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# The Eco Gender Gap in Boardrooms

Finance Working Paper N° 861/2022
December 2022

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ECGI Working Paper Series in Finance

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We are grateful for helpful comments from Pat Akey, Hao Liang, Daniel Skarlicki, Jing Xu, Chelsea Yang, and Yuxiang Zheng, seminar participants at University of Utah, and conference participants at the NTHU Symposium on Sustainable Finance and Economics. We thank excellent research support from McKenna Carpenter, Jianqiang Chen, Gen Li, and Huayi Tang. Li acknowledges financial support from the Social Sciences and Humanities Research Council of Canada (Grant Number: 435-2022-0285), the Canada Research Chair in Corporate Governance, and the Montalbano Centre for Responsible Leadership Development at UBC Sauder School of Business. All errors are our own.

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## Abstract

Using novel firm- and facility-level measures of corporate environmental performance over the period 2002–2021, we establish a positive association between board gender diversity and corporate environmental performance. For identification, we exploit variations in the legal protection and economic opportunity for women in states where directors went to college or when they were college-age, and the California law change in 2018 mandating female directors for firms headquartered in California. In terms of channels, we show that female directors bring more expertise on sustainability in boardrooms than male directors, that female directors are more likely to sit on sustainability committees and key monitoring committees than male directors, and that boards with more female directors are more likely to link top executives' compensation to corporate ESG performance. We conclude that there are important environmental benefits for board to be gender diverse.

Keywords: female directors; boards; corporate environmental performance; pollution prevention; emissions; board gender quota

JEL Classifications: G30; G38; G41

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# The Eco Gender Gap in Boardrooms


## Abstract

Using novel firm- and facility-level measures of corporate environmental performance over the period 2002–2021, we establish a positive association between board gender diversity and corporate environmental performance. For identification, we exploit variations in the legal protection and economic opportunity for women in states where directors went to college or when they were college-age, and the California law change in 2018 mandating female directors for firms headquartered in California. In terms of channels, we show that female directors bring more expertise on sustainability in boardrooms than male directors, that female directors are more likely to sit on sustainability committees and key monitoring committees than male directors, and that boards with more female directors are more likely to link top executives' compensation to corporate ESG performance. We conclude that there are important environmental benefits for board to be gender diverse.



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*"Boards with a diverse mix of genders, ethnicities, career experiences, and ways of thinking have, as a result, a more diverse and aware mindset. They are less likely to succumb to groupthink or miss new threats to a company's business model. And they are better able to identify opportunities that promote long-term growth."*

*– Blackrock CEO Larry Fink's Annual Letter to CEOs, January 19, 2018*

*"…a 'eco gender gap' revealing that men are less likely to pursue environmentally-friendly behaviours than their female counterparts."*

*– Jack Duckett, Senior Consumer Lifestyles Analyst at Mintel, July 27, 2018*

## 1. Introduction

Despite increasing attention and scrutiny from policy makers, regulators, and institutional investors regarding gender diversity in boardrooms, as of 2020, only 28% of board directors are female in the U.S. (Catalyst 2021). Ten European countries have responded to lack of gender diversity in boardrooms by adopting mandatory quotas since 2003. On September 30, 2018, California became the first U.S. state to set quotas for female directors on corporate boards (Senate Bill 826 2018). A number of studies document negative price reactions to affected firms in California, suggesting short-run shareholder value loss (Greene, Intintoli, and Kahle 2020; Hwang, Shivdasani, and Simintzi 2021; Meyerinck, Niessen-Ruenzi, Schmid, and Solomon 2021; Gertsberg, Mollerstrom, and Pagel 2022). In this paper, we study the benefit of board gender diversity from an environmental perspective. We examine whether and how board gender diversity influences corporate environmental performance, using novel firm- and facility-level environmental performance measures combined with a rich set of board/director characteristics for over 3,100 firms over the period 2002–2021.

Corporate environmental performance, similar to investments in intangible assets, is characterized by a prolonged period of resource commitment, and generates positive externalities to stakeholders, community, and environment in general. Our conceptual framework builds on a number of well-established gender differences in values and psychological traits that have implications for corporate decision making related to

environmental performance. These include gender differences in personal values regarding benevolence and universalism, and in long-term orientation (Silverman 2003; Schwartz and Rubel 2005; Castillo, Ferraro, Jordan, and Petrie 2011). In terms of psychological characteristics, relative to men, women possess more communal traits: they are affectionate, helpful, kind, sympathetic, interpersonally sensitive, nurturing, and concerned about others' welfare (Eagly, Johannesen-Schmidt, and van Engen 2003). Consistent with these gender differences in values, a 2019 PwC survey of more than 700 public company directors find that 71% of the surveyed female directors support a broader stakeholder model of governance compared to 54% of the surveyed male directors. Taken together, we expect that having more women on boards would encourage more open discussions among directors, and bring broader and more diverse perspectives to allow the board to better assess the needs of different stakeholders, improving corporate environmental performance.

On the flip side, Adams and Funk (2012) and Lewellen (2022) provide evidence suggesting that self-selection and professional expertise reduce, or even eliminate, gender differences in personal values and psychological characteristics. Rose and Bielby (2011) argue that the inclusion of women and visible minorities on corporate boards is symbolic to manage corporate image and external relations without real consequences. Galbreath (2011) further notes that sex-based bias and stereotyping could exist in boardrooms dominated by male directors who discount inputs from female directors on environmental issues. Therefore, it is an empirical question if female directors could indeed help improve corporate environmental performance.

Using Refinitiv's environmental score (and its three component scores) to capture corporate environmental performance over the period 2002–2021 and the fraction of female directors on a board from BoardEx to capture board gender diversity, we first show that there

is a positive and significant association between board gender diversity and corporate environmental performance.

For identification, we take a multi-pronged approach. First, we employ the instrumental variables approach. Following Huang and Kisgen (2013) and Field, Souther, and Yore (2020), we use two instruments for the fraction of female directors in a firm that capture different levels of legal protection and economic opportunity for women in states where directors went to college or when they were college-age. The first instrument is the Gender Equality Index of a state where a director went to college (Sugarman and Straus 1988). The index measures the attainments of women relative to men, in various economic, political, and legal areas, in each state. The second one exploits the passage of the Civil Rights Act of 1964 as an exogenous shock to the pool of female directors year-by-year who were of college age after the Act's passage. The Act makes it illegal for college admission to discriminate based on gender or race, thus improve higher education opportunities and occupational mobility for women and minorities reaching college age after the Act's passage. For each variable, we use the firm-year average across all directors on a board. Both instruments are expected to be positively correlated with a firm having more female directors, but not correlated with its environmental performance through other channels. Second, we include firm fixed effects to control for time invariant differences across firms that could be correlated with corporate environmental performance. Third, we take advantage of the 2018 law change in California and employ a difference-in-differences specification, comparing changes in environmental performance between treated California firms, and a matched control sample, to help establish the causal effect of board gender diversity on corporate environmental performance.

Given the divergence of corporate environmental ratings by various data providers (Berg, Koelbel, and Rigobon 2022), we employ facility-level data from the Toxic Release Inventory (TRI) database of the U.S. Environmental Protection Agency (EPA) as our

alternative measures of corporate environmental performance. The TRI database covers both pollution prevention activities and emissions of toxic chemicals at the facility-year level. Both measures are not subject to the common criticism associated with corporate environmental ratings.

Our facility-level analysis suggests that more female directors are associated with more pollution prevention activities and a lower amount of toxic emissions. Such associations hold when we control for facility- and firm-level characteristics, facility fixed effects, and industry times year fixed effects. These results support our hypothesis that firms with more female directors take more actions in preventing toxic emissions and thus effectively reduce industrial pollution, and provide micro-evidence for the effect of female directors on corporate environmental performance.

We next explore potential channels through which board gender diversity helps enhance corporate environmental performance. Motivated by the literature on gender differences in values, expertise, professional experience, and monitoring roles (see, for example, Hillman, Cannella, and Harris 2002; Eagly, Johannesen-Schmidt, and van Engen 2003; Schwartz and Rubel 2005; Adams and Ferreira 2009; Kim and Starks 2016), we posit that board gender diversity affects corporate environmental performance through three non-mutually exclusive channels: 1) Female directors bring more expertise on sustainability in boardrooms than male directors; 2) Female directors are more likely to sit on sustainability and key monitoring committees than male directors; and 3) Boards with more female directors are more likely to link top executives' compensation to corporate ESG performance.

Using director- and board-level data from the BoardEx data set supplemented by the Refinitiv Environmental, Social, and Governance (ESG) Board Member data set over the period 2001–2020, we first show that compared to male directors, female directors are younger, have shorter board tenure, are more highly educated, and are more likely to have

expertise outside industry and finance, suggesting that having female directors in boardrooms bring fresh perspectives and encourage open discussions. We further show that compared to male directors, female directors are more likely to sit on sustainability-related committees if there is one and key monitoring committees. Finally, we show that there are positive associations between a firm's board gender diversity and its linking executive pay to corporate ESG performance, between a firm's board gender diversity and its having an ESG (executive) committee, and between a firm's board gender diversity and its ESG disclosure.

We conduct a number of robustness checks on our main findings. First, including alternative fixed effects to control for state-level regulatory environments and/or local economic conditions such as state of incorporation times year fixed effects and state of headquarters times year fixed effects, we show that our main findings remain. Second, we show that there is a critical mass effect in our main findings whereby only having more than one female director is positively and significantly associated with corporate environmental performance. Third, controlling for a board's national cultural values based on each director's country of origin or a board's political leaning based on each director's political donation history do not change our main findings. Finally, using alternative environmental ratings from KLD and ASSET4, we show that our main findings remain.

Our paper makes the following contributions to the literature. First, we add new evidence on the real benefit of having a gender diverse board by focusing on corporate environmental performance, which complement existing literature on various short-run and long-run implications of board gender diversity (see, for example, Ahern and Dittmar 2012; Matsa and Miller 2013; Bertrand, Black, Jensen, and Lleras-Muney 2019; Griffin, Li, and Xu 2021; Eckbo, Nygaard, and Thorburn 2022). Our facility-level analysis also provides micro-evidence that firms with more female directors take more actions in preventing pollution and cutting toxic emissions, effectively reducing industrial pollution. More broadly, our results

highlight the importance of corporate leaders' social attitudes in affecting stakeholder outcomes.

Second, we propose and test potential channels through which board gender diversity affects corporate environmental performance. Our channel analyses highlight that board gender diversity influences corporate environmental performance through both their advising and monitoring roles. Thus, our evidence adds to the literature on whether and how directors' personal traits and professional backgrounds help fulfill their duties on boards (see, for example, Adams and Ferreira 2009; Adams and Funk 2012; Kim and Starks 2016; Adams, Akyol, and Verwijmeren 2018; Ginglinger and Raskopf 2021; Hwang, Shivdasani, and Simintzi 2021).

Third, we highlight important spillovers among the three pillars of ESG. While the popular press and most of the academic literature take improving corporate ESG policies and practices as the ultimate goal, less attention has been paid to the potential interactions (tradeoffs or synergies) among the three pillars. Our results suggest that policies targeting at social issues (e.g., improving board diversity) could have spillover effects for corporate environmental performance. Our paper thus complements Flammer, Hong, and Minor (2019) and Dyck et al. (2021) who show that governance could be an important channel through which investors' preferences for sustainability are materialized in better corporate environmental performance.

