.004	0.074	0.082	0.001	−0.008	0.076	0.021	−0.032	0.028	0.000	0.117	0.030	0.017	0.072	−0.134	0.133	−0.253	0.171	1.000			
20	IO	−0.062	0.015	0.040	0.023	0.043	0.039	−0.035	0.052	0.032	0.041	0.026	0.044	−0.020	0.016	0.027	0.093	0.212	0.122	0.132	1.000		
21	%_Insider owner	−0.009	−0.119	−0.105	0.032	0.039	−0.056	−0.075	0.016	−0.065	−0.016	−0.206	−0.024	−0.278	−0.115	0.101	−0.125	0.085	−0.251	−0.134	0.030	1.000	
22	Firm size	0.033	0.233	0.353	0.121	−0.131	0.185	0.265	0.045	0.240	0.044	0.585	0.063	0.198	0.183	−0.253	0.135	−0.193	0.080	0.265	−0.052	−0.287	1.000

Table 3 shows the correlation matrix. Refer to Table 1 for the definitions of the variables.

Table 4
Percentage of women on the board and renewable energy consumption.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	Lagged OLS (4)
	REN/TC			
WOBP	2.012***	1.034***	1.413***	1.581***
	(2.822)	(2.230)	(2.622)	(2.681)
WCEO	-	1.231	0.398	1.028
	-	(0.228)	(0.332)	(1.232)
Board size	-	5.323**	1.801**	1.923**
	-	(2.132)	(2.112)	(2.013)
Duality	-	−0.201*	−0.076*	−0.132*
	-	(−1.923)	(−1.892)	(−1.871)
%_Board independence	-	3.123**	2.901***	1.902**
	-	(2.131)	(2.763)	(2.192)
B_meeting	-	−8.183	−6.155	−3.126
	-	(−0.123)	(−0.671)	(−1.513)
Tobin's q	-	1.834	4.072*	2.011*
	-	(1.142)	(1.962)	(1.881)
ROA	-	1.121*	2.082*	2.081*
	-	(1.891)	(1.892)	(1.974)
Cash/net assets	-	0.123	0.109	0.121
	-	(0.201)	(0.338)	(1.129)
Leverage	-	−43.012	−32.374	−29.235
	-	(−0.308)	(−1.140)	(−1.034)
IO	-	−0.132*	−0.190	−0.183
	-	(−1.952)	(−1.021)	(−1.711)
%_Insider owner	-	−0.529*	−0.482*	−0.429*
	-	(−1.912)	(−1.991)	(−1.951)
Firm size	-	11.231**	10.231**	11.231***
	-	(2.121)	(2.192)	(2.824)
Constant	31.121***	19.271**	18.372*	11.326**
	(3.105)	(2.112)	(1.931)	(2.206)
Industry effects	Y	Y	Y	Y
Year effects	Y	Y	Y	Y
N	11,677	11,677	9190	7950
Adj. R-sq	0.137	0.232	0.223	0.246

This table presents the regression results of model (1): $renewable\_energy\_consumption_{i,\ t} = \alpha + \beta_1(board\_gender\_diversity)_{i,\ t} + \beta_2(Z)_{i,\ t} + \beta_3 \sum (industry\ effects)_i + \beta_4 \sum (year\ effects)_t + \varepsilon_{it}$ where gender diversity is measured by the percentage of female directors on the board (*WOBP*). Renewable energy is measured as a percentage of total energy consumption. Columns 2–4 present the results if all control variables are included. Columns 1 and 2 use the contemporaneous levels of the independent variables whereas Columns 3 and 4 use the two- and three-year lagged levels, respectively. Robust *t*-statistics are shown in parentheses. Industry (two-digit GICS) and year effects are included in all the regressions. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

4.3. Independent female directors and renewable energy consumption

To test the validity of *H1c*, we replace the board gender diversity variables in our regressions with the fraction of women executive directors (*WOB_insider*) and women independent directors (*WOB_independence*).Table 6 reports that female independent directors (*WOB_independence*) have a significantly positive impact (at the 5% level or better) on the use of renewable energy across the three regressions. Although female executive directors *(WOB_insider)* have a positive impact on renewable energy usage, their impact is less significant (at the 10% level at best) compared to women independent directors.[16] Our results remain qualitatively the same after controlling for a female CEO *(WCEO)* in these regressions.[17]

4.4. Board gender diversity, renewable energy, and firm financial performance

In this section, we investigate whether the relationship between women on the board and renewable energy consumption has an effect on firm performance (measured by *ROS* and *ROA*).[18]Table 7 presents the results of the baseline regression using OLS. Similar to Table 4, we start our analysis by regressing firm financial performance on the variable of interest (i.e., renewable energy consumption

[16] Our results are consistent if we exclude female *executive* directors from *W0*, *W1*, *W2*, and *W3*.

[17] We also include a female chairperson variable (a dummy variable equal to one if the chairperson of the board is female, and zero otherwise) in our regressions (untabulated) and still find results consistent with the significant impact of female independent directors on renewable energy consumption.

[18] We also test the relationship between renewable energy consumption and firm performance to establish whether renewable energy consumption is a value proposition for firms, irrespective of the presence of female directors. Our regression results (see Table D in the Appendix) suggest a positive relationship.

Table 5
Gender diversity level and use of renewable energy.

Variable	OLS (1)	Lagged OLS (2)	Lagged OLS (3)	OLS (4)	Lagged OLS (5)	Lagged OLS (6)
	REN/TC					
WOBN	1.714***	1.271**	1.422**			
	(2.503)	(2.113)	(2.149)			
W0	-	-	-	1.342	1.123	1.116
	-	-	-	(1.146)	(1.246)	(1.151)
W1	-	-	-	2.013*	2.186*	2.201
	-	-	-	(1.981)	(1.935)	(1.242)
W2	-	-	-	1.321**	1.452***	1.644***
	-	-	-	(2.094)	(2.352)	(2.391)
W3	-	-	-	1.012**	1.501**	1.131***
	-	-	-	(2.135)	(2.109)	(2.310)
WCEO	0.129	1.011	1.234*	0.441	0.361*	1.103*
	(0.542)	(1.399)	(1.899)	(1.132)	(1.999)	(1.992)
Board size	4.121**	2.019*	2.873*	3.112**	3.112**	2.121**
	(2.149)	(1.893)	(1.943)	(2.123)	(2.163)	(2.183)
Duality	−1.132	−1.431	−1.332	−2.120	−2.209	−2.154
	(−0.148)	(−1.109)	(−1.325)	(−1.631)	(−1.114)	(−1.252)
%_Board independence	2.112**	2.112**	2.112**	1.151*	1.133**	2.141**
	(2.102)	(2.109)	(2.132)	(1.919)	(2.179)	(2.143)
B_meeting	−9.193	−6.063	−6.132	−7.123	−5.211	−6.151
	(−0.123)	(−0.810)	(−1.421)	(−1.013)	(−1.431)	(−0.414)
Tobin's q	17.102	−7.283	−6.132	4.133*	4.117*	4.203**
	(0.634)	(−0.374)	(−1.142)	(1.911)	(1.890)	(2.122)
ROA	1.109*	2.142*	2.122*	2.236	2.092*	2.022**
	(1.912)	(1.991)	(1.991)	(1.126)	(1.873)	(2.194)
Cash/net assets	0.133	3.131	3.001	2.135	2.291	2.331
	(0.153)	(1.498)	(1.145)	(1.154)	(1.192)	(1.143)
Leverage	−28.132	−11.374	−12.121	−9.231	−9.118	−11.184
	(−0.342)	(−0.895)	(−0.882)	(−1.121)	(−0.331)	(−1.541)
IO	−0.121	−1.132	−1.324	−1.131	−1.231*	−1.122*
	(−0.236)	(−1.457)	(−1.143)	(−1.017)	(−1.891)	(−1.982)
%_Insider owner	0.288	0.682	1.032	0.149	0.421	0.423
	(0.173)	(0.154)	(1.123)	(1.113)	(0.149)	(0.154)
Firm size	14.321**	13.142**	11.429***	11.443**	9.137**	9.143**
	(2.114)	(2.153)	(2.523)	(2.093)	(2.104)	(2.142)
Constant	−11.843**	−17.750**	−14.124*	-	-	-
	(−2.132)	(−2.120)	(−1.898)	-	-	-
Industry effects	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y
N	11,677	9190	7950	11,677	9190	7950
Adj. R-sq	0.211	0.192	0.202	0.432	0.345	0.392
Coefficient test W1-W2				[10.139]	[11.108]	[9.472]
Coefficient test W2-W3				[7.171]	[6.742]	[8.334]

