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Finance Working Paper N° 617/2019
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ECGI Working Paper Series in Finance

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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 renewable energy consumption and board gender diversity on firm financial performance. Our findings are robust to different identification strategies and estimation techniques.

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Keywords: corporate governance, renewable energy, gender diversity, corporate social responsibility, environmental protection.

JEL Classifications: G30, G34

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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 renewable energy consumption and board gender diversity on firm financial performance. Our findings are robust to different identification strategies and estimation techniques.

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## 1. Introduction

Climate change, caused by carbon dioxide ($CO_2$) emissions from human activities, has emerged as one of the grand challenges for society (IPCC, 2007). Specifically, the consumption of fossil energy, such as coal, oil and natural gas, has been shown to account for 60% of global carbon dioxide ($CO_2$) emissions in 2013.[1] To reduce such emissions, it is imperative to substitute clean energy for fossil energy (Kolk and Pinkse, 2005; Lash and Wellington, 2007; Edenhofer et al., 2011; Ben-Amar et al., 2017).[2] The increase in the share of renewable energy in the total energy mix largely depends on the efforts of companies, since they consume significant amounts of energy.[3] Clearly, 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, board diversity improves the firm's decision making by increasing the chance that different knowledge domains, perspectives and ideas will be considered in the decision-making process (Post et al., 2011; Liao et al., 2015; Chen et al., 2019).

This paper contributes to the literature on board gender diversity and environmental corporate social responsibility (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. Women have been shown to be more caring, which includes a greater emphasis on CSR (Shaukat et al., 2016) as well as the reduction in negative business practices (Boulouta, 2013; Cumming et al., 2015) and related

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[1] Since the industrial revolution, $CO_2$ emissions from fossil fuel combustion have increased rapidly from almost zero to 32 Giga tons (Gt) in 2013 (IEA, 2016a, 2016b). 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).

[3] Many companies are attempting to develop products and processes that are both profitable and environmentally friendly (Katsikeas et al., 2016). Importantly, renewable forms of energy are recognized as potential alternatives for alleviating the environmental problems caused by the prolonged utilization of conventional sources of energy (Bang et al., 2000).

lawsuits (Liu, 2018). Recent research suggests that female leadership encourages the move towards energy efficiency and green building, as well as the implementation of climate change policies. Such firms also disclose more information on environmental aspects (Williams, 2003; Jizi, 2017).[4] Importantly, women are more likely to express environmental concerns, 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 tend to be significant because women are considered to favor 'soft' energies (i.e., renewables) and men 'hard' energies (i.e., fossil fuel and nuclear energy) (Longstreth et al., 1989). Hence, we expect that women play an important role on the board in supporting renewable energy consumption. In support of our conjecture, Pearl-Martinez and Stephens (2016) argue that improving gender diversity in the workforce is an important step towards a more sustainable society.

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 and timely questions. Does having 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 attempt to answer these questions by investigating a panel of data consisting of 1,491 firms for the period of 2008–2016, amounting to 11,677 firm-year observations from one of the leading economies in the world, i.e., the USA. We find that renewable energy consumption is positively related to the percentage of women on the board as well as the number of female directors. Importantly, we find that there need to be two or more women on the board to have a significant impact of female board representation on renewable energy consumption. This supports the critical mass

[4] Further, the Center for Responsible Business (CRB, 2012) reports that firms with women on their board of directors are more likely to invest proactively in renewable energy and to reduce carbon emissions throughout their value chain.

theory that "one is a token, two is a presence, and three is a voice" (Kristie, 2011, p.22). When distinguishing between female executive (inside) directors and female independent directors, we find that the effect of the latter is more pronounced than that of the former. This is intuitive given the monitoring role of independent directors. Moreover, we find a positive effect of the interaction of board gender diversity and renewable energy consumption on firm financial performance. Our results are robust to the use of alternative econometric specifications, as well as the use of alternative measures for renewable energy, firm financial performance, and the presence of women on the board.