## 2. Literature Review and Hypothesis Development

### *2.1. Literature review*

There is a growing body of research documenting gender diversity in boardrooms and its implications for governance and corporate policies.

Using board data for the S&P 1500 firms over the period 1996–2003, Adams and Ferreira (2009) show that female directors have better board attendance records than male directors, and are more likely to join monitoring committees such as audit, nomination, and corporate governance committees. Using a large survey of directors in Sweden in 2005, Adams and Funk (2012) find that female and male directors differ systematically in their core values and risk attitudes. Consistent with findings for the female population, female directors care less about self-enhancement values (achievement and power) and more about self-transcendent values (universalism and benevolence) than male directors. Different from findings for the female population, the authors show that female directors are more independent-minded, valuing self-direction and stimulation more than male directors, and tradition and conformity less than male directors. Taking advantage of the 2009 SEC Final Rule No. 33-9089 Proxy Disclosure Enhancements that require disclosure on director expertise, Kim and Starks (2016) show that female directors possess more skills than male directors, and that female directors bring unique skills to boards such as sustainability and human resources. They suggest that a mechanism through which board gender diversity improves firm value is that female directors contribute expertise different from male directors in boardrooms, resulting in greater board advisory effectiveness.

In terms of corporate investment policies and business practices, Levi, Li, and Zhang (2014) find that less overconfident female directors are less likely to overestimate merger gains. As a result, firms with female directors are less likely to make acquisitions and if they do, pay lower bid premia. Using plant-level data in the U.S., Tate and Yang (2015) study the impact of plant closures on workers and find that female workers experience a lower likelihood of job separation and a smaller pay cut at hiring firms with female leadership compared to their counterparts at hiring firms with male leadership. They conclude that female leaders cultivate more gender equal cultures inside their firms.

Using board gender quota introduced in Norway in 2003 as an exogenous shock to board gender diversity, a number of papers examine its financial and general labor market implications. Ahern and Dittmar (2012) find that such quota is negatively associated with firm performance. The quota leads to younger and less experienced boards, increases in leverage and acquisitions, and deterioration in operating performance. Matsa and Miller (2013) further show that affected firms (i.e., firms that have to add female directors as a result of the quota) undertake fewer workforce reductions than comparison firms, increasing relative labor costs and employment levels and reducing short-term profits, suggesting a more labor-friendly women leadership style. Bertrand, Black, Jensen, and Lleras-Muney (2019) examine the effect of the quote on female labor market outcomes in Norway and find that seven years after the board quota came into effect, it had very little impact on women in business beyond its direct effect on women who made into boardrooms. Using hand-collected data to help attribute quota-related news to specific events and accounting for contemporaneous cross-correlation of stock returns when the quota affects all firms simultaneously in calendar time, Eckbo, Nygaard, and Thorburn (2022) find that the Norwegian quota has a value-neutral effect.

Our paper is closely related to Ginglinger and Raskopf (2021). Using the enactment of France's board gender-quota law in 2011 as an exogenous shock to board gender diversity, the authors find that the presence of women on boards increases firms' environmental and social (E&S) performance. In terms of channels, they show that after the quota, French firms are more likely to have an E&S committee, female directors are more likely to sit on that committee and chair it, and they increasingly serve as members and chairs of audit, compensation, or nomination committees. They conclude that female directors with their unique qualities, experiences, and key committee roles, help improve corporate E&S performance. Our paper differs from Ginglinger and Raskopf (2021) in a number of

important dimensions. First, we focus on U.S. firms that are less subject to ESG regulations compared to their European counterparts, and are used as control firms in Ginglinger and Raskopf (2021). Moreover, societal views about environmental issues have become increasingly polarized in the U.S. over time (Chinn, Hart, and Sokora 2022), which makes it an interesting setting to study the role of female directors in corporate environmental performance. Second, we employ a novel data set of facility-level pollution prevention measures and toxic emissions to provide micro-level evidence on the effect of female directors on corporate environmental performance. Third, we explore both within and across firm variations in the fraction of female directors to help establish its causal effect on corporate environmental performance.

*2.2. Hypothesis development*

Our conceptual framework builds on a number of well-established gender differences in personal values and psychological traits that have implications for corporate decision making related to environmental performance.

Across cultures, Schwartz and Rubel (2005) find that men consistently attribute more importance to self-enhancement values (achievement and power), whereas women emphasize self-transcendence values (universalism and benevolence). These gender differences in personal values are also confirmed in a sample of Swedish directors by Adams and Funk (2012).

In terms of psychological characteristics, relative to men, women possess more communal traits: they are affectionate, helpful, kind, sympathetic, interpersonally sensitive, nurturing, and concerned about others' welfare (Eagly, Johannesen-Schmidt, and van Engen 2003). These psychological traits may make female directors particularly sensitive to corporate social responsibility and environmental practices that generate positive externalities

to various stakeholders and environment. Prior literature on the real effects of female leadership mainly focuses on labor market-related outcomes that could have direct cash flow consequence for a firm. Corporate environmental performance is more related to social attitudes and benefits to external constituents, thus could be more directly shaped by female directors' communal traits compared to labor market-related outcomes.

Relatedly, experimental and survey evidence in psychology indicates that women, on average, are more patient and less impulsive than men when trading off present versus future values (Silverman 2003; Castillo et al. 2011). As such, male directors may be more short-term oriented and shareholder focused in their approach to corporate strategy, whereas female directors may be willing to bear the higher costs and focus more broadly on a wide range of stakeholders with a longer-term outlook.

Consistent with these gender differences in personal values and psychological traits, the PwC's 2019 survey of over 700 public company directors find that 71% of the surveyed female directors support a broader stakeholder model of governance compared to 54% of the surveyed male directors. In addition, 62% of female directors agree that ESG issues have a financial impact on long-term company performance, compared to just 45% of male directors.[1]

Taken together, we expect that having more women on boards would encourage more open discussions among directors, and bring broader and more diverse perspectives to allow the board to better assess the needs of different stakeholders, improving corporate environmental performance.

On the flip side, Adams and Funk (2012) and Lewellen (2022) provide evidence suggesting that self-selection and professional expertise reduce, or even eliminate, gender

[1] See PwC's 2019 Annual Corporate Directors Survey at: http://www.circulodedirectores.org/wp-content/uploads/2019/12/pwc-2019-annual-corporate-directors-survey-full-report-v2.pdf

differences in personal values and psychological characteristics, especially in terms of risk attitudes.[2] Rose and Bielby (2011) argue that the inclusion of women and visible minorities on corporate boards is symbolic to manage corporate image and external relations without real consequences. Galbreath (2011) further notes that sex-based bias and stereotyping could exist in boardrooms dominated by male directors who discount inputs from female directors on environmental issues. Using the universe of firms with coverage in Compustat/ExecuComp/BoardEx/RiskMetrics (now the Institutional Shareholder Services) over the period 2006–2017, Field, Souther, and Yore (2020) find that female and minority directors are significantly less likely to serve in leadership positions on a board despite possessing stronger qualifications than non-diverse directors. In the context of the California law change, Hwang, Shivdasani, and Simintzi (2021) find that female directors appointed to meet the quota are given fewer board committee responsibilities compared to non-California firms, despite similar skill sets. Ultimately, the effect of female directors on corporate environment performances, along with the economic channels for it, could be an empirical question.

In terms of channels, Adams and Ferreira (2009) show that female directors are more diligent in their roles by having better board attendance than male directors, and that female directors engage in more monitoring than male directors do by sitting on key committees such as audit, nomination, and corporate governance committees. Hillman, Cannella, and Harris (2002) note that male directors tend to have more leadership experience in large corporations, whereas female directors tend to have more experience in community and service organizations. These differences in career trajectory may lead male directors to be

[2] Adams and Funk (2012) find that female directors emphasize benevolence more, but are less power or accomplishment oriented. Lewellen (2022) finds no evidence that gender differences in altruism affect decision making of hospital CEOs. However, in general, female corporate leaders' social attitudes could still differ from male ones due to reasons such as reciprocity, externalities, or beliefs about the alignment of long-term shareholder values and stakeholder values.

more attuned to traditional practices and policies whereas female directors may be more attuned to policies focusing on outreach and the community. Kim and Starks (2016) further show that female directors possess more skills than male directors, and that female directors bring unique skills to boards such as sustainability and human resources. The quality and diverse expertise that women bring to boards may also provide better oversight of management activities because of the increased heterogeneity among the board, with top management teams, especially in the environmental dimension given gender differences in values.

Flammer, Hong, and Minor (2019) find that the integration of corporate social responsibility (CSR) criteria in executive compensation helps direct management's attention to social and environmental initiatives, resulting in a reduction in toxic emissions. Using an international sample of over 3,000 firms from 41 countries, Dyck et al. (2021) show that the ability of investors to renew corporate boards and replace directors is a powerful mechanism to influence corporate environmental performance around the world. Given gender differences in values and psychological traits, we expect that one channel through which female directors will exert influences on corporate environmental performance is through their involvement in executive compensation design and establishing and/or sitting on sustainability-related committees.

In summary, we hypothesize that there is a positive association between board gender diversity and corporate environmental performance. We further hypothesize that there are a number of non-mutually exclusive channels through which female directors help enhance corporate environment performance. Female directors bring more expertise on sustainability in boardrooms than male directors, female directors are more likely to sit on sustainability-related committees and key monitoring committees than male directors, and/or boards with

more female directors are more likely to link top executives' compensation to corporate ESG performance.

## 3. Data and Sample Formation

### *3.1. Firm-level data*

We employ a number of data sources to measure corporate environmental performance. Our primary data source is Refinitiv, a wholly-owned subsidiary of the London Stock Exchange Group (LSEG), which produces one of the most comprehensive ESG databases. The Refinitiv database covers over 80% of the global market capitalization including most of the key global index constituent firms, about more than 12,000 public and private companies globally. It has a history dating back to 2002, and has been used in recent ESG studies (e.g., Dai, Liang, and Ng 2021; Dyck, Lins, Roth, Towner, and Wagner 2021; Li, Liu, Mai, and Zhang 2021). Refinitiv's ESG score consists of more than 630 data items that span most common environmental, social, and governance issues (Refinitiv 2022).

We focus on the emissions reduction score, innovation score, and resource use score under Refinitiv's environmental pillar to measure corporate environmental performance over the period 2002–2021.[3] These scores range from 0 to 1. A high score reflects a firm's good performance in a specific dimension captured by the measure. We use the average across these three scores to capture a firm's overall performance (*E score*).

As robustness checks, we also employ two other data sets from KLD and ASSET4, as alternative measures of corporate environmental performance. To capture a firm's overall environmental performance, we use the scaled strength score minus the scaled concern score

[3] The emissions reduction score measures a firm's commitment and effectiveness towards reducing environmental emissions in its production and operational processes. The resource use score reflects a firm's performance and capacity to reduce the use of materials, energy or water, and to find more eco-efficient solutions by improving supply chain management. The innovation score reflects a firm's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes, or eco-designed products.

under KLD's environmental dimension.[4] The sample period for the KLD data is from 2002 to 2017. With the ASSET4 data, we focus on a company's overall environmental score (ENVSCORE) that is based on three component scores: emissions reduction (ENER), product innovation (ENPI), and resource reduction (ENRR).[5] The sample period for the ASSET4 data is from 2002 to 2018.