This table presents the results of model 1 where gender diversity is replaced with alternative measures. Columns 1–3 show the effect of *WOBN* on renewable energy from OLS regressions using contemporaneous, two-year and three-year lagged levels, respectively. Columns 4–6 (without constant) show the effect of *W0*, *W1*, *W2*, and *W3* on renewable energy for OLS regressions using contemporaneous, two- and three-year lagged levels, respectively. Industry (two-digit GICS) and year effects are included in all the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

interacted with the percentage of female directors). The first four columns are based on *ROS* as the dependent variable whereas the last four columns are based on *ROA*. The regressions in Columns 1 and 5 include only the interaction variable as well as the industry and year effects. The regressions in Columns 2 and 6 include the contemporaneous corporate governance and firm characteristics, and the regressions in Columns 3 and 7, and 4 and 8 include the two-year and three-year lagged control variables, respectively.[19]

All of the above specifications suggest that the interaction between female directors and renewable energy consumption has a significantly positive impact (at the 5% level or better) on firm performance. Overall, these findings support *H2*. In addition, *Board size*, *%_Board independence*, and *Firm size* also have a significantly positive relationship with firm performance.

[19] We drop *Tobin's q* in Table 7 as it may influence the relationship between *WOBP*×*REN/TC* and firm value.

Table 6
Gender diversity channels: independent vs inside women directors.

	OLS (1)	Lagged OLS (2)	Lagged OLS (3)
Variable	REN/TC		
WOB_independence	1.212***	1.212**	1.350**
	(2.392)	(2.021)	(2.013)
WOB_insider	1.132*	1.489	1.468
	(1.992)	(1.623)	(1.722)
WCEO	0.128	1.233*	1.113*
	(0.413)	(1.923)	(1.919)
Board size	2.112***	2.644*	2.132*
	(2.499)	(1.992)	(1.922)
Duality	−2.132*	−2.130*	−2.122*
	(−1.993)	(−1.992)	(−1.991)
%_Board independence	2.323**	1.211**	1.132**
	(2.168)	(2.012)	(2.012)
B_meeting	−7.132	−7.123	−6.132*
	(−1.143)	(−1.685)	(−1.891)
Tobin's q	9.120*	5.121*	3.132*
	(1.969)	(1.935)	(1.892)
ROA	1.543*	1.169*	1.181*
	(1.992)	(1.883)	(1.963)
Cash/net assets	1.133	3.231	3.014
	(1.121)	(1.791)	(1.013)
Leverage	−10.126	−11.122*	−9.122
	(−1.197)	(−1.893)	(−1.606)
IO	−0.201	−0.224	−0.211*
	(1.021)	(1.692)	(1.982)
%_Insider owner	0.299	−1.321	−1.149
	(1.182)	(1.036)	(1.331)
Firm size	9.239**	7.133***	7.122**
	(2.011)	(2.424)	(2.124)
Constant	−11.298**	−17.634*	−11.120**
	(−2.034)	(−1.961)	(−2.042)
Industry effects	Y	Y	Y
Year effects	Y	Y	Y
N	11,677	9190	7950
Adj. R-sq	0.181	0.176	0.191

This table presents the results of model 1 where gender diversity is replaced by the percentage of female independent directors (*WOB_independence*) and the percentage of female inside directors (*WOB_insider*). Columns 1–3 present the results from OLS regressions using contemporaneous, two- and three-year lagged levels, respectively. Industry (two-digit GICS) and year effects are included in all the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

5. Robustness checks, identification, and further analysis

5.1. Robustness checks

In this section, we perform a battery of sensitivity checks to test the robustness of our results. In what follows and unless otherwise stated, the industry sectors are based on the two-digit GICS codes. (i) We use different variables to measure renewable energy consumption. Instead of *REN/TC*, we use renewable energy consumption scaled by sales; renewable energy consumption scaled by industry-mean-adjusted sales; the logarithm of total renewable energy consumption; a dummy variable that equals one for a firm using renewable energy, and zero otherwise; renewable energy consumption scaled by industry-adjusted total energy consumption (i.e., mean and median); and industry mean-adjusted *WOBP*. We also use different variables to measure firm financial performance and firm value, i.e., the return on equity (*ROE*) and *Tobin's q*. Additionally, we use the four-digit rather than the two-digit GICS industry codes for the industry dummies. Finally, we include state effects in the regressions to account for potential differences in state level policies toward green energy across the 50 US states. (ii) We use alternative estimation techniques (i.e., Tobit and firm-fixed effects regressions). (iii) We exclude firm-year observations with a female CEO (*WCEO*) to confirm that the positive effect of female directors is not driven by female CEOs but by female independent directors. In addition, we exclude firm-year observations for the *Consumer*