Importantly, our study is subject to endogeneity concerns as an omitted variable may drive the positive association between women on the board and renewable energy consumption, thereby biasing our results. For example, male directors responsive to environmental concerns may also be responsive 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 and use two-stage least squares (2SLS) to extract the exogenous component from the percentage of women on the board. Our 2SLS results 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 from 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 and again, to the best of our knowledge this is the only 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. Extant literature tends to focus on the impact of female directors on environmental CSR ratings (e.g., Post et al., 2011) and environmental disclosure (e.g., Williams, 2003; Liao et al., 2015; Jizi, 2017). From a policy perspective, this study offers new insights for policy makers into the value of board gender diversity. If having women on the board increases renewable energy consumption, then policy makers aiming at sustainability should encourage firms to recruit more female directors.

Second, we test the validity of the critical mass theory from a novel perspective. If this theory is valid, we should observe a positive effect of women directors on renewable energy consumption only for boards with two or more women. We find such evidence. This evidence contributes 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. We distinguish between female executives and female independent directors. We find that the effect is stronger for female independent directors. 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, our findings also suggest that the interplay of 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 of a positive link between firm environment and financial performance, we unveil a context within which this link is 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 start this section by reviewing the literature that investigates the business case for board gender diversity. We then review gender socialization and ethicality theories as well as diversity theory, which provide a number of reasons why females in general and female board directors in particular are more likely to make environmentally friendly decisions. Finally, we review extant literature on board gender diversity and environmental CSR, and 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

The theoretical basis for the business case for diverse groups is diversity theory and group decision-making theory (see also Section 2.2). 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 in preferences are the same as "typical" gender differences, then it is plausible that increasing board gender diversity will lead to different and better board dynamics and decision making (Croson and Gneezy, 2009; Adams, 2016).

A fast-growing body of literature provides empirical support for the above theoretical benefits from having females on the board of directors, thereby confirming the business case for board gender diversity. First, female directors 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 reduce 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. Female directors also decrease corporate tax aggressiveness (Lanis et al., 2017). Second, female directors tend to enhance corporate governance practices: Female directors put more emphasis on monitoring as reflected by more board meetings, and better attendance by both males and females at board meetings (Adams and Ferreira, 2009; Goergen and Renneboog, 2014), as well as a higher dividend payout for firms with otherwise weaker governance (Chen et al., 2017). Third, they improve decision making, such as decisions about mergers and acquisitions (Levi et al., 2014)[5] as well as reducing cognitive biases, such as overconfidence, in male CEOs (Chen et al., 2019). Fourth, although there is still some disagreement as to the effect of board gender diversity on firm value and performance, a consensus is emerging that female directors at best add value and at worst do not add value (Post and Byron, 2015).[6] Further, Owen and Temesvary (2018) find that female directors increase firm value once they have reached a critical mass on the board of directors. Fifth, female directors also improve firm reputation (Hill and Jones, 1992; Heugens et al., 2004), especially in consumer-oriented industries (Brammer et al., 2009). Moreover, there is also a literature, which suggests that firms with female directors have a stronger stakeholder orientation (e.g., 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 greater 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 be more philanthropic, as reflected by e.g., a greater response to natural disasters in their region (Jia and Zhang, 2013).

To sum up, the above review of the literature suggests that female directors typically have a positive impact on corporate decision making, including its quality, and that they also tend to have a greater stakeholder orientation than their male counterparts. In what follows, we use gender socialization theory, ethicality theory and diversity theory to provide a number of reasons why female board directors in particular 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.

[5] Levi et al. (2014) interpret their findings as evidence that female directors are less overconfident than their male counterparts.
[6] 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), and Owen and Temesvary (2018).

### 2.2 Women, morality and ethics

Why would women in general and female directors in particular be more inclined to use renewable energy? Diversity theory and group decision-making theory as well as gender socialization and ethicality theories provide theoretical arguments for the greater use of renewable energy by firms with female directors.