Our board and director data mainly come from BoardEx, which contains information such as board composition, committee composition, and biographic information of directors for more than 20,000 companies since 1999. The data coverage is more comprehensive after 2000 which determines the beginning of our sample period in 2001. We supplement BoardEx data with board and director data from the Refinitiv ESG Board Member data set.

We collect firms' financial data from Compustat. We calculate the fraction of shares outstanding held by the five institutional investors with the largest holdings using the Thomson Reuters Institutional Holdings (13F) data set. We extract firms' (historical) headquarters states and industry classifications (based on the Standard Industry Classification (SIC) codes) using the Augmented 10-X Header Data downloaded from Bill McDonald's website.[6]

### *3.2. Facility-level data*

[4] We scale the number of strengths (concerns) in each dimension by the total number of strengths (concerns) available in that dimension in that year as the scaled strength (concern) score. We then use the scaled strength score minus the scaled concern score to obtain the performance score in that dimension. For example, suppose there are 4 strengths and 3 concerns in the environmental dimension. If a firm scores 3 in strengths and 2 in concerns, then its performance score is 0.083 (= 3/4 – 2/3).

[5] ENER measures a company's commitment and effectiveness in reducing air emissions, waste, water discharges and spills or its impact on biodiversity. ENPI measures a company's research and development on eco-efficient products or services. ENRR measures a company's ability to reduce the use of materials, energy, or water and to find more eco-efficient solutions by improving supply chain management. The detailed description is provided in ASSET4 ESG Data Glossary (2013 version). It is worth noting that the ASSET4 data set is different from the Refinitiv data set and is no longer active, as shown in Appendix IA1 in the Internet Appendix.

[6] https://sraf.nd.edu/data/augmented-10-x-header-data/

Given the divergence of corporate environmental ratings by various ESG data providers (Berg, Koelbel, and Rigobon 2022), we employ facility-level data on pollution prevention (P2) activities and toxic emissions from the TRI database maintained by the U.S. EPA as our alternative measures of corporate environmental performance. Both measures are based on regulatory reporting and hence not subject to the common criticism associated with corporate environmental ratings that might be subjective in nature. We provide more detailed description of the TRI database in Appendix IA1 in the Internet Appendix.

The EPA requires all facilities to report their new source reduction practices (with aim to prevent pollution) in File Type 2A of the TRI database every year. Each facility reports the newly implemented source reduction practices by choosing one or more predefined codes (W-codes) that correspond to a specific practice within the following eight categories: raw material modifications, product modifications, cleaning and degreasing, surface preparation and finishing, process modifications, spill and leak prevention, inventory control, and good operating practices. Prior literature uses the number of these practices to capture facility-level initiatives to prevent pollution at the annual frequency (Akey and Appel 2021; Bellon 2022).

It is natural to expect that a high production capacity in a facility leads to more toxic release hence more pollution prevention measures. Thus, we use the National Establishment Time-Series (NETS) database (2017 version) to collect some additional information about the EPA's reporting facilities' estimated sales or value created.[7] We capture a facility's pollution prevention intensity in a year using (i) the number of its unique source reduction practices reported in a year; and (ii) this number scaled by its estimated sales, which proxies for production capacity/economic output.

[7] The TRI database offers the crosswalk between TRIFD and dunsnumber, which allows us to merge two datasets. For more details about the NETS database, please refer to https://maryannfeldman.web.unc.edu/data-sources/longitudinal-databases/national-establishment-time-series-nets/

The EPA stipulates 775 chemicals and 33 chemical categories (as of August 2022) to be reported by facilities that meet the following criteria: (1) in the mining, utility, manufacturing, publishing, hazardous waste, or federal industry; (2) manufacturing, processing, or otherwise using a TRI-listed chemical in quantities above certain threshold levels set by the EPA in a given year; and (3) having ten or more full-time equivalent employees. The reported data constitute the TRI database.[8]

The TRI database also contains the amount of chemical pollutants (pounds) released and their names.[9] We use the sum of total releases (or on-site releases) of all TRI-listed chemicals released to the environment by a facility to measure its pollution (and as an inverse indicator for its environmental performance, Hsu, Li, and Tsou 2022).[10] To account for the production scale of a facility, we capture a facility's emission intensity in a year using its total releases or on-site releases, scaled by its estimated sales.[11]

### *3.3. Sample overview*

Table 1 Panel A lists the steps taken and filters applied to form our main sample of 21,728 firm-year observation for a sample of 3,198 firms over the period 2002–2021. Panel B

[8] In our facility sample, 14% of facility-year observations do not report any toxic emissions. In addition, about 9% of the facilities with TRI data have zero pollutants reported (neither production wastes nor toxic emissions). It is worth noting that if we drop those facilities from our regression analysis, our main findings remain.
[9] For the detailed list, please refer to https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals. The Office of Inspector General, an independent office within the EPA, performs audits, evaluations, and investigations of the EPA and its contractors to prevent and detect fraud, waste, and abuse. In addition, the EPA regularly implements an extensive quality analysis of the TRI reporting data and offers analytical support for enforcement efforts led by its Office of Enforcement and Compliance Assurance (OECA). The release amount of the TRI database has been widely used in the literature to measure industrial pollution, see, for example, Currie, Davis, Greenstone, and Walker (2015), Akey and Appel (2021), and Xu and Kim (2022).
[10] The three terms "release," "emission," and "discharge" are used interchangeably throughout this paper. Releases include spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment. The on-site releases is the sum of air release, surface release, and land release at a facility. There are also off-site transfers of TRI chemicals (i.e., the transfer of chemical-containing waste to a location that is geographically or physically separate from the reporting facility). When such transfers are for release purposes, they are off-site releases. The total releases include both on-site and off-site releases. We provide some description in the Internet Appendix. For more details, please see: https://www.epa.gov/toxics-release-inventory-tri-program/common-tri-terms.
[11] Akey and Appel (2021) and Bellon (2022) point out that compared to off-site releases, on-site releases are more traceable and will subject emitting firms to greater environmental responsibility.

lists the steps taken to form our facility-level sample of 41,280 facility-year observations for a sample of 4,514 facilities associated with 627 firms over the period 2002–2017.[12] Detailed variable definitions are provided in the Appendix.

Table 2 Panel A presents the summary statistics for the firm sample. In terms of corporate environmental performance, the average *E score* is 0.211, and the average emissions reduction, innovation, and resource use scores are 0.241, 0.148, and 0.245, respectively. Over our sample period, the average share of female directors is 15%, the average board size is 11 directors, and the average share of independent directors is 76%. The average share of female CEOs is about 4%.

Figure 1 plots the temporal trend in the share of female directors over the sample period 2001–2020. Consistent with the increasing attention and scrutiny from policy makers, regulators, and institutional shareholders regarding gender diversity in boardrooms, there is a clear upward trend in the share of female directors over the sample period, ranging from about 10% in early 2000s to over 20% by the end of the sample period, and the rise in the female director share is steeper than before since 2017 when the three largest asset managers – State Street, BlackRock, and Vanguard – adopted a policy initiative to require at least one female director on every board of their portfolio firms (Gormley et al. 2021).

Table 2 Panel B presents the correlation matrix for the firm sample. We show that there is a positive and significant correlation between the share of female directors and *E score*. Examination of the correlation matrix more generally suggests little problem of multi-collinearity. Given that omitted variable bias in univariate correlations can mask the true relations between the variables, we employ multiple regressions in next section to examine the factors associated with corporate environmental performance.

[12] The sample period for our facility-level analysis is 2002–2017 given our NETS subscription to the 2017 version.

Table 2 Panel C presents the summary statistics for the facility sample. We show that facilities in our sample on average have 0.218 pollution prevention activities (and 0.026 after being scaled by sales in millions of dollars) and generate 0.266 million pounds of total emissions and 0.213 million pounds of on-site emissions. For every dollar of sales, a sample facility on average generates 0.033 pounds total and 0.021 pounds on-site emissions, respectively.

## 4. Female Directors and Corporate Environmental Performance

### *4.1. Baseline results*

To examine the relation between the fraction of female directors on a board and corporate environmental performance, we start with the following lead-lag panel data regression specification:

$$
\begin{aligned}
&E\ performance\ measure_{it} \\
&\quad = \alpha_0 + \alpha_1 Female\ director\ ratio_{it-1} \\
&\quad + \alpha_2 Governance\ characteristics_{it-1} + \alpha_2 Firm\ characteristics_{it-1} \\
&\quad + Industry \times Year\ FE \\
&\quad + \varepsilon_{it}, \qquad (1)
\end{aligned}
$$

where the dependent variables are *E score* and its three component scores provided by Refinitiv. The control variables include other governance characteristics (board size, share of independent directors, share of busy directors, female CEO, and ownership by the top five institutional investors) and firm characteristics (e.g., M/B, firm size, and ROA). Our variable of interest is *Female director ratio.* The choice of our control variables largely follows prior work (e.g., Dyck et al. 2019, 2021; Starks, Venkat, and Zhu 2020). We include (three-digit SIC) industry times year fixed effects to control for industry-specific time-trends in both the share of female directors and corporate environmental performance. Standard errors are

clustered at the firm level to account for possible intertemporal dependence in a firm's environmental scores.

Table 3 reports the regression results using the specification in Equation (1), with different environmental scores in different columns. We show that the coefficients on *Female director ratio* are negative and significant in all columns. In terms of economic significance, a one-standard-deviation increase in *Female director ratio* is associated with an increase of 0.024 ( = 0.222 × 0.107) in *E score*, about 9.4% of its standard deviation (11% of its mean). The economic magnitude of the effect of female directors on *Emissions reduction score* is similar to that on *Resource use score,* whereas the economic magnitude of the effect of female directors on *Innovation score* is only half that on *Emissions reduction score* or *Resource use score*.

However, several omitted, hard-to-measure variables could potentially bias the above OLS estimates in either direction. On the one hand, the management literature (e.g., Ryan and Haslam 2007) highlights the phenomenon of glass cliff—women and minorities are more likely to take leadership positions in struggling firms. If unsuccessful firms likely have poor environmental performance (i.e., firms in crises are positively correlated with *Female director ratio*, but negatively correlated with *E-score*), then not properly controlling for this firm characteristic will lead to a downward bias in the OLS estimates of the coefficient on *Female director ratio*. On the other hand, a firm's attitudes or strategic position towards the overall ESG issues could correlate with *Female director ratio* and *E-score* in the same direction, so not properly controlling for it will lead to an upward bias in the OLS estimates of the coefficient on *Female director ratio*.

To establish the causal effect of female directors on corporate environmental performance, we employ several strategies. First, we use the instrumental variables approach. Our two instruments capture different levels of legal protection and economic opportunity for

women in states where directors went to college or when they were college-age, thus provide exogenous cross-sectional variations in the share of female directors. Second, we examine within-firm temporal variations in the share of female directors in relation to within-firm temporal variations in corporate environmental performance by controlling for firm fixed effects. Third, we take advantage of the board gender quota mandated by California's Senate Bill (SB) 826 in 2018 and employ a difference-in-differences specification to examine changes in the environmental outcomes for California firms subject to this regulation, versus changes in similar firms headquartered outside California not subject to this regulation, around the passage of SB 826.