Table 7
Percentage of women on the board, renewable energy, and firm value.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	Lagged OLS (4)	OLS (5)	OLS (6)	Lagged OLS (7)	Lagged OLS (8)
	ROS				ROA			
REN/TC	0.110*	0.015*	0.011	1.013	0.122*	0.011*	0.020	1.021
	(1.931)	(1.891)	(1.691)	(1.313)	(1.994)	(1.897)	(1.591)	(1.112)
WOBP	0.142**	0.124**	1.391***	1.171**	0.111**	0.125**	1.201**	1.113**
	(2.101)	(2.134)	(2.412)	(2.151)	(2.110)	(2.113)	(2.092)	(2.124)
WOBP × REN/TC	0.143***	0.116**	0.137***	0.123***	0.101***	0.100**	0.114**	0.114**
	(2.823)	(2.159)	(2.243)	(2.302)	(2.433)	(2.113)	(2.172)	(2.011)
WCEO	-	0.114	0.016	1.239	-	0.114	0.028	1.111
	-	(1.441)	(0.232)	(1.441)	-	(1.192)	(1.234)	(1.134)
Board size	-	3.103**	0.631**	1.912**	-	2.142**	0.629**	1.812**
	-	(2.109)	(2.021)	(2.114)	-	(2.117)	(2.014)	(2.183)
Duality	-	−0.199*	−0.014*	−0.120*	-	−0.170*	−0.023	−0.123*
	-	(−1.899)	(−1.998)	(−1.973)	-	(−1.899)	(−1.683)	(−1.913)
%_Board independence	-	2.112**	2.012**	1.982**	-	2.210**	2.122**	2.008**
	-	(2.031)	(2.101)	(2.124)	-	(2.011)	(2.013)	(2.011)
B_meeting	-	−6.232	−2.114	−4.132	-	−4.102	−2.133	−4.164
	-	(−0.167)	(−1.142)	(−1.703)	-	(−1.190)	(−1.113)	(−1.632)
Cash/net assets	-	0.091	0.143	0.143	-	1.101	1.016	0.132
	-	(1.612)	(1.105)	(1.152)	-	(1.153)	(1.123)	(1.113)
Leverage	-	−27.122	−23.134	−20.133	-	−19.134	−11.123	−11.134
	-	(−1.313)	(−1.634)	(−1.213)	-	(−0.853)	(−1.801)	(−1.432)
IO	-	−0.234*	−0.129	−0.141	-	−0.322*	−0.203	−0.144
	-	(−1.912)	(−1.033)	(−1.431)	-	(−1.890)	(−1.143)	(−1.644)
%_Insider owner	-	−0.513*	−0.151*	−0.221*	-	−0.321*	−0.167*	−0.113*
	-	(−1.916)	(−1.912)	(−1.951)	-	(−1.942)	(−1.916)	(−1.162)
Firm size	-	8.101**	9.117**	10.235***	-	7.011**	6.243**	8.112**
	-	(2.016)	(2.142)	(2.434)	-	(2.119)	(2.144)	(2.215)
Constant	7.153***	11.143**	10.191**	13.122**	6.223***	6.155***	8.122**	8.112**
	(3.431)	(2.121)	(2.211)	(2.101)	(4.112)	(2.356)	(2.121)	(2.172)
Industry effects	Y	Y	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y	Y	Y
N	11,677	11,677	9190	7950	11,677	11,677	9190	7950
Adj. R-sq	0.185	0.201	0.212	0.202	0.193	0.225	0.221	0.211

This table presents the regression results of model 2: $firm\ perf_{i,\ t} = \alpha + \beta_1(renewable\_energy\_consumption)_{i,\ t} + \beta_2(board\_gender\_diversity)_{i,\ t} + \beta_3(board\_gender\_diversity \times renewable\_energy\_consumption)_{i,\ t} + \beta_4(Z)_{i,\ t} + \beta_5 \sum (industry\ effects)_i + \beta_6 \sum (year\ effects)_t + \varepsilon_{i,\ t}$ where firm performance is measured by the return on sales (*ROS*) and return on assets (*ROA*). Columns 1 and 5 show the results without the control variables. Columns 2–4 and 6–8 present the results when all the control variables are included. Columns 2 and 6 use the contemporaneous levels of the independent variables whereas Columns 3 and 7 use the two-year and Columns 4 and 8 use the three-year lagged levels. Industry (two-digit GICS) and year effects are included in all the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Discretionary and *Industrial* sectors due to their high numbers of observations.[20] (iv) We control for additional director characteristics, i.e., tenure, age, and qualifications.[21]

Table 8 reports the results of the above-mentioned tests based on models 1 and 2. Panel A repeats the OLS regressions from Tables 4 and 7, each regression using a different measure for the dependent variable and an alternative measure for the key independent variable (*WOBP-adjusted*). Nevertheless, the regression in Column 1 of Panel A of Table 8 is identical to the regression in Column 2 of Table 4, except for the use of four-digit GICS industry codes and state effects. When we use the alternative measures of renewable energy consumption (i.e., *REN/Sales, REN/Sales* (industry mean-adjusted), *Ln_REN*, and *REN_D*) in Columns 2–5, we can confirm the positive effect of the percentage of female directors. The relationship also remains consistent when using the alternative industry-mean-adjusted measure for the percentage of female directors *(WOBP-adjusted)* and renewable energy consumption (*REN/TC* (*industry mean*) and *REN/TC* (*industry median*)) in Columns 6–7. This provides further support for *H1a*.[22] Similarly, there is a positive effect of *WOBP×REN/TC* on the alternative measures of firm performance and firm value (*ROE*, and *Tobin's q* in Column 8 and 9, respectively), providing further support for *H2*. Panel B confirms that these positive effects of female directors on renewable energy (including the alternative measures for both the independent and dependent variables) are observed when using Tobit and firm-fixed

[20] Our results (untabulated) are consistent if we exclude the *Consumer Staples* and *Utilities* industry sectors, i.e., the two sectors with the highest *WOBP*.

[21] BoardEx provides data on directors' qualifications, i.e., Bachelor, Master, Doctoral degrees, and professional qualifications. We calculate the directors' overall average qualification score, ranging from 0 to 4, from four dummy variables representing the different qualifications (equal to one in case of the presence of a qualification or multiple qualifications at the same level, and zero otherwise).

[22] Our results remain largely consistent when using *W1*, *W2*, and *W3*, as well as the percentage of female independent directors, supporting *H1b* and *H1c*.

Table 8
Robustness analysis.

Variable	REN/TC (1)	REN/ Sales (2)	REN/Sales (industry adjusted) (3)	Ln_REN (4)	REN_D (5)	REN/TC (industry mean) (6)	REN/TC (industry Median) (7)	ROE (8)	Tobin's q (9)
Panel A OLS regression (N = 11,677)									
WOBP	1.036**	0.001***	0.022**	0.050***	0.002**	-	-	-	-
	(2.181)	(2.322)	(2.014)	(4.111)	(2.171)	-	-	-	-
WOBP-adjusted	-	-	-	-	-	0.023**	0.021**	-	-
	-	-	-	-	-	(2.149)	(2.032)	-	-
WOBP × REN/TC	-	-	-	-	-	-	-	0.126**	0.021**
	-	-	-	-	-	-	-	(2.121)	(2.122)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects (GICS four-digit codes)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Tobit regression (N = 11,677)									
WOBP	2.017***	0.048***	0.004**	0.044***	0.057**	-	-	-	-
	(2.904)	(2.256)	(2.014)	(3.081)	(2.195)	-	-	-	-
WOBP-adjusted	-	-	-	-	-	0.001*	0.009*	-	-
	-	-	-	-	-	(1.943)	(1.934)	-	-
WOBP × REN/TC	-	-	-	-	-	-	-	0.013*	0.025**
	-	-	-	-	-	-	-	(1.933)	(2.100)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel B Firm fixed-effects regression (N = 11,677)									
WOBP	0.921**	0.084**	0.032**	0.121***	0.114*	-	-	-	-
	(2.021)	(2.121)	(2.012)	(2.840)	(1.892)	-	-	-	-
WOBP-adjusted	-	-	-	-	-	0.024**	0.015**	-	-
	-	-	-	-	-	(2.132)	(2.123)	-	-
WOBP × REN/TC	-	-	-	-	-	-	-	0.009**	0.005**
	-	-	-	-	-	-	-	(2.148)	(2.110)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel C Excluding WCEO (N = 10,180)									
WOBP	1.860***	0.002**	0.003**	0.048**	0.001***	-	-	-	-
	(3.404)	(2.131)	(2.013)	(2.129)	(4.240)	-	-	-	-
WOBP-adjusted	-	-	-	-	-	0.019**	0.012*	-	-
	-	-	-	-	-	(2.116)	(1.889)	-	-
WOBP × REN/TC	-	-	-	-	-	-	-	0.122**	0.019**
	-	-	-	-	-	-	-	(2.108)	(2.129)
Excluding Consumer Discretionary and Industrial sectors (N = 7974)									
WOBP	0.688**	0.001**	0.010*	0.038**	0.001**	0.014***	0.019**	-	-
	(2.112)	(2.159)	(1.991)	(2.181)	(2.013)	(2.241)	(2.111)	-	-
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel D Controlling for Director tenure, age, qualifications, (*N* = 7801)									
WOBP	1.141**	0.019**	0.013**	0.031**	0.001*	-	-	-	-
	(2.110)	(2.112)	(2.189)	(2.079)	(1.873)	-	-	-	-
WOBP-adjusted	-	-	-	-	-	0.015**	0.019*	-	-
	-	-	-	-	-	(2.131)	(1.889)	-	-
WOBP × REN/TC	-	-	-	-	-	-	-	0.113*	0.028**
	-	-	-	-	-	-	-	(1.886)	(2.131)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the results of additional analyses using alternative variables (*REN/Sales* in Column 2, *REN/Sales (industry adjusted)* in Column 3, *Ln_REN* in Column 4, *REN_D* in Column 5, *REN/TC* industry mean and median adjusted in Columns 6 and 7, and *ROE* and *Tobin's q* in Columns 8 and 9, respectively, and *WOBP-adjusted* across four panels); alternative estimation techniques (panel B); excluding firm-year observations with *WCEO* and *Consumer Discretionary* and *Industrial* sectors (panel C); and controlling for director tenure, age, and qualifications (panel D). Industry (two-digit GICS) and year effects are included in the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table 9
Two-stage least squares.