Diversity theory and group decision-making theory suggest that more diverse social groups – including boards of directors – make better decisions. More diverse groups benefit from the different experiences, backgrounds and demographic traits of their members are likely to bring different perspectives and opinions to the table, which are crucial when making complex decisions (e.g., Forbes and Milliken, 1999; Page, 2007). Conversely, homogenous groups may suffer from "groupthink" (Mullen et al., 1994), a phenomenon characterized by a lack of independent critical thinking and the avoidance of disagreement at all cost (Janis, 1983).[7]

More specifically, gender socialization and ethicality theories suggest a number of reasons why women tend to be more sensitive to ethical issues (Cumming et al., 2015), in turn increasing their propensity to make environmentally friendly corporate decisions. Freud (1925) already pointed out that there are gender differences in morality. Similarly, Kohlberg (1971) and Carlson (1972) highlight differences in morality and ethicality across gender. According to gender socialization theory (e.g., Dawson, 1997), such differences stem from nurture as men and women have a different relation with their mother and are therefore taught different gender roles, which are characterized by their own rules and values.

[7] In contrast, Westphal and Bednar (2005) argue that too much diversity among *independent* directors may lead to what they call "pluralistic ignorance" in badly performing firm. Such pluralistic ignorance consists of independent directors avoiding to voice their concerns about the firm's failing strategy given their erroneous belief that the other independent director, who likely have similar concerns, have confidence in the firm's strategy.

Importantly, Gilligan (1977) argues that, given the differences in gender socialization, women define morality and ethics differently from men. For women morality is about responsibilities whereas for men it is about rights. For women 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. In other words, the male definition of morality tends to refer to non-interference with the rights of others. Based on a survey of directors, Adams and Funk (2012) find confirmation that, similar to women in general, female directors care more about society at large than their male counterparts. On a slightly different note, Eagly and Crowley (1986) conclude from their meta-analysis of the social psychology literature that the helping behavior of men also differs from that of women. While men's helping behavior tends 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. The above gender differences in morality, ethicality and helping behavior suggest that female directors should be more likely to care about global warming, a long-term societal challenge, and should therefore be more likely to promote renewable energy consumption than their male counterparts. In what follows, 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 (see Section 2.2), 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; Isidro and Sobral, 2015; Al-Shaer and Zaman, 2016; McGuinness et al., 2017). They are also more inclined to take actions to reduce perceived risks (Schubert et al., 1999; Carter et al., 2003; Adams and Ferreira, 2009). 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. Similarly, Bear et al. (2010) and McGuinness et al. (2017) find that female directors increase CSR ratings, in particular strengths in CSR, thereby improving the firm's reputation. Finally, firms with female directors are also more likely to make voluntary disclosures about CSR,[8] which in turn are more valued by the market than voluntary disclosures by firms without female directors (Nekhili et al., 2017).

Closer to the focus of this paper, there is evidence that female directors are more concerned about their firm's environmental impact. For example, firms with female directors are less likely to be subject to environmental lawsuits (Liu, 2018). More generally, Pearl-Martinez and Stephens (2016) hypothesize that increased gender diversity in the workforce is a necessary condition for the transition towards a more sustainable society, given that women are likely to accelerate innovation, including the introduction of sustainable practices.

The above review of the literature has pointed out that female directors have a significant effect on firm decision making and this effect tends to be positive. Further, as predicted by morality, ethicality and diversity theories, women in general and female directors in particular should have a greater propensity to pursue the common good, which includes tackling society's long-term, grand challenges. This prediction is confirmed by empirical studies, which find that female directors are less likely to engage in corporate wrongdoing, and are more concerned about CSR, including environmental CSR. This leads us to our first hypothesis:

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

[8] In contrast, we do not find that firms with female directors are more likely to disclose their consumption of renewable energy. In detail, for the sub-sample 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*).