*4.2. Identification using the instrumental variables approach*

Following Huang and Kisgen (2013) and Field, Souther, and Yore (2020), we use two instruments that capture exogenous shocks to the pool of female directors. The first instrument, *Gender Equality Index*, is the historic Gender Equality Index of a state where a director obtained her undergraduate degree. The index assesses "the extent to which women have the same access to economic resources, legal rights, or positions of political power as men" (Sugarman and Straus 1988, p. 234). Sugarman and Straus (1988) construct the index using data from the State and Regional Indicators Archive over the period 1977–1983, when many of our sample directors would have begun their career. The second instrument, *Affirmative Action*, takes the value of one if a director was 18 years old or younger when the Civil Rights Act of 1964 was passed. The Act makes it illegal for college admission to discriminate based on gender or race, thus improves higher education opportunities and job mobility for women and minorities reaching college age after the Act's passage.

For each variable, we calculate the firm-year average across all directors on a board. Both instruments are expected to be positively correlated with a firm having more female

directors through expanding the pool of qualifying female directors (the relevance condition), but not correlated with its environmental performance through other channels (the exclusion restriction).

Table 4 presents the results from the instrumental variables approach. Column (1) tabulates the first-stage regression results, and confirms that both are valid and strong instruments for *Female director ratio*. The first-stage F-statistic at 38 is far larger than 10, the conventional cutoff for weak instruments.

Columns (2) to (5) tabulate the second-stage regression results. We note that we fail to reject the overidentification (Hansen's J) test, consistent with our argument that the instruments are valid. Similar to the OLS regression results in Table 3, we show that *Female director ratio* is positively and significantly related to *E score* and its three component scores. The IV estimates of the coefficient on *Female director ratio* are larger than those OLS estimates, but still within the same order of magnitude, which could be due to the fact that our instruments are less subject to the omitted variable bias associated with the existence of a "glass cliff", as laid out in Section 4.1.

### *4.3. Addressing endogeneity by controlling for firm fixed effects*

Next, we examine within-firm temporal variations in the share of female directors in relation to within-firm temporal variations in corporate environmental performance by controlling for firm fixed effects in Equation (1). Table 5 presents the results.

After controlling for potential time-invariant determinants of both the fraction of female directors and corporate environmental performance, for example, corporate vision related to ESG issues or stakeholder orientation, we show that *Female director ratio* is still positively and significantly correlated with *E score* and two of its three component scores: *Emissions reduction score* and *Resource use score.* We note that with firm fixed effects, the

magnitude of the effect of female directors becomes much smaller though, generally about one third of that in the specification without firm fixed effects (see Table 3), suggesting that some time-invariant factors such as a firm's general preferences towards ESG and/or its stakeholder orientation are likely associated with both its share of female directors and its environmental performance. At the same time, because the variation in our key variable of interest, *Female director share,* largely comes from across firms (instead of from within-firm over time), firm fixed effects regressions, which rely on within-firm variations, might under-estimate the true effect of *Female director share* on corporate environmental performance. Such issue has been raised in prior studies involving slowly changing explanatory variables (Zhou 2001; Hall, Jaffe, and Trajtenberg 2005). We conclude that an increase in the fraction of female directors in a firm is associated with a subsequent increase in its environmental performance.

In summary, using either the instrumental variables approach or including firm fixed effects, we find consistent results that more female directors help improve corporate environmental performance, especially when corporate environmental performance is measured by the emissions reduction and resource use scores.

### *4.4. Identification using the 2018 California SB 826*

To further establish the causal effect of female directors on corporate environmental performance, we take advantage of a mandate to increase female representation on boards, California's SB 826, the first mandate in the U.S. that imposes a female director quota on corporate boards. Signed into law on September 30, 2018, it requires public companies headquartered in California to have at least one female director by the end of 2019, and depending on board size, some firms are required to have multiple female directors by the end of 2021.

We employ a difference-in-differences (DiD) specification to examine changes in both the fraction of female directors and corporate environmental outcomes between treated and control firms around the enactment of SB 826 in 2018. Our three-year pre-event window is from 2015 to 2017, and three-year post-event window is from 2019 to 2021. The treated firms are public firms without female directors in 2018 and headquartered (and stayed) in California. To find control firms, we first search for public firms without female directors in 2018 and headquartered outside California. For each treated firm, we then find a control firm that is in the same (three-digit SIC) industry, and has the smallest total absolute difference in (standardized) total assets and *E score* in 2018 to the treated firm. We end up with 50 treated firms and their matched controls, after the above steps.

Table IA1 in the Internet Appendix tabulates the average values of *Female director ratio* and *E score,* for the treated and control firms, in the time period before and after the California law change. These summary statistics could be viewed as the simplest DiD analysis without any control variables, and show that the treated and control firms have similar fractions of female directors as well as similar environmental performance in the period before the law change. However, these values diverge between the treated and control firms after the law change.

Table 6 Panel A presents our sanity check – the impact of the California law change on the share of female directors in the treated firms compared to that in the control firms. In column (1), we regress *Female director ratio* on *Treated* × *Post*, an interaction term between the indicator variable *Treated* and the indicator variable, *Post*, for the post-event window (from 2019 to 2021). As before, we control for other governance measures and firm characteristics, as well as industry times year fixed effects and firm fixed effects. These fixed effects absorb the standalone indicator variables *Treated* and *Post*. We cluster standard errors in this DiD specification by firms' headquarters states, since this is the level at which

treatment is assigned and cross-firm dependence in the error term may occur (e.g., Bertrand, Duflo, and Mullainathan 2004; MacKinnon, Nielsen, and Webb 2022). We show that the coefficient on the interaction term *Treated* × *Post* is positive and significant, suggesting that the treated firms significantly increased their shares of female directors relative to the control firms, once the mandate is enacted. In column (2), we employ a dynamic DiD specification, by interacting *Treated* with the year indicators for each year within the event window examined. The omitted baseline interaction term is *Treated* × *Year 2018*. The coefficients on the first three interactions (from 2015 to 2017) confirm what we find using summary statistics (see Table IA1 in the Internet Appendix) that before the mandate, both the treated and control firms have very few female directors. The difference between the two groups in terms of *Female director ratio* and its trend is thus both economically and statistically insignificantly different before the mandate. After the mandate, we show that the gap in the share of female directors grows wider over time.

Panel B presents the DiD analysis using the environmental scores as the dependent variables. In column (1), we regress *E score* on *Treated* × *Post*, and find a positive and significant coefficient, suggesting that the increase in the number of female directors mandated by SB 826 leads to better environmental performance of the treated firms in California, compared to the control firms outside California, once the mandate is in effect. The dynamic DiD specification in column (2) confirms there are similar levels of *E score* and temporal trends in *E score* before the mandate, whereas the treated firms exhibit significantly better environmental performance, relative to the control firms, in the post-event period of 2019 to 2021. Other board characteristics such as independence and busyness have little explainatory power, while the fraction of institutional investors has a significant and positive correlation with the environmental scores. Interestingly, the DiD analysis in columns (3) to (6) suggest that the effect from more female directors mainly comes from the significant

improvement in the emissions reduction score. It is possible that the emission performance is the most visible and important dimension of corporate environmental performance, which we will explore further at the facility level, in Section 5.

We note that the treated firms in this exercise do not have a single female director before SB 826, despite headquartered in California. Therefore, despite the general female-friendly attitudes in California (i.e., California has one of the highest *GEI* values) compared to some other states, the treated and matched control firms exhibit similar patterns in the share of female directors and environmental performance before 2018, while they start to diverge since 2019. In other words, the identification strategy in this section focuses on the temporal within-firm change in the share of female directors, thus complements the identification strategy focusing on the cross-sectional variation in Section 4.2. Moreover, since we control for firm fixed effects in this test, any time invariant differences such as a firm's ESG vision or pro-stakeholder attitude that could be correlated with corporate environmental performance are unlikely to be drivers of our main findings. Finally, we do not find any significant environmental regulation change around SB 826 in California,[13] which mitigates the concern of other confounding regulatory changes driving our results.[14]

In summary, we conclude that there is a potential causal effect of female directors on corporate environmental performance, especially through emissions reduction measures.

## 5. Female Directors and Facility-level Environmental Performance

Given the divergence of ESG ratings by various data providers (Berg, Koelbel, and Rigobon 2022), we employ facility-level data from the EPA that are based on regulatory

[13] https://oag.ca.gov/environment/ceqa/planning

[14] It is worth noting that in robustness checks (reported in Section 7.1), we further control for headquarters state times year fixed effects and incorporation state times year fixed effects, and conclude that the effect of female directors on corporate environmental performance does not come from, nor is confounded by, regulatory changes.

reporting and hence are not subject to the common criticism associated with ESG ratings, to provide novel micro-evidence on the positive association between female director share and corporate environmental performance, especially emission-related outcomes.

We run the following lead-lag panel data regressions:

$$
\begin{aligned}
Facility-level\ outcome_{jt} &= \alpha_0 + \alpha_1 Female\ director\ ratio_{it-1} + \alpha_2 Facility\ characteristics_{jt-1} \\
&+ \alpha_3 Governance\ characteristics_{it-1} + \alpha_4 Firm\ characteristics_{it-1} \\
&+ \theta Facility\ FE_j + \gamma Industry \times Year\ FE \\
&+ \varepsilon_{jt}, \qquad (2)
\end{aligned}
$$

where $Facility-level\ outcome_{jt}$ is the natural logarithm of one plus the value of one of the following four measures of facility *j* of firm *i* in industry *s* in year *t*: 1) facility *j*'s number of source reduction practices in year *t*; 2) facility *j*'s number of source reduction practices scaled by its estimated sales in year *t*; 3) facility *j*'s total releases scaled by its estimated sales in year *t*; and 4) facility *j*'s on-site releases scaled by its estimated sales in year *t.* Our variable of interest is $Female\ director\ ratio_{it}$, denoting the share of female directors in firm *i* in year *t*. $Facility\ characteristics_{jt}$ include facility *j*'s credit ratings, sales (in logarithm), and number of employees (in logarithm) in year *t*. Other control variables are similar to those included in Equation (1) for our firm-year level analysis. We control for facility fixed effects ($Facility\ FE_j$) that absorb facility-level, time-invariant factors. We also control for industry times year fixed effects that absorb industry-specific time trends.[15] We cluster standard errors at the firm level to account for possible interdependence within a firm across its facilities in their industrial pollution-related outcomes.

[15] In unreported robustness check, we include facility state times year fixed effects to absorb all time-varying local factors, and it is worth noting that our main findings remain.

Table 7 present the results using the regression specification in Equation (2). In Panel A where the dependent variables are the number of source reduction practices, we find that the positive association between the share of female directors and the number of source reduction practices is of marginal significance. The coefficients on *Female director ratio* are 0.106 and 0.107 in columns (1) and (2), respectively, based on the raw number, and are 0.163 and 0.145 in columns (3) and (4), respectively, based on the scaled number. In terms of economic significance, using column (2) as an example, an increase from zero to 0.079 (the standard deviation of the female director ratio in the facility-level sample) in the female director ratio is associated with an increase of 0.010 in firms' pollution prevention activities, which corresponds to 4.7% of the sample mean.[16] We conclude that the share of female directors is positively associated with more corporate initiatives to reduce industrial pollution.