Variable	First-stage	Second-stage
	WOBP	REN/TC
	(1)	(2)
Female_male_ratio	0.189**	-
	(2.172)	-
WOBP-Fitted	-	1.002**
	-	(2.112)
WCEO	1.131	0.132
	(1.032)	(1.121)
Board size	0.091**	1.341**
	(2.011)	(2.179)
Duality	0.922	−1.123*
	(0.123)	(−1.921)
%_Board independence	0.121**	3.122**
	(2.120)	(2.117)
B_meeting	1.122	−3.183*
	(1.134)	(−1.924)
Tobin's q	0.023**	2.103
	(2.081)	(−1.629)
ROA	0.023**	1.121*
	(2.019)	(1.899)
Cash/net assets	1.121	0.214
	(1.022)	(1.463)
Leverage	−0.132	−19.123
	(−0.731)	(−1.638)
IO	1.211*	−1.120*
	(1.891)	(−1.881)
%_Insider owner	−0.014	−0.531
	(−1.125)	(−1.448)
Firm size	2.128*	6.132**
	(1.092)	(2.134)
Constant	3.174***	3.134***
	(2.453)	(2.331)
Industry effects	Y	Y
Year effects	Y	Y
N	11,677	11,677
Model fits		
F-statistic	10.241***	
	[0.001]	
Cragg-Donald Wald F-statistic	202.170	
Stock-Yogo weak ID test critical values at 10% IV size	13.121	

The table presents the results of the 2SLS regressions. Column 1 shows the first-stage regression where *WOBP* is the dependent variable and model fits for the instrumental variable. *Female_male_ratio* is the ratio of female workforce participation rate to male workforce participation rate in a given state. Column 2 shows the second-stage regression results where *REN/TC* is the dependent variable. Industry (two-digit GICS) and year effects are included in the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

effects regressions across all the columns (Columns 1–9). Our findings are also robust to the exclusion of firm-year observations relating to female CEOs and the exclusion of firm-year observations for the *Consumer Discretionary* and *Industrial* industry sectors using OLS in Panel C. Finally, Panel D suggests that our results remain consistent even after controlling for additional characteristics of directors, i.e., age, tenure, and qualifications. Control variables, as specified in models 1 and 2, are included in all the regression specifications across the four panels.

To sum up, we find that having women on the board is positively associated with renewable energy consumption. Further, the interaction between women on the board and renewable energy consumption has a positive effect on firm performance. We can confirm the existence of both effects when using alternative measures for the dependent and independent variables, using alternative estimation techniques, excluding firm-year observations relating to female CEOs and the two industry sectors with the highest numbers of observations, and including additional director characteristics.

5.2. *Identification*

The gender diversity literature typically faces concerns about the potential endogeneity of female board representation (see also Abdallah et al., 2015). For instance, male directors sensitive to the positive effect of renewable energy on the environment may also be more responsive to calls for greater board gender diversity (Chen et al., 2017). Hence, our key results may reflect correlation rather

Table 10
Propensity score matching.

Panel A	Pre-match (1)	Post-match (2)	REN/TC (3)
Variable	W_dummy		
WOBP	-	-	1.019***
	-	-	(3.439)
WCEO	0.112	0.019	0.101
	(1.334)	(1.011)	(1.055)
Board size	1.133***	1.003	1.103*
	(3.128)	(1.165)	(1.876)
Duality	0.851	−0.119	−1.143*
	(1.245)	(−1.219)	(−1.942)
%_Board independence	1.128***	1.098	0.106**
	(3.089)	(1.014)	(2.124)
B_meeting	4.121*	2.183	−2.102*
	(1.906)	(0.190)	(−1.858)
Tobin's q	1.239***	1.022	1.013***
	(4.012)	(1.269)	(2.922)
ROA	0.212***	0.184	1.014**
	(2.442)	(1.159)	(2.091)
Cash/net assets	1.414	0.123	0.105
	(1.101)	(0.025)	(1.113)
Leverage	−4.134***	2.450	13.194
	(−2.332)	(1.634)	(1.634)
IO	1.021*	1.002	−1.055*
	(1.883)	(1.612)	(1.902)
%_Insider owner	−1.228***	−0.014	−1.125
	(−3.420)	(−1.108)	(−1.454)
Firm size	4.124***	1.225	5.163***
	(6.114)	(1.229)	(2.997)
Constant	−5.183***	−3.113*	4.032***
	(−2.669)	(−1.932)	(2.352)
Industry effects	Y	Y	Y
Year effects	Y	Y	Y
N	2724	1134	1134
Pseudo R-sq	0.255	0.015	0.199

Panel B: Differences in firm characteristics				
Variable	Treatment	Control	Difference	*t*-stat
WCEO	0.022	0.019	0.003	0.016
Board size	11.105	10.099	1.006	0.354
Duality	0.451	0.448	0.003	0.456
%_Board independence	85.129	84.103	1.026	1.749
B_meeting	8.830	8.740	0.090	0.024
Tobin's q	1.745	1.753	−0.008	−0.312
ROA	6.291	6.343	−0.052	−1.033
Cash/net assets	0.332	0.331	0.001	0.554
Leverage	0.239	0.251	−0.012	−0.643
IO	0.765	0.766	−0.001	−0.653
%_Insider owner	2.105	3.104	−0.999	−1.443
Firm size	7.323	6.687	0.636	0.394

The table presents the results of the propensity score matching in two panels. Panel A shows the logits explaining *W_dummy* (which equals one if two or more female directors are on the board, and zero otherwise) for the pre- and post-match sample, and the matched sample regression results explaining renewable energy consumption. Industry (two-digit GICS) and year effects are included in the regressions. Panel B presents the differences in firm characteristics for the treatment and control sub-samples. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

than causation. Another possible reason for the endogeneity of female board representation is that, given the shortage of qualified women, female directors are at liberty to choose board seats in firms in line with their personal preferences. Such board seats may be in firms with high levels of CSR, including high levels of renewable energy usage. Therefore, our main independent variable *(WOBP)* may suffer from a self-selection bias and, as a result, may not be systematically associated with our dependent variable *(REN/TC)*. In this section, we address endogeneity concerns using the following three approaches: (i) the instrumental variable approach; (ii) propensity score matching (PSM); and (iii) difference-in-differences (DID) matching estimates.