While the above-mentioned literature review suggests that women have an impact on firm policies, including CSR and environmental policies, the same literature also tends to suggest that having just one female director on the board may not be sufficient to affect corporate decision making. Kanter (1977a) provides a reason why this might be the case: A single woman on the board may be a "token", i.e., an individual whose role is to be the sole representative of a particular group (e.g., a woman). Kanter (1977a) further suggests that dominant 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). Such gender-role stereotypes of women leaders also contribute to the pay gap between male and female directors (Kulich et al., 2007) since men hold most of the top positions and are likely to be associated with strong managerial attributes (Powell et al., 2002; Powell and Butterfield, 2003). This historical token status of women in top management reinforces the stereotypes that women have weaker attributes for serving in top positions (Lee and James, 2007).

Importantly, this token status of women suggests a need for a critical mass of women 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 voice. Real change occurs when there are enough women on the board (Konrad et al., 2008; 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, suggesting that there needs to be a critical mass of female directors for there to be an impact on CSR.[9] 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 support roles (Hillman and Dalziel, 2003; Lara et al., 2017). In other words, 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 different impact on corporate decision making when compared to 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 dividend 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. 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.*

[9] 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.

## 2.4 Relationship between firm environmental and financial performance

Several empirical studies investigate the relationship between environmental responsibility and financial performance. Some of these studies argue that the firm's investment in environmental protection has an adverse impact on its economic and financial performance. Walley and Whitehead (1994), Klassen and Whybark (1999), and Telle (2006) find support for this argument in the form of a negative relationship between firm environmental management and financial performance. They conclude that firms attempting to improve their environmental performance deploy their scarce assets and resources away from the central areas of the business, resulting in lower financial performance.

In contrast, another group of studies, such as Porter and Van der Linde (1995), Hart (1997), 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 risks through various environmental initiatives (e.g., renewable energy consumption) while maximizing new business prospects and ultimately achieving both greater environmental and financial performance. Nevertheless, a few 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.

Considering this inconclusive evidence from empirical studies, some recent studies, such as 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 from 1978 to 2008, Horváthová (2010) shows that 55% of the studies found a positive, 15% a negative, and 30% an insignificant effect of environmental improvement on financial performance. In the same vein, reviewing the findings of 149 studies, Endrikat et al. (2014) conclude that there is a positive relationship between firm environmental and financial performance. Finally, Busch and Lewandowski (2018), covering a total of 101,775 observations from 32 empirical studies, highlight that better carbon performance is positively linked to greater financial performance. Hence, overall, the evidence suggests that there is a positive relationship between firm environment performance and financial performance.

Similarly, and as discussed in Section 2.1, the literature on the impact of female directors on firm performance and firm value is somewhat inconclusive. Nevertheless, and similar to the literature on the link between environmental CSR and firm performance, most of the literature either finds a positive or neutral effect of female directors on firm performance and firm value. We speculate that the interplay of female board representation and greater 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 in isolation. 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. 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.[10] 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

[10] 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.

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 1,491 firms or 11,677 firm-year observations.[11]

### 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:

$$renewable\ energy\ consumption_{i,t} = \alpha + \beta_1(board\ gender\ diversity)_{i,t}$$

$$+\beta_2(Z)_{i,t} + \beta_3\sum(industry\ effects)_i + \beta_4\sum(year\ effects)_t + \varepsilon_{it} \quad (1)$$

$$firm\ perf_{i,t} = \alpha + \beta_1(renewable\ energy\ consumption)_{i,t}$$

$$+\beta_2(board\ gender\ diversity)_{i,t}$$

$$+\ \beta_3(board\ gender\ diversity \times\ renewable\ energy\ consumption)_{i,t}$$

$$+\ \beta_4(Z)_{i,t} + \beta_5\sum(industry\ effects)_i$$

[11] 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.

$$+ \beta_6 \sum (year\ effects)_t + \varepsilon_{i,t} \qquad (2)$$

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*). We use the return on equity (*ROE*) and *Tobin's q* as additional 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 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 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.

[Insert Table 1 about here]

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[12] 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

[12] 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.

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.

[Insert Table 2 about here]

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%).