In Panel B where the dependent variables are *Total releases* and *On-site releases*, we find that the share of female directors are negatively and significantly associated with the facility-level emissions with or without facility-level characteristics. The coefficients on *Female director ratio* range between -0.023 and -0.015. In terms of economic significance, using column (2) as an example, an increase from zero to 0.079 (the standard deviation of the female director ratio in the facility-level sample) in the female director ratio is associated with a decrease of 0.002 in firms' total releases scaled by sales, which corresponds to 5.7% of the sample mean.[17]

One concern for the facility-level analysis is that firms may opportunistically relocate some of their most polluting production across facilities to help improve their environmental

[16] When a firm increases its female director ratio from 0 to 0.079, it is associated with a 0.010 (= (1 + 0.218) × (exp(0.079 × 0.107) − 1)) increase in its number of pollution prevention activities. Such increase corresponds to 4.7% of the average number of pollution prevention activities (0.218).

[17] When a firm increases its female director ratio from 0 to 0.079, it is associated with a –0.002 (= (1 + 0.033) × (exp(0.079 × (–0.023) − 1)) increase in its total releases scaled by sales. Such increase corresponds to 5.7% of the average of total releases scaled by sales (0.033).

ratings. Including facility fixed effects in our facility-level regressions potentially controls for across-facility relocation of toxic emissions. Our results suggest that there is a general positive association between within-facility change (which still captures within-firm temporal change) in the female director share and within-facility improvement in environmental performance as measured by pollution prevention and toxic emissions.

In summary, Table 7 based on the EPA's TRI data sets provides direct evidence in support of our main findings using firm-level data that firms' environmental performance increases with their share of female directors.

## 6. The Channels

In our hypothesis development, we posit that board gender diversity may affect corporate environmental performance through the following mutually non-exclusive channels: 1) Female directors bring more expertise on sustainability in boardrooms than male directors; 2) Female directors are more likely to sit on sustainability-related committees and key monitoring committees than male directors; and 3) Boards with more female directors are more likely to link CEO compensation to corporate ESG performance. Our director- and board-level data for the channel analysis are primarily from BoardEx, supplemented by the Refinitiv ESG Board Member data set.

Motivated by the literature on director qualifications separated by gender (Hillman, Cannella, and Harris 2002; Kim and Starks 2016; Ginglinger and Raskopf 2021; Hwang, Shivdasani, and Simintzi 2021), in Table 8, we examine whether female directors are significantly different from their male counterparts in terms of qualifications, committee roles, and governance roles, using a sample of firm-director-year observations derived from the firm sample in Table 3.

Panel A presents the two-sample t-test comparing female and male directors in age, board tenure, and educational background. We note that the female share of directors for this analysis is 17.9%. The average age of female (male) directors is 59.6 (62.9) years old. The average female (male) director tenure on a board is 6.0 (8.4) years. The t-test shows that female directors are significantly younger and have significantly shorter board tenure compared to their male counterparts. We further note that female directors are significantly less likely to study business or STEM compared to their male counterparts, whereas female directors have significantly more highly educated (in terms of the highest degree achieved) compared to their male counterparts.[18]

Panel B presents the two-sample t-test comparing female and male directors in skill sets as well as industry and finance experience. We first show that compared to male directors, female directors are more likely to have skills in academic, community, environment/sustainability, government, risk management, and research & development, consistent with the findings in Kim and Starks (2016). Moreover, female directors have significantly more skills than male directors. However, we note that female directors are significantly less likely to have finance or same-industry experience (as classified by Refinitiv). In untabulated analysis, we note that these differences remain when including firm times year fixed effects.

All the above are consistent with our conjecture that female directors bring diverse skill sets and work experiences to corporate boards, facilitate open discussions on timely societal issues (given their relatively younger age and shorter tenures than male directors), thus improving corporate environmental performance.

[18] Highest degree received by a director takes the value of 3 for PhD, JD, and MD, 2 for MBA and other master's degree, or 1 for bachelor's degree, and zero otherwise.

Next, motivated by the literature on director monitoring separated by gender (Adams and Ferreira 2009; Field, Souther, and Yore 2020) and well-known gender differences in values and psychological traits, we examine whether female directors are more likely to be involved in monitoring in general, and monitoring and advising corporate environmental performance in particular.

Table 8 Panel C presents the two-sample t-test comparing female and male directors in board leadership roles and committee affiliations.[19] We first show that female directors are significantly less likely to serve leadership roles on boards (as the chairperson or the lead director) compared to their male counterparts, consistent with prior findings (Field, Souther, and Yore 2020). We further show that across all four key committees on a board: audit, compensation, ESG, and nomination committees, female directors are significantly more likely to serve on those committees compared to their male counterparts.

Panel D presents the regression analysis to explain directors' board leadership roles and committee affiliations controlling for director characteristics, industry times year fixed effects, and firm fixed effects. We continue to find that female directors are significantly under-represented in board leadership roles and are significantly more likely to serve on any of the four key committees: audit, compensation, ESG, and nomination committees, than male directors.[20]

Our findings thus far are generally consistent with the findings in Adams and Ferreira (2009) with a much recent sample. Importantly, we show that there is a positive and significant association between a director being female and her likelihood to be on the ESG committee.

[19] Table IA2 Panel A in the Internet Appendix provides summary statistics for directors' board leadership roles and committee affiliations.
[20] In untabulated analysis, we note that our main findings remain when including firm times year fixed effects.

Finally, to improve corporate environmental performance, incentives and disclosure are vital (Flammer, Hong, and Minor 2019). Given gender differences in values, we expect the presence of female directors will help establish the link between incentives and disclosure to corporate environmental performance.

At the firm-year level, we obtain data on whether there is compensation policy linking ESG metrics to executive pay, whether there is a ESG committee (either at the executive level or board level), and whether there is ESG reporting, from the Refinitiv ESG data set. Table IA2 Panel B in the Internet Appendix provides summary statistics. We find that about a quarter of the firm-year observations have a compensation policy linking ESG metrics to executive pay. About 28% of the firm-year observations have an ESG committee either at the senior management level or at the board level. About 28% of the firm-year observations also publish a separate ESG report.

Table 8 Panel E presents the regression results using a similar specification as Equation (1) including firm fixed effects. We show that across the board, there is a positive and significant association between a firm's *Female director share* and its having ESG-linked compensation policy for executives, ESG-related committee, and ESG reporting.

We conclude that director expertise and committee affiliations are important channels through which board gender diversity help improve corporate environmental performance.

## 7. Additional Investigation

### *7.1. Incorporating different fixed effects*

We acknowledge that our baseline results may be affected by time-varying local economic conditions and/or by different state-level regulations and environmental policies. To address these concerns, we further include the following fixed effects in Equation (1): headquarters state times year fixed effects and incorporation state times year fixed effects.

The former absorb all local economic conditions and government regulations related to corporate operations and environmental issues, while the latter absorb all state laws and regulations related to board composition.

Table IA3 in the Internet Appendix presents the results. We find that the effect of female director ratio remains statistically significant and the economic magnitude does not change much when including those fixed effects. In the setting with firm and year fixed effects, the coefficient on the female director ratio drops from 0.108 in column (1) to 0.104 and 0.080 in columns (2) and (3) that include headquarters state times year fixed effects and incorporation state times year fixed effects, respectively. In the setting with firm and industry times year fixed effects, the coefficient on the female director ratio drops from 0.074 in column (1) of Table 5 to 0.071 and 0.061 in columns (4) and (5) that include headquarters state times year fixed effects and incorporation state times year fixed effects, respectively. All these results suggest that our main finding is robust to controlling for local economic conditions and state-level laws and regulations.

### *7.2. The nonlinear effect of board gender diversity*

To examine any possible nonlinear effect of the number of women on a board, we introduce indicator variables representing a board having one or more woman, two or more women, or three or more women.[21] Table IA4 column (1) in the Internet Appendix reports the results. We show that the effect of female directors on corporate environmental performance is only significant when there are more than one female director.

[21] When a firm has three female directors, all three indicator variables "Female director count ≥ 3", "Female director count ≥ 2", and "Female director count ≥ 1" take the value of one. When a firm has two female directors, the indicator variable "Female director count ≥ 3" takes the value of zero, whereas the two other indicator variables "Female director count ≥ 2" and "Female director count ≥ 1" take the value of one. As a result, the indicator variable "Female director count ≥ 3" captures the marginal effect of having three or more female directors at a firm.

*7.3. Controlling for directors' country of origin and political affiliation*

To make sure that our main findings are not due to directors' cultural heritage nor their political affiliation, we additionally control for director cultural heritage at the board level, or a board's political leaning and polarization. To determine a director's cultural heritage, we use her last name to infer her ancestral origin, based on historical immigration records (see Pan, Siegel, and Wang (2017, 2020) for more details). For national cultural values, we rely on the well-established national cultural measures developed by Hofstede (1980, 2001), in a director's country of origin. For each director, we calculate her Hofstede cultural values (standardized to be between 0 and 1). We then average each value across all directors for a firm-year. For each director's political affiliation, we collect her political donation data from the Federal Election Commission. We then average each director's political leaning across all directors for a firm-year. Table IA4 columns (2)-(5) in the Internet Appendix present the results. It is worth noting that our main findings remain controlling for directors' national culture or political affiliation.

*7.4. Using alternative corporate environmental performance data*

To ensure that our baseline results are not driven by some specific features of the Refinitiv data set, we also consider two other commonly-used ESG data sets: the KLD and ASSET4 data sets. The KLD data set assesses a firm's ESG activities using over 80 indicators in seven dimensions that include community, corporate governance, diversity, employee relations, environment, human rights, and product. The ASSET4 data set from Thomson Reuters has been used in previous ESG studies (e.g., Ferrell, Liang, and Renneboog 2016; Dyck, Lins, Roth, and Wagner 2019; Hsu, Liang, and Matos 2021). We note that Thomson Reuters' ASSET4 is the predecessor to Refinitiv's ESG data set, but Refinitiv has made it clear that these two ESG data sets are based on different methodologies (see

Appendix IA2 in the Internet). The ASSET4 ESG score consists of more than 280 data items. The former is available until 2017 and the latter is available until 2018. Table IA5 in the Internet Appendix presents the results using these two variables.

Panel A repeats the analysis in Tables 3 and 5. Panel B repeats the analysis in Table 4. We show that our main findings remain when using alternative measures of *E score* from KLD and ASSET4.

## 8. Conclusions

Using novel firm- and facility-level measures of corporate environmental performance over the period 2002–2021, we establish a robust and positive association between board gender diversity and corporate environmental performance. This relation appears to be causal, based on identification strategies using either the instrumental variables approach, or the California law change in 2018 mandating female directors for firms headquartered in California.

Using granular board- and director-level data, we further establish a number of mutually non-exclusive channels for such effect. We find that female directors bring more expertise on sustainability in boardrooms than male directors. Female directors are more likely to sit on sustainability-related committees and key monitoring committees than male directors. Boards with more female directors are more likely to link top executives' compensation to corporate ESG performance.

We conclude that there are important environmental benefits for board to be gender diverse. Moreover, we establish novel evidence on the important interactions among the three pillars of ESG in this paper: policies targeting at *s*ocial issues (e.g., improving board diversity) could have spillover effects for corporate *e*nvironmental performance, possibly also through *g*overnance channels.