5.2.1. Instrumental variable approach

To address the above endogeneity concerns, we first employ the instrumental variable (IV) approach and estimate the regressions using two-stage least squares (2SLS) to extract the exogenous component from board gender diversity. We then use the latter to explain renewable energy consumption. The challenge in using 2SLS is the identification of exogenous IVs that do not have a direct relationship with the dependent variable. We use the female-to-male workforce participation ratio (*Female_male_ratio*) as an IV for *WOBP*. The IV is computed as the female participation ratio divided by the male participation ratio for the state of the firm's head office.[23] The female (male) participation ratio is computed as the percentage of the non-institutional population of females (males) in the civilian workforce. Similar to Chen et al. (2017), we use this instrument given that firms in states with a higher female-to-male participation ratio are more likely to find good female directors due to the larger pool of candidates and should therefore have a higher percentage of female directors. In contrast, there is little evidence, if any, that suggests that the female-to-male participation ratio of the state affects the firm's renewable energy consumption. Hence, we expect the IV to be positively correlated with *WOBP*. Column 1 of Table 9 shows the results of the first-stage regression where the dependent variable is the percentage of women on the board *(WOBP)*. The regression includes the same explanatory variables as the regression in Column 2 of Table 4. Consistent with the requirements for a valid instrument, *WOBP* is positively correlated with the IV in Column 1 and the coefficient is significant at the 5% level, suggesting the validity of the IV. Moreover, the value of the *F-statistic* is high, and the *p-value* of the Cragg-Donald F weak-instrument test is 0.001, rejecting the null hypothesis that the instrument is weak (Cragg and Donald, 1993; Stock and Yogo, 2005).

Column 2 of Table 9 reports the results for the second-stage regression, which uses the predicted percentage of women on the board from the first-stage regression (*WOBP-Fitted*) to estimate renewable energy consumption. The results are similar to those from our main regression analysis that suggests a positive relationship between the percentage of women on the board and renewable energy consumption. The coefficient on the predicted percentage of women on the board is significant at the 5% level in Column 2.

5.2.2. *Propensity score matching*

Second, we use propensity score matching (PSM) (e.g., Rosenbaum and Rubin, 1983; Lennox et al., 2011; Hossain et al., 2019) to address the above endogeneity concerns. We assign firm-year observations with two or more female directors to the treatment group and those with fewer than two female directors to the control group. We then proceed as follows. First, we estimate the probability that a firm has two or more female directors. We run a logit regression to explain *W_dummy* (which equals one if two or more female directors are on the board, and zero otherwise) with the same explanatory variables used in the regression in Column 2 of Table 4. Panel A (Column 1) of Table 10 reports the results for the logit regression. The pseudo R-square for the regression is high (0.255) and most of the independent variables are (highly) significant.

Further, we use the nearest neighbor approach to ensure that firms in the treatment and control groups are sufficiently identical. Notably, each firm-year observation with two or more female directors on the board is matched with a firm-year observation with less than two female directors and with the closest propensity score. We further require the maximum difference between the propensity score of each firm-year observation and that of its matched peer not to exceed 0.1% in absolute value.[24]

To verify that the firm-year observations in the treatment and control groups are indistinguishable in terms of observable characteristics, we conduct two diagnostic tests following Chen et al. (2017) and Atif et al. (2019a). The first test consists of re-estimating the logit regression for the post-match sample. The results (Column 2 in Table 10) suggest that none of the coefficients on the explanatory variables is statistically significant, indicating that there are no significant differences in renewable energy consumption between the two groups. Moreover, the coefficients in Column 2 are typically smaller in magnitude than those in Column 1 indicating the decline in the degrees of freedom in the restricted sample. Finally, the pseudo R-square declines from 0.255 to 0.015. This suggests that propensity score matching removes all observable differences other than the difference in the presence of two or more female directors. The second test examines the differences in the mean of each observable characteristic between the treatment and the control firm-year observations. Panel B of Table 10 shows that none of the differences in the observable characteristics between the treatment and control groups is statistically significant.[25] Overall, the two diagnostic tests suggest that the propensity score matching removes all of the observable differences in the explanatory variables other than those relating to female board representation.

We rerun the regression explaining renewable energy consumption based on the matched sample of firm-year observations (Column 3, Panel A in Table 10). The coefficient on *WOBP* is significantly positive suggesting that women on the board have a strong impact on renewable energy consumption.[26] This confirms our previous results and suggests that our results are not driven by (observable) differences between firm-year observations with two or more women and those with fewer than two women.

5.2.3. *Difference-in-differences matching estimates*

Third, we employ a difference-in-differences (DID) analysis around female director board appointments to adjust for possible endogeneity. The DID exploits the assumption of "parallel trends" using two groups (i.e., the treatment and the control groups) to

[23] The data for female-to-male participation is sourced from the US Census Bureau website.

[24] Our results hold if we allow firm-year observations with female directors to be matched with multiple firm-year observations without female directors, as well as increasing the permissible difference in propensity scores (i.e., the caliper) to 0.5% or 1.0% in absolute value. These results are not tabulated.

[25] The mean difference between the treatment group and the control group is based on the average treatment effect on the treated group (ATT).

[26] We also check the average treatment effect. The (untabulated) results suggest that there are significant differences (at the 1% level) in renewable energy consumption between firm-year observations with female directors and those without. These results confirm that an increase in the use of renewable energy is attributable to the systematic difference in the presence of female directors on the board and is not attributable to other differences between firm-year observations with and those without female directors.

Table 11
Difference-in-differences analysis.

Panel A: Differences in firm characteristics

Variable	Treatment	Control	Differences	*t*-stat
WCEO	0.001	0.001	0.000	0.012
Board size	10.123	10.131	−0.008	−0.392
Duality	0.332	0.321	0.011	0.326
%_Board independence	79.132	80.208	−1.076	−0.732
B_meeting	8.721	8.792	−0.071	−0.231
Tobin's q	1.738	1.539	0.199	0.752
ROA	5.128	5.138	−0.010	−0.081
Cash/net assets	0.114	0.102	0.012	0.133
Leverage	0.224	0.259	−0.035	−0.627
IO	0.771	0.753	0.018	0.423
%_Insider owner	2.031	1.299	0.732	0.443
Firm size	4.043	4.086	−0.043	−0.432

Panel B: Difference-in-differences estimator

	OLS (1)	Fixed-effects (2)
	REN/TC	
f_appointment × post period	2.341**	2.012**
	(2.121)	(2.064)
f_appointment	3.237*	2.117*
	(1.988)	(1.891)
post period	−3.722	−3.100
	(−1.592)	(−1.012)
All controls	Y	Y
Industry effects	Y	
Year effects	Y	Y
N	404	404
adj. R-sq	0.211	0.182

The table presents the results of the difference-in-differences analysis in two panels. Panel A shows the differences in firm characteristics of the treatment and control sub-samples and Panel B presents the difference-in-differences estimator for the matched sample. Column 1 of Panel B reports the OLS regression whereas Column 2 reports the equivalent fixed-effects regression both using REN/TC as dependent variable. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

capture the change in outcomes. Therefore, any differences in the changes in outcome before and after the treatment between the two groups should be due to the impact of the treatment rather than differences between the two groups prior to treatment. We implement the DID estimator using the following model.