Figure 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. Figure 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 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 0.70% 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). Figure 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.[13]

[Insert Figures 1, 2 and 3 about here]

[13] 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 3 shows the correlations among the variables used in our 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 of the variables have a variance inflation factor (VIF) of less than 1.24 and the overall mean VIF value is 1.23.[14] This suggests that multicollinearity is not an issue.

[Insert Table 3 about here]

## 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.[15] 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 corporate governance and firm characteristics, while the regressions in Columns 3 and 4 include the two-year and three-year lagged corporate governance and firm characteristics, respectively.[16]

[Insert Table 4 about here]

[14] Lardaro (1993) suggests that multicollinearity is an issue if the VIF exceeds 10.
[15] We consider the firm's renewable consumption usage rather than production.
[16] The results based on the one-year lagged levels are consistent with the main findings and are presented in Table B (Appendix).

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.[17] 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 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. The number In addition, the dummy

[17] 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., 2019). 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 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, including a more extensive discussion, in the Appendix (Table F).

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.

[Insert Table 5 about here]

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 and 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.

### 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. [18] Our results

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

remain qualitatively the same after controlling for a female CEO *(WCEO)* in these regressions.[19]

[Insert Table 6 about here]

### 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*).[20] 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 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.[21]

[Insert Table 7 about here]

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*

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[19] 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.
[20] 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.
[21] We drop *Tobin's q* in Table 7 as it may influence the relationship between *WOBP×REN/TC* and firm value.

*independence*, and *Firm size* also have a significantly positive relationship with firm performance.

## 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 towards 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*

*Discretionary* and *Industrial* sectors due to their high numbers of observations.[22] (iv) We control for additional director characteristics, i.e., tenure, age, and qualifications.[23]

Table 8 reports the results of the above-mentioned tests based on models 1 and 2. Panel A repeats the OLS regressions from Table 4 and Table 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*.[24] 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 Columns 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 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

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

[23] 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).

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

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.

[Insert Table 8 about here]

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 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 (2SLS); (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.[25] 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-

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

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.

[Insert Table 9 about here]

### 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.[26]

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.[27] 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.

[Insert Table 10 about here]

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*

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[26] 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.
[27] The mean difference between the treatment group and the control group is based on the average treatment effect on the treated (ATT).

is significantly positive suggesting that women on the board have a strong impact on renewable energy consumption.[28] 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 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.,

[28] 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.

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.[29] 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 between the two groups.

[Insert Table 11 about here]

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.[30]

[29] 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).
[30] 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).

### 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 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*.

[Insert Table 12 about here]

## 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 renewable energy and have gender diverse boards enjoy better financial performance. These findings are robust to alternative econometric specifications, alternative measures of board gender diversity, renewable energy consumption, 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. Such a study may also be able 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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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 |

Table 2. Descriptive statistics

| | Full Sample N = 11,677 | | With female N = 8,926 | | Without female N = 2,751 | | | | Firms with REN | | Firms without REN | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | 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 | 133.154 | 4216.033 | 0.000 | 0.000 | 133.154*** | 15.126 |
| **Panel B: Gender diversity** | | | | | | | | | | | | | | |
| WOBP | 13.503 | 10.303 | 17.665 | 8.084 | 0.000 | 0.000 | 17.665*** | 110.023 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| WOBN | 1.242 | 1.122 | 1.624 | 1.013 | 0.000 | 0.000 | 1.624*** | 84.116 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| W1 | 0.323 | 0.468 | 0.459 | 0.493 | 0.000 | 0.000 | 0.459*** | 44.866 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| W2 | 0.244 | 0.429 | 0.349 | 0.468 | 0.000 | 0.000 | 0.349*** | 35.873 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| W3 | 0.128 | 0.335 | 0.189 | 0.374 | 0.000 | 0.000 | 0.189*** | 23.561 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| WOB_independence | 0.112 | 0.081 | 0.158 | 0.067 | 0.000 | 0.000 | 0.158*** | 105.432 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| WOB_insider | 0.009 | 0.310 | 0.011 | 0.039 | 0.000 | 0.000 | 0.011*** | 29.872 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| **Panel C: Corporate governance** | | | | | | | | | | | | | | |
| WCEO | 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.