## Appendix
## Variable definitions

All continuous variables are winsorized at the 1st and 99th percentiles.

| Variable | Definition | Source |
|---|---|---|
| **Environmental performance measures** | | |
| E score | Average of emissions reduction score, resource use score, and innovation score. | Refinitiv ESG |
| Emissions reduction score | The emission reduction score measures a firm's commitment and effectiveness towards reducing environmental emissions in its production and operational processes. | Refinitiv ESG |
| Innovation score | The innovation score reflects a firm's capacity to reduce the environmental costs and burdens for its customers, thereby creating new market opportunities through new environmental technologies and processes or eco-designed products. | Refinitiv ESG |
| Resource use score | The resource use score reflects a firm's performance and capacity to reduce the use of materials, energy, or water and to find more eco-efficient solutions by improving supply chain management. | Refinitiv ESG |
| ln(#Source reduction practices + 1) | Natural logarithm of one plus the total number of a facility's source reduction activities (i.e., activities a facility implements to prevents pollution) in a year. The value is collected from TRI File Type 2A Form (more details are provided in the Internet Appendix). | EPA Pollution Prevention (P2) |
| ln(#Source reduction practices/Sales + 1) | Natural logarithm of one plus the total number of a facility's source reduction activities (i.e., activities a facility implements to prevents pollution) scaled by its estimated sales in a year. The value is collected from TRI File Type 2A Form (more details are provided in the Internet Appendix). | EPA Pollution Prevention (P2) and NETS |
| ln(Total emissions/Sales + 1) | Natural logarithm of one plus a facility's total emissions (in millions of pounds) scaled by its estimated sales (in millions of dollars) in a year. Total emissions is the total quantity of toxic chemicals released to air, water, and land off-site or on-site at the facility according to TRI. | EPA TRI and NETS |
| ln(On-site emissions/Sales + 1) | Natural logarithm of one plus a facility's on-site emissions (in millions of pounds) scaled by its estimated sales (in millions of dollars) in a year. On-site emissions is the total quantity of toxic chemicals released to air, water, and land on-site at the facility according to TRI. | EPA TRI and NETS |
| **Firm characteristics** | | |

| | | |
|---|---|---|
| Female director ratio | Number of female directors scaled by board size. | BoardEx |
| Board size | Number of directors on a board. | BoardEx |
| Board independence | Number of independent directors scaled by board size. | BoardEx |
| Board busyness | Number of independent directors with three or more board seats scaled by board size. | BoardEx |
| Female CEO | Indicator variable that takes the value of one if a firm has a female CEO, and zero otherwise. | BoardEx |
| Top5 institutions | Fraction of shares outstanding held by the five institutional investors with the largest holdings. | WRDS Thomson 13F |
| M/B | Market value of equity scaled by book value of equity. | Compustat |
| Firm size | Natural logarithm of total assets. | Compustat |
| ROA | Net income after subtracting expenses or losses, including extraordinary items scaled by total assets. | Compustat |
| Leverage | Sum of long-term debt and debt in current liabilities scaled by total assets. | Compustat |
| Cash holdings | Cash and short-term investments scaled by total assets. | Compustat |
| SG&A | Selling, general, and administrative expenses scaled by sales. | Compustat |
| E score_KLD | Difference between a firm's environmental strength score scaled by the total number of environmental strength score items and its environmental concern score scaled by the total number of environmental concern score items. | KLD |
| E score_ASSET4 | Overall score of a firm's environmental performance based on three component scores: emission reduction, product innovation, and resource reduction. | ASSET4 |
| Female director count ≥ 1 | Indicator variable that takes the value of one if a firm has one or more female directors, and zero otherwise. | BoardEx |
| Female director count ≥ 2 | Indicator variable that takes the value of one if a firm has two or more female directors, and zero otherwise. | BoardEx |
| Female director count ≥ 3 | Indicator variable that takes the value of one if a firm has at least three or more female directors, and zero otherwise. | BoardEx |
| Board IDV (UAI, PDI, MAS) | Average of the individualism (uncertainty avoidance, power distance, or masculinity) score of directors on a board in a year, based on a director's ancestral background inferred from her last names. See Pan, Wang, and Siegel (2017, 2020) for details. | Hofstede Culture Dimension website, Pan, Wang, and Siegel (2017, 2020) |

| | | |
|---|---|---|
| Board Republican share | Average of the political ideology measure of directors on a board in a year. A director's political ideology is captured by her contribution amount to the Republican ($R_k$) and Democratic ($D_K$) parties over her donation history as follows: $$Rep_k = \frac{R_k - D_k}{R_k + D_k}.$$ | Federal Election Commission |
| Board polarization | A board's political polarization index at the firm-year level is computed as follows: $$PolarIndex_{it} = \frac{\sum_1^N \left| Rep_k - \frac{\sum_1^N Rep_{kit}}{N} \right|}{N}$$ where *i* denotes firm, *k* denotes director, and *N* denotes the total number of directors on firm *i*'s board in year *t*. | Federal Election Commission |
| **Facility characteristics** | | |
| Credit score | The Minimum Dun & Bradstreet PayDex Score – a 100-point indexing system that captures trade experiences reported to NETS, compares payment to terms of sale, and scores the overall manner of payment. The index is dollar-weighted by the amount of credit involved. A PayDex Score of 80 indicates that on average, a business pays its bills in a "Prompt" manner. | NETS |
| ln(Sales) | Natural logarithm of estimated sales (in millions of dollars) of a facility in a year. | NETS |
| ln(#Employees) | Natural logarithm of reported number of employees working in a facility in a year. | NETS |
| Female manager | Indicator variable that takes the value of one if a facility's officer/manager is a female, and zero otherwise. | NETS |
| **Instrumental variable** | | |
| Gender Equality Index | Firm-year average of the Gender Equality Index (GEI) of the state where a director obtained her undergraduate degree. We first assign GEI to each director based on the state where she went to college. We then calculate the firm-year average GEI across all directors on a board in a year. The index includes state-level indicators of economic, political, and legal gender equality. It combines seven economic gender equality (such as labor market participation and labor income), four indicators of political gender equality (such as female representation in state house and as mayors), and thirteen indicators of | Sugarman and Straus (1988) |

| | | |
|---|---|---|
| | legal gender equality (such as fair employment practices law and equal pay law), using data from the State and Regional Indicators Archive over the period 1977–1983. | |
| Affirmative Action | Firm-year average of the Affirmative Action indicator across all directors on a board in a year. The Affirmative Action indicator takes the value of one if a director was 18 years old or younger in 1965 following the passage of the Civil Rights Act of 1964, and zero otherwise. The Act makes it illegal for college admission to discriminate based on gender or race, providing more higher education opportunities and job mobility for women and minorities. | Field, Souther, and Yore (2020) |
| **Channel variables** | | |
| *Director-level* | | |
| Female | Indicator variable that takes the value of one if a director is a female, and zero otherwise. | BoardEx |
| Age | Director age. | BoardEx |
| Tenure | Director tenure. | BoardEx |
| Field_business | Indicator variable that takes the value of one if a director has earned a degree in economics or business (e.g., MBA, BBA, BCOM, DBA), and zero otherwise. | BoardEx |
| Field_law | Indicator variable that takes the value of one if a director has earned a degree in law (e.g., JD, LLB, LLM), and zero otherwise. | BoardEx |
| Field_medicine | Indicator variable that takes the value of one if a director has earned a degree in medicine (e.g., MD), and zero otherwise. | BoardEx |
| Field_STEM | Indicator variable that takes the value of one if a director has earned a degree in science (e.g., BS, BSc, Bachelor of Engineering, MSc), and zero otherwise. | BoardEx |
| #Fields | Sum of a director's fields of study. | BoardEx |
| Highest degree | Highest degree received by a director. It takes the value of 3 for PhD, JD, and MD, 2 for MBA and other master's degree, 1 for bachelor's degree, and zero otherwise. | |
| Skill_academic | Indicator variable that takes the value of one if a director has worked at universities and her prior job roles contain any of the following key words: professor, lecturer, faculty, instructor, dean, director, chair, provost, chancellor, principal, or president, and zero otherwise. | BoardEx |

| | | |
|---|---|---|
| Skill_community | Indicator variable that takes the value of one if a director has worked at charities, or her prior job roles or job descriptions contain any of the following key words: community, non-profit, nonprofit, philanthropic, social, or CSR, and zero otherwise. | BoardEx |
| Skill_environment | Indicator variable that takes the value of one if a director has experience in environmental and/or sustainability issues, and zero otherwise. A director has experience in environment if her prior job roles or job descriptions contain any of the following key words: environment, safety, sustainability, sustainable, or ESG. | BoardEx |
| Skill_government | Indicator variable that takes the value of one if a director has worked at government agencies, or her prior job roles contain any of the following key words such as commissioner, council member, senior advisor, or director, and zero otherwise. | BoardEx |
| Skill_risk management | Indicator variable that takes the value of one if a director has experience in risk management, and zero otherwise. A director has experience in risk management if her prior job roles or job descriptions contain any of the following key words: risk, compliance, litigation, legal, or cyber. | BoardEx |
| Skill_technology | Indicator variable that takes the value of one if a director has experience in engineering, science, or research and development, and zero otherwise. A director has experience in technology if her prior job roles or job descriptions contain any of the following key words: engineer, scientific, scientist, science, research and development, R&D, R & D, technology, or technological. | BoardEx |
| #Skills | Sum of a director's skill sets. | BoardEx |
| Industry experience | Indicator variable that takes the value of one if a director has industry-related experience (to the focal firm), and zero otherwise. | Refinitiv |
| Finance experience | Indicator variable that takes the value of one if a director has finance and/or accounting experience, and zero otherwise. | Refinitiv |
| Chairman | Indicator variable that takes the value of one if a director is Chairman of the Board, and zero otherwise. | BoardEx |
| Lead director | Indicator variable that takes the value of one if a director's role contains any of the following key words: lead independent director, lead independent chairman, presiding lead independent director, lead independent corporate director, lead independent vice chairman, lead director, vice chairman (lead independent director), or lead independent outside director, and zero otherwise. | BoardEx |
| Audit committee | Indicator variable that takes the value of one if a director sits on audit committee in a year, and zero otherwise. | BoardEx |

| | | |
|---|---|---|
| Compensation committee | Indicator variable that takes the value of one if a director sits on compensation committee in a year, and zero otherwise. | BoardEx |
| ESG committee | Indicator variable that takes the value of one if a director sits on ESG committee in a year, and zero otherwise. A board committee is responsible for ESG if its committee name contains any of the following key words: CSR, ESG, environ*, social, or sustain*. | BoardEx |
| Nomination committee | Indicator variable that takes the value of one if a director sits on nomination committee in a year, and zero otherwise. | BoardEx |
| *Firm-level* | | |
| Compensation policy including ESG metric | Indicator variable that takes the value of one if a firm has an executive compensation policy that takes into account its ESG performance, and zero otherwise. The data item from Refinitiv is as follows: "Does the company have an extra-financial performance oriented compensation policy? - the compensation policy includes remuneration for the CEO, executive directors, non-board executives, and other management bodies based on ESG or sustainability factors." | Refinitiv |
| ESG (executive) committee | Indicator variable that takes the value of one if a firm has an ESG committee at either the board level or at the senior management level, and zero otherwise. The data item from Refinitiv is as follows: "Does the company have a CSR committee or team? - board level or Senior management committee responsible for decision making on CSR strategy." | Refinitiv |
| ESG reporting | Indicator variable that takes the value of one if a firm has implemented ESG reporting, and zero otherwise. The data item from Refinitiv is as follows: "Does the company publish a separate CSR/H&S/Sustainability report or publish a section in its annual report on CSR/H&S/Sustainability?" | Refinitiv |