$$renewable\_energy\_consumption_{i,t} = \alpha + \beta_1 (f\_appointment \times post\ period)_{i,t} + \beta_2 (f\_appointment)_{i,t} + \beta_3\ (post\ period)_{i,t} + \beta_4 (Z)_{i,t} + \beta_5 \sum (industry\ effects)_i + \beta_6 \sum (year\ effects)_t + \varepsilon_{i,t} \quad (3)$$

The variable *f_appointment* is a dummy variable equal to one if the firm is in the treatment group, and zero if the firm is in the control group. *Post period* is a dummy variable equal to one for the period after the treatment, and zero for the period before. The sample for this analysis includes firm-year observations one year before and one year after the director appointment, excluding the year of the appointment. We select our treatment group with female director appointments on the board based on prior studies (e.g., Sila et al., 2016; Chen et al., 2017). We require a firm to appoint one female director to replace a departing male director in the year of the appointment. We further require the departing male director to be older than 60 to ensure that director turnover is less likely to be influenced by factors such as bad performance and strategic changes.[27] Applying these criteria, we are able to identify 101 female director appointments to be included in the treatment group. Moreover, we identify 624 observations where the departing male director aged above 60 is replaced with a newly appointed male director. Next, we match the treatment and control firm-year observations using propensity score matching to ensure that the DID is not driven by differences in firm or industry characteristics. The matching procedure is similar to that explained in Section 5.2.2. Panel A of Table 11 presents the differences in observable characteristics between firm-year observations relating to female director appointments and their matched controls in the pre-treatment period. The univariate comparisons show that there are no statistically significant differences in the observable characteristics

[27] To check the robustness of our results, we alternatively require the departing directors to be aged 65 or more. The results continue to hold with a smaller sample of 79 matched pairs (the results are not tabulated).

Table 12
Industry sub-sample analysis.

GICS Industry sector	OLS (1)	OLS (2)
	REN/TC	ROS
Energy	0.073**	0.021**
	(2.097)	(2.127)
Materials	0.024**	0.001*
	(2.112)	(1.891)
Industrial	0.011**	0.212**
	(2.110)	(2.190)
Consumer Discretionary	0.012**	0.032*
	(2.031)	(1.869)
Consumer Staples	0.123*	0.033**
	(1.859)	(2.105)
Health Care	0.253*	0.115
	(1.876)	(1.701)
Financials	0.021***	0.033**
	(2.891)	(2.025)
Information Technology	0.023**	0.001**
	(2.173)	(2.179)
Communication	1.042**	2.004**
	(2.091)	(2.111)
Utilities	0.011***	1.341**
	(2.431)	(2.152)
Real Estate	0.210*	1.042**
	(1.932)	(2.119)
Other controls	Y	Y
Year effects	Y	Y

Column 1 reports the coefficient on the percentage of women on the board for regressions explaining renewable energy consumption. The regression is run separately for each GICS (two-digit) industry sector. Column 2 shows the coefficient on the interaction between renewable energy and gender diversity for regressions explaining the firm financial performance (measured by *ROS*). Both columns use OLS regressions controlling for year effects and including the control variables as specified in models 1 and 2. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

between the two groups.

The results, based on the matched sample from the DID analysis, are reported in Panel B. The coefficient on the interaction variable (*f_appointment* × *post period*) is statistically significant (at the 5% level) and positive using OLS and fixed effects (Column 1 and 2, respectively). This suggests that, a year after the appointment of a female director, firms use significantly more renewable energy than after the appointment of a male director.[28]

5.3. Further analysis

In this section, we investigate the relationship between renewable energy consumption and board gender diversity for different industry sectors to rule out that our results are driven by any specific industry sector (see also Cumming et al., 2015). We also study the impact of board gender diversity in traditionally male dominated industry sectors because one could argue that its impact may be different in such industry sectors. According to the Institute for Women's Policy Research, the *Manufacturing, Communication*, *Utilities*, *Mining and Construction* industry sectors are male dominated. Column 1 in Table 12 reports the coefficient of interest (i.e., the coefficient on *WOBP*) for each OLS regression based on model 1 for the 11 industry sectors (based on the two-digit GICS codes). The regressions also include the control variables as specified in model 1. Although there are differences across industry sectors, there are no clear patterns for the industry sector differences we obtain. More importantly, we still observe a positive effect of female directors on renewable energy consumption in all industry sectors. To sum up, these results are consistent with our main findings.

Finally, we investigate the effect of the interaction between board gender diversity and renewable energy on firm financial

[28] To establish further whether female directors increase renewable energy, we redo the difference-in-differences analysis considering only those female director appointments as part of the treatment group for which renewable energy is reported as zero prior to the appointment. Our results suggest a positive relationship (at the 10% level of significance) and we report the analysis as well as its discussion in the Appendix (Table E).

performance (*ROS*). Our results suggest a positive impact of this interaction on firm financial performance (Column 2) across all industry sectors, except for the *Health Care* sector, at the 10% level of significance or better. These results provide further support for *H2*.

6. Conclusions, policy implications, and limitations

This study extends the existing gender diversity literature by providing novel empirical evidence that women on the board have a significantly positive impact on the use of renewable energy. Our main results are as follows. First, our findings suggest that there is a positive impact of board gender diversity on renewable energy consumption. Importantly, this effect is only observed if the number of female directors exceeds one, supporting critical mass theory. Second, the impact of women directors on renewable energy consumption is mainly attributable to female independent directors rather than female executive directors. Finally, our results also indicate that firms that both use more renewable energy and have gender diverse boards enjoy better financial performance. These findings are robust to alternative econometric specifications and alternative measures of board gender diversity, renewable energy consumption, and firm performance, as well as the exclusion of certain observations and the inclusion of additional director characteristics variables. When using two-stage least squares (2SLS), propensity score matching (PSM), and a difference-in-differences (DID) analysis to adjust for potential endogeneity, we can confirm our results.

The main policy implication of our study is that gender-diverse boards are beneficial in terms of greater renewable energy consumption and that the interaction between board gender diversity and renewable energy consumption improves firm financial performance. As a result, firms with fewer than two women on their board should consider adding female directors to their boards.

Our study is limited to renewable energy consumption. Unfortunately, our data does not allow us to distinguish between the various sources of energy as this information is typically not disclosed. It also does not allow us to identify whether firms that use renewable energy produce part or all of that energy themselves. Future research, benefiting from improved disclosure, should re-investigate the relationship between board gender diversity and the various sources of renewable energy. Importantly, better disclosure should make it possible to distinguish between the consumption of renewable energy and its production. Future research may also investigate the relationship between female directors and renewable energy in different markets with a distinct cultural background and institutional setting, as well as with different female director traits.