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

| | OLS (1) | OLS (2) | Lagged OLS (3) | Lagged OLS (4) |
|---|---|---|---|---|
| Variable | | 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 | 9,190 | 7,950 |
| Adj. R-sq | 0.137 | 0.232 | 0.223 | 0.246 |

This table presents the regression results of model (1):

$$renewable_{energy_{consumption}\,i,t} = \alpha + \beta_1\left(board\ \ gender_{diversity}\right)_{i,t} + \beta_2(Z)_{i,t} + \beta_3\sum(industry\ effects)_i + \beta_4\sum(year\ effects)_t + \varepsilon_{it}$$

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 5. Gender diversity level and use of renewable energy

| | OLS | Lagged OLS | Lagged OLS | OLS | Lagged OLS | Lagged OLS |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Variable | | | 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 | 9,190 | 7,950 | 11,677 | 9,190 | 7,950 |
| 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.

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

| | OLS | Lagged OLS | Lagged OLS |
|---|---|---|---|
| | (1) | (2) | (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 | 9,190 | 7,950 |
| 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.

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

| | OLS (1) | OLS (2) | Lagged OLS (3) | Lagged OLS (4) | OLS (5) | OLS (6) | Lagged OLS (7) | Lagged OLS (8) |
|---|---|---|---|---|---|---|---|---|
| Variable | 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 | 9,190 | 7,950 | 11,677 | 11,677 | 9,190 | 7,950 |
| 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:

$$firm_{perf\,i,t} = \alpha + \beta_1 \left(renewable_{energy_{consumption}}\right)_{i,t} + \beta_2 \left(board_{gender_{diversity}}\right)_{i,t}$$

$$+ \beta_3 \left(board_{gender_{diversity}} \times renewable_{energy_{consumption}}\right)_{i,t} + \beta_4 (Z)_{i,t}$$

$$+\beta_5 \sum(industry\ effects)_i + \beta_6 \sum(year\ effects)_t + \varepsilon_{i,t}$$

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 3-4 and 7-8 use the two-year 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.

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* = 7,974) | | | | | | | | | |
| 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* = 7,801) | | | | | | | | | |
| 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

| | First-stage | Second-stage |
|---|---|---|
| Variable | 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.

Table 10. Propensity score matching

| Panel A | Pre-match (1) | Post-match (2) | REN/ TC |
|---|---|---|---|
| Variable | W_dummy | | (3) |
| 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 | 2,724 | 1,134 | 1,134 |
| 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.

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.

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's 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.