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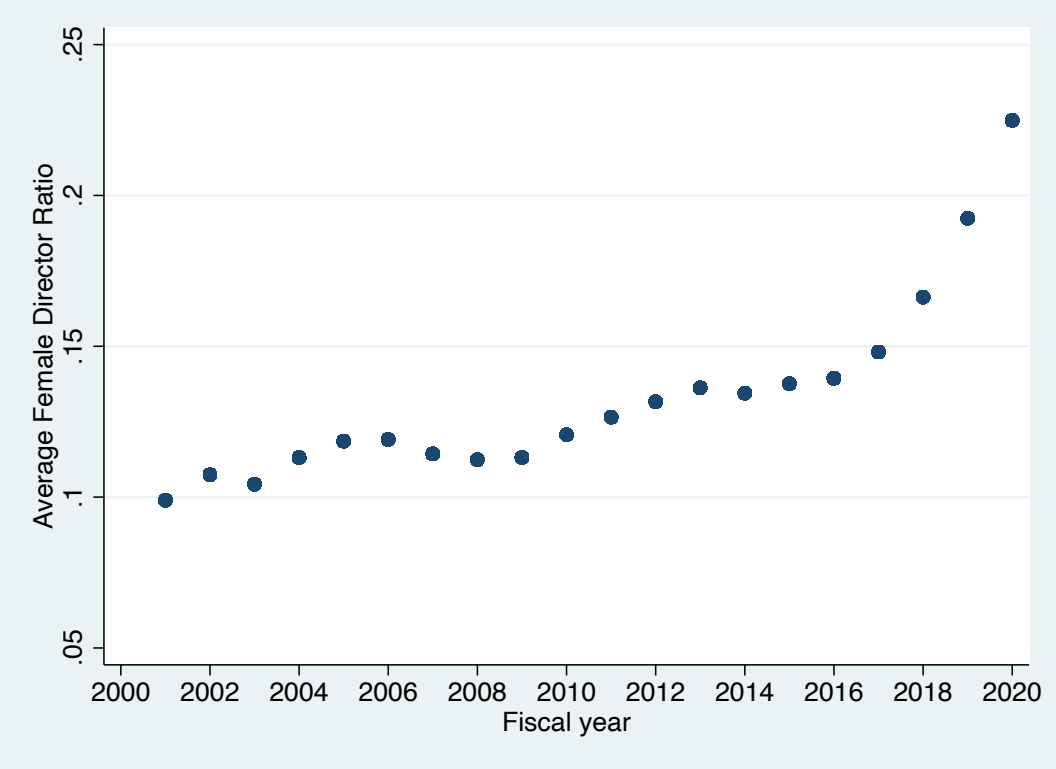
**Figure 1**
**The share of female directors over time**

This figure plots the temporal trend in the share of female directors over the period 2001–2021. The x-axis shows the fiscal year. The y-axis is the average *Female director ratio* across sample firms in a fiscal year. Our sample comprises 21,728 firm-year observations representing 3,198 firms over the period 2002–2021.



## Table 1
## Sample formation

This table lists the steps taken and filters applied to form the samples used in our analyses. Panel A reports the steps and filters applied to form our main sample of 21,728 firm-year observations for a sample of 3,198 firms over the period 2002–2021. Panel B reports the steps and filters applied to form our facility-level sample of 41,280 facility-year observations for a sample of 4,514 facilities associated with 627 firms over the period 2002–2017.

Panel A: Firm sample formation

| | #firm-year obs. | #firm-year obs. removed | #unique firms |
|---|---|---|---|
| WRDS Refinitiv ESG over the period 2002–2021 | 24,525 | | 3,588 |
| Remove observations with missing data from BoardEx | 23,799 | 726 | 3,504 |
| Remove observations with missing data form Compustat | 23,135 | 664 | 3,365 |
| Remove observations with missing data form WRDS Thomson 13F | 23,070 | 65 | 3,360 |
| Remove observations without Augmented 10-X Header Data | 22,848 | 222 | 3,258 |
| Remove observations due to fixed effects | 21,728 | 1,120 | 3,198 |
| Final sample | 21,728 | | 3,198 |

Panel B: Facility sample formation

| | #facility-year obs. | #facility-year obs. removed | #unique facilities |
|---|---|---|---|
| TRI facility-year observations matched to GVKEY over the period 1991–2020 | 161,814 | | 13,811 |
| Remove observations not in our baseline firm sample | 87,048 | 74,766 | 8,415 |
| Remove observations not covered by NETS (NETS ending in 2017) | 53,702 | 33,346 | 6,850 |
| Remove observations with missing data used in regression analysis | 42,385 | 11,317 | 5,149 |
| Remove observations due to fixed effects | 41,280 | 1,105 | 4,514 |
| Final sample | 41,280 | | 4,514 |

## Table 2
## Summary statistics

This table provides the summary statistics for our firm and facility samples. Panel A presents the summary statistics for the firm-level variables of 21,728 firm-year observations for a sample of 3,198 firms over the period 2002–2021. Panel B presents the correlation matrix for variables in the firm sample. Panel C presents the summary statistics for the facility-level variables of 41,280 facility-year observations for a sample of 4,514 facilities associated with 627 firms over the period 2002–2017. Definitions of the variables are provided in the Appendix.

Panel A: Summary statistics for the firm sample

| | Obs. | Mean | SD | P5 | Median | P95 |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| E score | 21,728 | 0.211 | 0.253 | 0.000 | 0.097 | 0.737 |
| Emissions reduction score | 21,728 | 0.241 | 0.302 | 0.000 | 0.082 | 0.875 |
| Innovation score | 21,728 | 0.148 | 0.258 | 0.000 | 0.000 | 0.788 |
| Resource use score | 21,728 | 0.245 | 0.312 | 0.000 | 0.046 | 0.891 |
| Female director ratio | 21,728 | 0.150 | 0.107 | 0.000 | 0.143 | 0.333 |
| Board size | 21,728 | 10.977 | 3.721 | 6.000 | 10.000 | 17.000 |
| Board independence | 21,728 | 0.761 | 0.125 | 0.545 | 0.778 | 0.909 |
| Board busyness | 21,728 | 0.146 | 0.141 | 0.000 | 0.125 | 0.412 |
| Female CEO | 21,728 | 0.038 | 0.192 | 0.000 | 0.000 | 0.000 |
| Top5 institutions | 21,728 | 0.313 | 0.120 | 0.123 | 0.310 | 0.505 |
| M/B | 21,728 | 3.428 | 5.691 | 0.491 | 2.201 | 11.895 |
| Firm size | 21,728 | 8.186 | 1.883 | 5.015 | 8.185 | 11.287 |
| ROA | 21,728 | 0.002 | 0.173 | -0.289 | 0.027 | 0.155 |
| Leverage | 21,728 | 0.274 | 0.221 | 0.000 | 0.244 | 0.696 |
| Cash holdings | 21,728 | 0.161 | 0.203 | 0.005 | 0.077 | 0.638 |
| SG&A | 21,728 | 0.276 | 0.659 | 0.000 | 0.160 | 0.689 |

Panel B: Correlation matrix of the firm sample

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | E score | 1.000 | | | | | | | | | | | | |
| 2 | Female director ratio | 0.250*** | 1.000 | | | | | | | | | | | |
| 3 | Board size | 0.424*** | 0.104*** | 1.000 | | | | | | | | | | |
| 4 | Board independence | -0.215*** | 0.124*** | -0.414*** | 1.000 | | | | | | | | | |
| 5 | Board busyness | 0.209*** | 0.075*** | 0.161*** | -0.019*** | 1.000 | | | | | | | | |
| 6 | Female CEO | 0.032*** | 0.252*** | -0.022*** | 0.044*** | 0.012* | 1.000 | | | | | | | |
| 7 | Top5 institutions | -0.039*** | 0.074*** | -0.205*** | 0.189*** | -0.007 | 0.019*** | 1.000 | | | | | | |
| 8 | M/B | 0.009 | 0.036*** | -0.019*** | -0.049*** | 0.021*** | 0.020*** | 0.014** | 1.000 | | | | | |
| 9 | Firm size | 0.499*** | 0.143*** | 0.703*** | -0.319*** | 0.142*** | -0.026*** | -0.128*** | -0.128*** | 1.000 | | | | |
| 10 | ROA | 0.184*** | 0.043*** | 0.214*** | -0.160*** | -0.010 | -0.033*** | -0.012* | -0.037*** | 0.350*** | 1.000 | | | |
| 11 | Leverage | 0.101*** | 0.051*** | -0.033*** | 0.015** | 0.031*** | 0.011 | 0.123*** | -0.064*** | 0.110*** | -0.043*** | 1.000 | | |
| 12 | Cash holdings | -0.178*** | -0.033*** | -0.245*** | 0.029*** | 0.062*** | 0.033*** | 0.062*** | 0.226*** | -0.452*** | -0.401*** | -0.252*** | 1.000 | |
| 13 | SG&A | -0.120*** | -0.019*** | -0.119*** | 0.056*** | -0.013* | 0.021*** | -0.008 | 0.095*** | -0.257*** | -0.354*** | -0.087*** | 0.296*** | 1.000 |

Panel C: Summary statistics for the facility sample

| | Obs. | Mean | SD | P5 | Median | P95 |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| #Source reduction practices | 41,280 | 0.218 | 0.692 | 0.000 | 0.000 | 1.000 |
| #Source reduction practices/Sales (in million dollars) | 41,280 | 0.026 | 0.438 | 0.000 | 0.000 | 0.040 |
| Total emissions (in million pounds) | 41,280 | 0.266 | 1.354 | 0.000 | 0.002 | 1.222 |
| On-site emissions (in million pounds) | 41,280 | 0.213 | 1.142 | 0.000 | 0.000 | 0.944 |
| Sales (in million dollars) | 41,280 | 201.197 | 637.305 | 2.737 | 54.000 | 882.113 |
| Total emissions/Sales | 41,280 | 0.033 | 1.140 | 0.000 | 0.000 | 0.023 |
| On-site emissions/Sales | 41,280 | 0.021 | 0.425 | 0.000 | 0.000 | 0.015 |
| ln(#Source reduction practices + 1) | 41,280 | 0.120 | 0.332 | 0.000 | 0.000 | 0.693 |
| ln(#Source reduction practices/Sales + 1) | 41,280 | 0.026 | 0.438 | 0.000 | 0.000 | 0.040 |
| ln(Total emissions/Sales + 1) | 41,280 | 0.013 | 0.113 | 0.000 | 0.000 | 0.022 |
| ln(On-site emissions/Sales + 1) | 41,280 | 0.010 | 0.098 | 0.000 | 0.000 | 0.014 |
| Female director ratio | 41,280 | 0.119 | 0.079 | 0.000 | 0.118 | 0.250 |
| Board size | 41,280 | 13.124 | 3.270 | 7.000 | 13.000 | 18.000 |
| Board independence | 41,280 | 0.704 | 0.110 | 0.545 | 0.688 | 0.900 |
| Board busyness | 41,280 | 0.287 | 0.211 | 0.000 | 0.267 | 0.667 |
| Female CEO | 41,280 | 0.028 | 0.165 | 0.000 | 0.000 | 0.000 |
| Top5 institutions | 41,280 | 0.266 | 0.100 | 0.103 | 0.265 | 0.430 |
| M/B | 41,280 | 2.870 | 4.121 | 0.863 | 2.223 | 7.156 |
| Firm size | 41,280 | 9.018 | 1.935 | 6.038 | 8.896 | 12.620 |
| ROA | 41,280 | 0.046 | 0.068 | -0.043 | 0.046 | 0.136 |
| Leverage | 41,280 | 0.274 | 0.147 | 0.051 | 0.258 | 0.551 |
| Cash holdings | 41,280 | 0.087 | 0.080 | 0.006 | 0.066 | 0.239 |
| SG&A | 41,280 | 0.129 | 0.110 | 0.000 | 0.112 | 0.340 |
| Credit score | 41,280 | 68.041 | 7.867 | 53.000 | 69.000 | 78.000 |
| ln(Sales) | 41,280 | 17.707 | 1.720 | 14.822 | 17.804 | 20.598 |
| ln(#Employees) | 41,280 | 5.177 | 1.530 | 2.398 | 5.303 | 7.496 |