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Appendix A. Difference-in-differences analysis

We employ a difference-in-differences (DID) analysis similar to that in Section 5.2.3. The sample for this analysis includes firm-year observations one year before and one year after the director appointment, excluding the year of the appointment. We require a firm to appoint one female director to replace a departing male director in the year of appointment. We only retain in the treatment group female director appointments for firms with zero renewable energy consumption prior to the appointment. Applying these criteria, we are able to identify 32 female director appointments to be included in the treatment group. Moreover, we identify 86 observations where the departing male director is replaced with a newly appointed male director. We use the following model.

$$renewable\_energy\_consumption_{i,t} = \alpha + \beta_1 (f\_appointment \times post\ period)_{i,t} + \beta_2 (f\_appointment)_{i,t} + \beta_3\ (post\ period)_{i,t} + \beta_4 (Z)_{i,t} + \beta_5 \sum (industry\ effects)_i + \beta_6 \sum (year\ effects)_t + \varepsilon_{i,t} \tag{4}$$

The variable *f_appointment* is a dummy variable equal to one if the firm is in the treatment group, and zero if the firm is in the control group. *Post period* is a dummy variable equal to one for the period after the treatment, and zero for the period before. We match the treatment and control firm-year observations using propensity score matching similar to that used in Section 5.2.2.

The results, based on the matched sample from the DID analysis, are reported in Table E. The coefficient on the interaction *f_appointment* × *post period* is statistically significant (at the 10% level) and positive. This suggests that, a year after the appointment of a female director, firms use significantly more renewable energy than after the appointment of a male director. The lower level of coefficient significance may be due to the relatively low number of observations.

Table A
Average energy consumption (000’ MWh).

GICS industry sectors	N	WOBP	Renewable energy (1)	Total energy (2)	(1)/(2)
Energy	680	8.422	2923.500	11,965.977	24.43%
Materials	704	12.742	13,089.639	25,244.034	51.85%
Industrial	1793	12.454	4551.252	22,955.858	19.83%
Consumer Discretionary	1910	15.252	2842.384	14,006.450	20.29%
Consumer Staples	555	19.489	5131.662	18,508.899	27.73%
Health Care	1278	13.728	2318.417	11,098.074	20.89%
Financials	1683	14.088	726.686	2890.408	25.14%
Information Technology	1690	11.143	702.480	2484.176	28.28%
Communication	121	14.446	1660.630	8869.549	18.72%
Utilities	479	20.442	31,700.400	219,751.433	14.43%
Real Estate	784	11.584	6650.415	11,682.943	56.92%

Table A reports the number of observations, the percentage of women on the board, average renewable energy, and average total energy consumption in thousands of MWh as well as the former expressed as a percentage of the latter across different industry sectors based on the two-digit GICS codes.

Table B
One-year lagged variables analysis.

Variable	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
	REN/TC				ROS	ROA
WOBP	1.519***	-	-	-	0.119**	1.114**
	(2.652)	-	-	-	(2.122)	(2.192)
WOBN	-	1.352**	-	-	-	-
	-	(2.126)	-	-	-	-
W0	-	-	1.142	-	-	-
	-	-	(1.595)	-	-	-
W1	-	-	1.140	-	-	-
	-	-	(1.665)	-	-	-
W2	-	-	1.525***	-	-	-
	-	-	(2.466)	-	-	-
W3	-	-	1.587**	-	-	-
	-	-	(2.119)	-	-	-
WOB_independence	-	-	-	1.142**	-	-
	-	-	-	(2.094)	-	-
WOB_insider	-	-	-	1.588	-	-
	-	-	-	(1.713)	-	-
REN/TC	-	-	-	-	0.013*	1.024
	-	-	-	-	(1.879)	(1.149)
WOBP × REN/TC	-	-	-	-	0.139***	0.119**
	-	-	-	-	(2.309)	(2.131)
WCEO	0.485	1.012	1.611*	1.353*	0.019	1.130
	(0.334)	(0.486)	(1.977)	(1.985)	(0.334)	(1.118)
Board size	1.780**	2.344*	3.134	2.543*	0.621**	1.194**
	(2.114)	(1.898)	(1.224)	(1.882)	(2.119)	(2.145)
Duality	−0.078*	−1.132	−2.841	−2.230*	−0.019*	−0.132*
	(−1.837)	(−0.124)	(−0.441)	(−1.984)	(−1.993)	(−1.951)
%_Board independence	2.803***	2.338**	2.263*	1.425**	2.013**	2.064**
	(2.811)	(2.067)	(1.914)	(2.147)	(2.115)	(2.015)
B_meeting	−6.066	−7.152	−7.126	−8.012	−2.113	−4.178
	(−0.572)	(−0.772)	(−0.618)	(−1.705)	(−1.153)	(−1.611)
Tobin’s q	4.086*	−6.650	−7.162	4.410	-	-
	(1.943)	(−0.223)	(−0.246)	(1.232)	-	-
ROA	2.094*	2.021*	2.017*	1.179*	-	-
	(1.942)	(1.923)	(1.896)	(1.918)	-	-
Cash/net assets	0.023	3.011	2.732	3.120	0.199	0.145
	(1.228)	(1.354)	(0.149)	(1.393)	(1.217)	(1.182)
Leverage	−14.135	−14.257	−13.138	−11.312	−23.224	−14.315
	(−0.414)	(−0.784)	(−0.773)	(−1.713)	(−1.690)	(−1.642)
IO	−0.134	−0.123	−0.133	−0.203	−0.124	−0.142
	(−0.389)	(−0.429)	(−0.311)	(−1.401)	(−1.137)	(−1.663)
%_Insider owner	−0.503*	0.627	0.462	−1.345	−0.154*	−0.211*
	(−1.943)	(0.131)	(0.101)	(1.466)	(−1.991)	(−1.994)
Firm size	9.431***	16.173***	16.246***	7.122***	9.123**	8.011**
	(3.132)	(2.858)	(2.737)	(2.314)	(2.114)	(2.146)
Constant	15.546*	−25.740*	-	−16.740*	11.143**	10.111**
	(1.883)	(−1.849)	-	(−1.890)	(2.211)	(2.183)

(continued on next page)

Table B (*continued*)

Variable	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
	REN/TC				ROS	ROA
Industry effects	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y
N	10,434	10,434	10,434	10,434	10,434	10,434
Adj. R-sq	0.211	0.191	0.186	0.169	0.215	0.210

This table presents the results of regressions based on models 1 and 2 using one-year lagged variables. Columns 1–4 show the effects of *WOBP*, *WOBN*, the four dummy variables *W0*, *W1*, *W2, W3*, *WOB_independence,* and *WOB_insider* on renewable energy consumption based on OLS regressions, using one-year lagged levels. Columns 5 and 6 show the combined effect of *WOBP* and *REN/TC* on *ROS* and *ROA*, respectively, using one-year lagged levels. Industry (two-digit GICS) and year effects are included in all the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table C
Percentage of women on the board and renewable energy consumption for sub-period 2008–2012.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	Lagged OLS (4)
	REN/TC			
WOBP	1.081**	1.019**	1.001***	1.111**
	(2.153)	(2.194)	(2.426)	(2.143)
WCEO	-	2.226	1.275	1.132
	-	(1.239)	(1.122)	(1.011)
Board size	-	3.221*	1.712*	1.640***
	-	(1.945)	(1.912)	(2.432)
Duality	-	−1.156*	−0.046*	−0.066**
	-	(−1.893)	(−1.929)	(−2.173)
%_Board independence	-	2.264**	3.137***	1.703**
	-	(2.167)	(2.533)	(2.143)
B_meeting	-	−5.323	−4.132	−4.263
	-	(−1.143)	(−0.431)	(−1.645)
Tobin's q	-	1.444	4.023*	3.143*
	-	(1.232)	(1.899)	(1.942)
ROA	-	2.320*	3.038**	3.191**
	-	(1.995)	(2.111)	(2.148)
Cash/net assets	-	0.119	0.102	0.154
	-	(0.223)	(0.467)	(1.163)
Leverage	-	−17.043	−12.114	−14.154
	-	(−1.135)	(−1.171)	(−1.167)
IO	-	−0.099	−0.274	−0.163
	-	(−1.402)	(−1.152)	(−1.264)
%_Insider owner	-	−0.424*	−0.238*	−0.339*
	-	(−1.881)	(−1.986)	(−1.992)
Firm size	-	7.154**	5.645***	6.332***
	-	(2.173)	(3.133)	(2.754)
Constant	16.101***	15.142**	14.174**	10.132***
	(4.113)	(2.192)	(2.113)	(2.312)
Industry effects	Y	Y	Y	Y
Year effects	Y	Y	Y	Y
N	5984	5984	4218	3620
Adj. R-sq	0.118	0.201	0.241	0.222