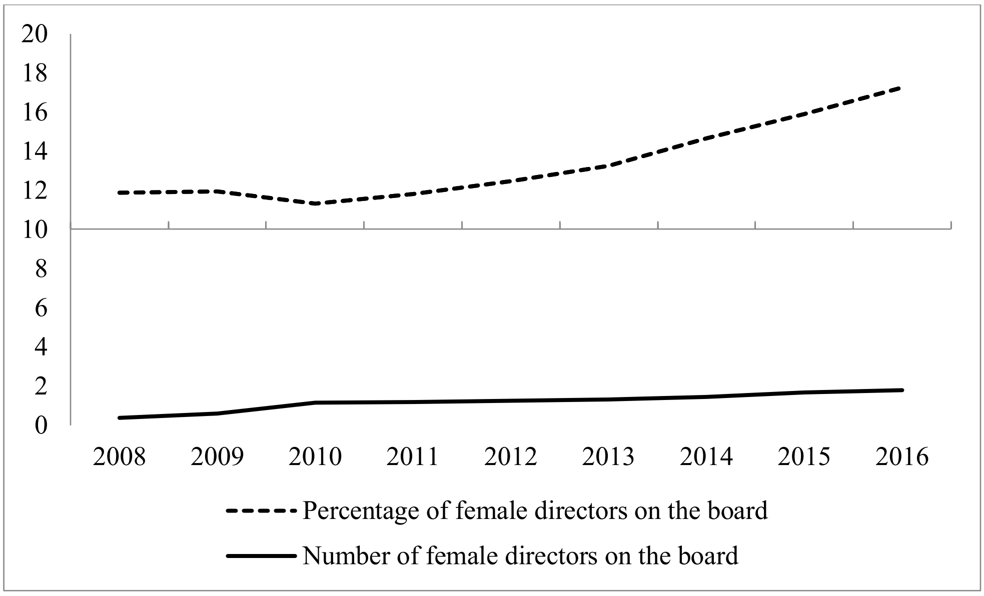


Figure 1 Average percentage of female directors on the board by year

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 1,491 S&P 1500 firms.

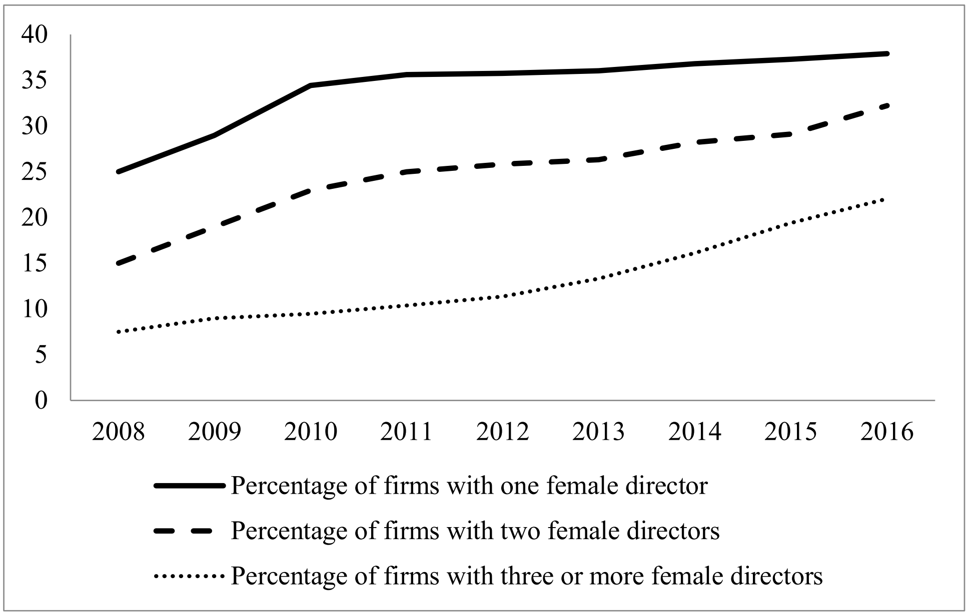


Figure 2 Percentage of firms with one, two and more female directors on the board by year

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 1,491 S&P 1500 firms.

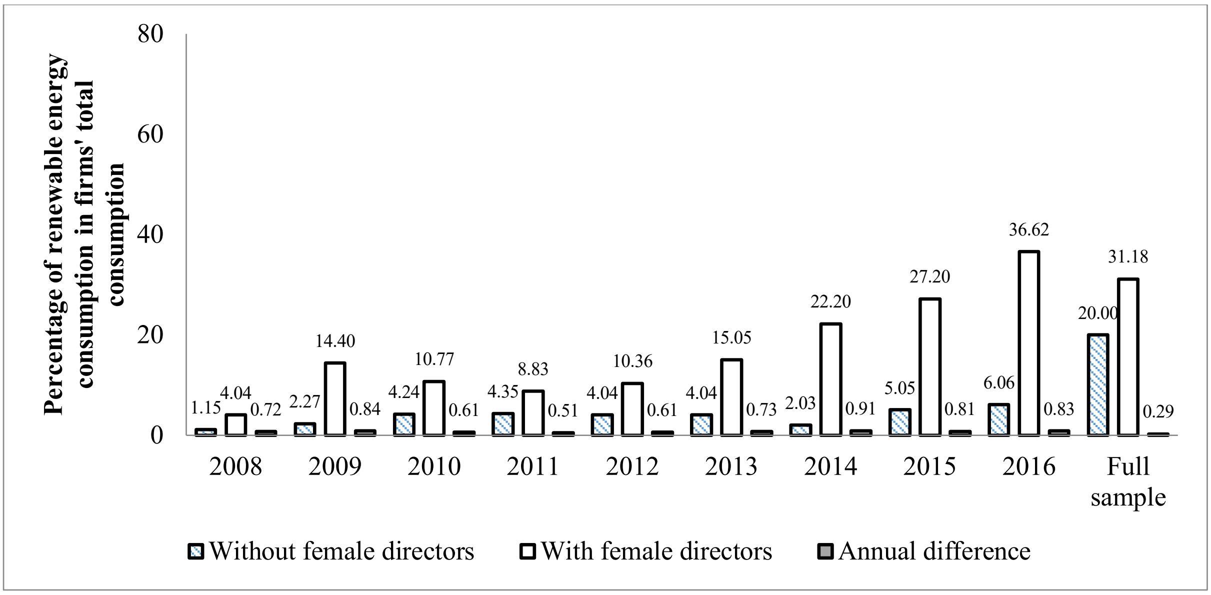


Figure 3 Renewable energy consumption as a percentage of total energy consumption per year

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 1,491 S&P 1500 firms.

## Appendix

### 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.

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

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 | 2,923.500 | 11,965.977 | 24.43% |
| Materials | 704 | 12.742 | 13,089.639 | 25,244.034 | 51.85% |
| Industrial | 1,793 | 12.454 | 4,551.252 | 22,955.858 | 19.83% |
| Consumer Discretionary | 1,910 | 15.252 | 2,842.384 | 14,006.450 | 20.29% |
| Consumer Staples | 555 | 19.489 | 5,131.662 | 18,508.899 | 27.73% |
| Health Care | 1,278 | 13.728 | 2,318.417 | 11,098.074 | 20.89% |
| Financials | 1,683 | 14.088 | 726.686 | 2,890.408 | 25.14% |
| Information Technology | 1,690 | 11.143 | 702.480 | 2,484.176 | 28.28% |
| Communication | 121 | 14.446 | 1,660.630 | 8,869.549 | 18.72% |
| Utilities | 479 | 20.442 | 31,700.400 | 219,751.433 | 14.43% |
| Real Estate | 784 | 11.584 | 6,650.415 | 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

| | OLS | OLS | OLS | OLS | OLS | OLS |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Variable | | 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) |
| 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 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 levels, respectively. 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

| | OLS (1) | OLS (2) | Lagged OLS (3) | Lagged OLS (4) |
|---|---|---|---|---|
| Variable | | 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 | 5,984 | 5,984 | 4,218 | 3,620 |
| 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

| | OLS (1) | OLS (2) | Lagged OLS (3) | OLS (4) | OLS (5) | Lagged OLS (6) |
|---|---|---|---|---|---|---|
| Variable | | 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** |
| | - | (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 | 9,190 | 11,677 | 11,677 | 9,190 |
| 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 (consists of female director appointment with zero renewable energy consumption prior to such appointment) and control group (where male director replaces 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

| | OLS (1) | OLS (2) | Lagged OLS (3) |
|---|---|---|---|
| Variable | | REN/ TC_RES | |
| WOBP_RES | 1.800** | 2.903** | 3.820** |
| | (2.159) | (2.182) | (2.139) |
| WCEO | - | 5.962 | 6.900 |
| | - | (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 | 9,190 |
| Adj. R-sq | 0.091 | 0.132 | 0.145 |

This table presents the regression results where gender diversity is measured by predicted percentage of female directors on the board (*WOBP_RES*). Renewable energy is measured as the 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 use 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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