This table presents the regression results for the sub-period 2008–2012 based on model 1: $renewable\_energy\_consumption_{i,t} = \alpha + \beta_1(board\_gender\_diversity)_{i,t} + \beta_2(Z)_{i,t} + \beta_3 \sum(industry\ effects)_i + \beta_4 \sum(year\ effects)_t + \varepsilon_{it}$ where gender diversity is measured by the percentage of female directors on the board (*WOBP*). Renewable energy is measured as a percentage of total energy consumption. Columns 2–4 present the results if all control variables are included. Columns 1 and 2 use the contemporaneous levels of the independent variables whereas Columns 3 and 4 use the two- and three-year lagged levels, respectively. Robust *t*-statistics are shown in parentheses. Industry (two-digit GICS) and year effects are included in all the regressions. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table D
Renewable energy and firm value.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	OLS (4)	OLS (5)	Lagged OLS (6)
	ROS			ROA		
REN/TC	0.024**	0.019**	0.009**	0.108**	0.013**	0.016*
	(2.154)	(2.101)	(2.111)	(2.143)	(2.177)	(1.942)
WCEO	-	0.201	0.018	-	0.119	0.019
	-	(1.223)	(0.201)	-	(1.188)	(1.432)
Board size	-	2.099**	1.220**	-	2.232**	0.432**

(*continued on next page*)

Table D (*continued*)

Variable	OLS (1)	OLS (2)	Lagged OLS (3)	OLS (4)	OLS (5)	Lagged OLS (6)
	ROS			ROA		
	-	(2.143)	(2.098)	-	(2.131)	(2.142)
Duality	-	−0.089**	−0.010*	-	−0.148*	−0.019*
	-	(−2.109)	(−1.894)	-	(−1.991)	(−1.887)
%_Board independence	-	2.029**	2.001**	-	1.143**	1.133**
	-	(2.131)	(2.144)	-	(2.101)	(2.079)
B_meeting	-	−4.175	−2.101	-	−2.113	−2.101
	-	(−1.148)	(−1.163)	-	(−1.202)	(−1.281)
Cash/net assets	-	1.022	1.155	-	1.302	1.019
	-	(1.562)	(1.101)	-	(1.133)	(1.233)
Leverage	-	−15.103	−13.111	-	−11.321	−9.111
	-	(−1.543)	(−1.544)	-	(−1.157)	(−1.732)
IO	-	−1.421*	−1.017*	-	−1.123*	−1.143
	-	(−1.984)	(−1.052)	-	(−1.891)	(−1.121)
%_Insider owner	-	−0.412*	−0.143*	-	−0.123	−0.109*
	-	(−1.923)	(−1.955)	-	(−1.681)	(−1.886)
Firm size	-	5.202**	5.111*	-	4.013**	3.432**
	-	(2.115)	(1.883)	-	(2.132)	(2.119)
Constant	2.243***	5.132***	6.342***	3.124***	4.107***	5.432***
	(4.112)	(2.874)	(2.321)	(3.232)	(2.674)	(2.743)
Industry effects	Y	Y	Y	Y	Y	Y
Year effects	Y	Y	Y	Y	Y	Y
N	11,677	11,677	9190	11,677	11,677	9190
Adj. R-sq	0.132	0.182	0.221	0.201	0.233	0.244

This table presents the results for the regressions explaining firm performance measured by the return on sales (*ROS*) and return on assets (*ROA*), respectively. Columns 1 and 4 show the results without the control variables. Columns 2–3 and 5–6 present the results when all the control variables are included. Columns 1–2 and 4–5 use the contemporaneous levels of the independent variables whereas Columns 3 and 6 use the two-year lagged variables. Industry (two-digit GICS) and year effects are included in all the regressions. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table E
Difference-in-differences estimator.

	REN/TC
f_appointment × post period	0.092*
	(1.937)
f_appointment	0.102*
	(1.878)
post period	−1.174
	(−1.032)
All controls	Y
Industry dummies	Y
Year dummies	Y
N	128
adj. R-sq	0.103

The table presents the difference-in-differences estimator for the matched sample where *f_appointment* represents treatment group (consisting of female director appointments with zero renewable energy consumption prior to such appointment) and control group (where a male director replaces a male director). The OLS regression results are reported using REN/TC as the dependent variable. The regression includes year and industry effects. Robust *t*-statistics are shown in parentheses. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

Table F
De-trending analysis of the percentage of women on the board and renewable energy consumption.

Variable	OLS (1)	OLS (2)	Lagged OLS (3)
	REN/TC_RES		
WOBP_RES	1.800**	2.903**	3.820**
	(2.159)	(2.182)	(2.139)
WCEO	-	5.962	6.900

(*continued on next page*)

Table F (*continued*)

Variable	OLS (1)	OLS (2)	Lagged OLS (3)
	REN/TC_RES		
	-	(0.032)	(0.292)
Board size	-	10.126*	8.129
	-	(1.859)	(0.036)
Duality	-	−0.132	−0.045
	-	(−1.323)	(−1.562)
%_Board independence	-	2.438	3.320*
	-	(0.760)	(1.943)
B_meeting	-	−7.079	−2.441
	-	(−0.025)	(−0.095)
Tobin's q	-	−6.044	4.389*
	-	(−1.214)	(1.891)
ROA	-	2.324*	0.029**
	-	(1.992)	(2.103)
Cash/net assets	-	0.101	0.144
	-	(0.321)	(1.158)
Leverage	-	−15.509	−20.383
	-	(−0.840)	(−0.801)
IO	-	−0.127*	−0.051
	-	(−1.882)	(−0.033)
%_Insider owner	-	−0.659*	0.051*
	-	(−1.892)	(1.987)
Firm size	-	16.280***	26.761***
	-	(2.640)	(3.281)
Constant	2.690*	18.480*	11.484**
	(1.917)	(1.872)	(2.141)
Industry effects	Y	Y	Y
Year effects	Y	Y	Y
N	11,677	11,677	9190
Adj. R-sq	0.091	0.132	0.145

This table presents the regression results where gender diversity is measured by the predicted percentage of female directors on the board (*WOBP_RES*). Renewable energy is measured by its predicted percentage of total energy consumption (*TEN/TC_RES*). Columns 2 and 3 present the results if all control variables are included. Columns 1 and 2 use the contemporaneous levels of the independent variables whereas Column 3 uses the two-year lagged levels. Robust *t*-statistics are shown in parentheses. Industry (two-digit GICS) and year effects are included in all the regressions. ***, **, * denote statistical significance at the 1%, 5%, and 10% level, respectively. All variables are defined in Table 1.

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