## Table 3
## Female directors and corporate environmental performance

This table examines the relation between the fraction of female directors on a board and corporate environmental performance. The sample consists of 21,728 firm-year observations over the period 2002–2021. We use four different environmental scores as the dependent variables: *E score*, *Emissions reduction score*, *Innovation score*, and *Resource use score*. Our variable of interest is *Female director ratio*, the number of female directors scaled by board size. We include (three-digit SIC) industry times year fixed effects to control for industry-specific time trends in both the share of female directors and corporate environmental performance. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

| | E score | Emissions reduction score | Innovation score | Resource use score |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female director ratio | 0.222*** | 0.274*** | 0.109*** | 0.285*** |
| | (0.027) | (0.033) | (0.031) | (0.034) |
| Board size | 0.015*** | 0.018*** | 0.008*** | 0.018*** |
| | (0.001) | (0.002) | (0.002) | (0.002) |
| Board independence | -0.185*** | -0.230*** | -0.099*** | -0.227*** |
| | (0.030) | (0.037) | (0.034) | (0.037) |
| Board busyness | 0.105*** | 0.128*** | 0.043* | 0.143*** |
| | (0.021) | (0.025) | (0.025) | (0.025) |
| Female CEO | -0.001 | -0.006 | 0.003 | 0.000 |
| | (0.014) | (0.016) | (0.018) | (0.016) |
| Top5 institutions | -0.091*** | -0.119*** | -0.069*** | -0.085*** |
| | (0.023) | (0.027) | (0.026) | (0.027) |
| M/B | 0.001** | 0.001** | 0.000 | 0.001** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.068*** | 0.076*** | 0.046*** | 0.081*** |
| | (0.003) | (0.004) | (0.004) | (0.004) |
| ROA | -0.033** | -0.024 | -0.040*** | -0.036** |
| | (0.014) | (0.017) | (0.015) | (0.017) |
| Leverage | -0.056*** | -0.059*** | -0.047*** | -0.062*** |
| | (0.015) | (0.019) | (0.017) | (0.019) |
| Cash holdings | 0.025 | 0.032 | 0.054** | -0.011 |
| | (0.020) | (0.024) | (0.023) | (0.023) |
| SG&A | 0.001 | 0.003 | -0.001 | 0.001 |
| | (0.002) | (0.003) | (0.002) | (0.002) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| Obs. | 21,728 | 21,728 | 21,728 | 21,728 |
| *Adj-$R^2$* | 0.562 | 0.522 | 0.370 | 0.516 |

## Table 4
## Female directors and corporate environmental performance: 2SLS

This table examines the relation between the fraction of female directors on a board and corporate environmental performance using 2SLS regressions. The sample consists of 21,509 firm-year observations over the period 2002–2021. Column (1) reports the first-stage regression results, where *Gender Equality Index* and *Affirmative Action* are used as the instrumental variables. Columns (2) to (5) tabulate the second-stage regression results with the four environmental scores as the dependent variables: *E score*, *Emissions reduction score*, *Innovation score*, and *Resource use score*. Our variable of interest is *Female director ratio*, the number of female directors scaled by board size. We include (three-digit SIC) industry times year fixed effects to control for industry-specific time trends in both the share of female directors and corporate environmental performance. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

| | Female director ratio | E score | Emissions reduction score | Innovation score | Resource use score |
|---|---|---|---|---|---|
| | 1st stage | 2nd stage | | | |
| | (1) | (2) | (3) | (4) | (5) |
| Gender Equality Index | 0.118*** | | | | |
| | (0.034) | | | | |
| Affirmative Action | 0.068*** | | | | |
| | (0.009) | | | | |
| Female director ratio | | 1.023*** | 1.124*** | 0.876*** | 1.068*** |
| | | (0.253) | (0.297) | (0.285) | (0.311) |
| Board size | 0.004*** | 0.012*** | 0.015*** | 0.006*** | 0.015*** |
| | (0.001) | (0.002) | (0.002) | (0.002) | (0.002) |
| Board independence | 0.088*** | -0.260*** | -0.309*** | -0.172*** | -0.298*** |
| | (0.013) | (0.038) | (0.046) | (0.043) | (0.048) |
| Board busyness | 0.042*** | 0.070*** | 0.090*** | 0.011 | 0.108*** |
| | (0.010) | (0.025) | (0.029) | (0.028) | (0.030) |
| Female CEO | 0.117*** | -0.095*** | -0.106*** | -0.087** | -0.092** |
| | (0.008) | (0.034) | (0.040) | (0.039) | (0.041) |
| Top5 institutions | 0.014 | -0.111*** | -0.140*** | -0.088*** | -0.103*** |
| | (0.012) | (0.025) | (0.029) | (0.028) | (0.029) |
| M/B | 0.000 | 0.001 | 0.001 | 0.000 | 0.001* |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.011*** | 0.058*** | 0.066*** | 0.037*** | 0.071*** |
| | (0.001) | (0.005) | (0.005) | (0.005) | (0.005) |
| ROA | 0.020*** | -0.045*** | -0.036* | -0.051*** | -0.048** |
| | (0.008) | (0.016) | (0.019) | (0.017) | (0.019) |
| Leverage | -0.011 | -0.048*** | -0.049** | -0.040** | -0.054*** |
| | (0.008) | (0.017) | (0.020) | (0.019) | (0.020) |
| Cash holdings | 0.006 | 0.014 | 0.020 | 0.043* | -0.022 |
| | (0.010) | (0.021) | (0.026) | (0.025) | (0.025) |
| SG&A | -0.003 | 0.003 | 0.005* | 0.001 | 0.003 |
| | (0.002) | (0.002) | (0.003) | (0.002) | (0.003) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| First-stage F-statistic | 38.17*** | | | | |
| Overidentificaiton test (Hansen's J statistic) | | 0.617 | 0.635 | 0.714 | 0.616 |
| Obs. | 21,509 | 21,509 | 21,509 | 21,509 | 21,509 |
| *Adj-$R^2$* | 0.291 | 0.264 | 0.254 | -0.038 | 0.276 |

## Table 5
## Female directors and corporate environmental performance: firm fixed effects

This table examines within-firm temporal variations in the share of female directors in relation to within-firm temporal variations in corporate environmental performance by including firm fixed effects. The sample consists of 21,485 firm-year observations over the period 2002–2021. We use four different environmental scores as the dependent variables: *E score*, *Emissions reduction score*, *Innovation score*, and *Resource use score*. Our variable of interest is *Female director ratio*, the number of female directors scaled by board size. We include firm fixed effects and (three-digit SIC) industry times year fixed effects. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

| | E score | Emissions reduction score | Innovation score | Resource use score |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female director ratio | 0.074*** | 0.080*** | 0.027 | 0.114*** |
| | (0.023) | (0.029) | (0.031) | (0.032) |
| Board size | 0.003*** | 0.004** | 0.002 | 0.004** |
| | (0.001) | (0.002) | (0.001) | (0.002) |
| Board independence | -0.117*** | -0.105*** | -0.109*** | -0.138*** |
| | (0.026) | (0.033) | (0.033) | (0.036) |
| Board busyness | -0.008 | -0.001 | -0.033 | 0.008 |
| | (0.016) | (0.020) | (0.023) | (0.022) |
| Female CEO | -0.005 | -0.023 | 0.001 | 0.007 |
| | (0.014) | (0.022) | (0.017) | (0.017) |
| Top5 institutions | -0.041** | -0.057** | -0.015 | -0.050** |
| | (0.018) | (0.023) | (0.024) | (0.022) |
| M/B | -0.000 | -0.000 | 0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.024*** | 0.041*** | -0.003 | 0.033*** |
| | (0.005) | (0.007) | (0.006) | (0.006) |
| ROA | -0.017* | -0.018 | -0.002 | -0.030** |
| | (0.010) | (0.013) | (0.011) | (0.013) |
| Leverage | -0.023* | -0.025 | -0.032* | -0.012 |
| | (0.013) | (0.018) | (0.017) | (0.019) |
| Cash holdings | 0.026 | 0.044** | -0.007 | 0.040* |
| | (0.018) | (0.022) | (0.022) | (0.023) |
| SG&A | -0.002 | -0.003 | -0.002* | -0.001 |
| | (0.002) | (0.003) | (0.001) | (0.003) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Firm Fixed Effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| Obs. | 21,485 | 21,485 | 21,485 | 21,485 |
| *Adj-$R^2$* | 0.843 | 0.807 | 0.734 | 0.805 |

## Table 6
## Female directors and corporate environmental performance: California's SB 826

This table examines changes in both the fraction of female directors and corporate environmental outcomes between treated and control firms around the enactment of California's SB 826, which imposes a female director quota on corporate boards in California starting from 2018. The treated firms are public firms without female directors in 2018 and headquartered (and stayed) in California. We find the closest control firm for each treated firm by matching on (three-digit SIC) industry, firm size, and *E score*. Panel A presents our sanity check on the impact of the California law change on the share of female directors in the treated firms compared to that in the control firms. In column (1), we regress *Female director ratio* on *Treated* × *Post*, an interaction term between the indicator variable *Treated* and the indicator variable, *Post*, for the post-event window (2019 to 2021). Column (2) employs a dynamic DiD specification by interacting *Treated* with the year indicators for each year within the event window examined. Panel B presents the DiD analysis with the four environmental scores as the dependent variables. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the state level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Panel A: CA law change and female director share

| | Female director ratio | |
|---|---|---|
| | (1) | (2) |
| Treated × Post | 0.063*** | |
| | (0.010) | |
| Treated × Year 2015 | | -0.004 |
| | | (0.012) |
| Treated × Year 2016 | | -0.002 |
| | | (0.012) |
| Treated × Year 2017 | | -0.010 |
| | | (0.013) |
| Treated × Year 2019 | | 0.040** |
| | | (0.014) |
| Treated × Year 2020 | | 0.064*** |
| | | (0.015) |
| Treated × Year 2021 | | 0.080*** |
| | | (0.023) |
| Board size | 0.008*** | 0.009*** |
| | (0.002) | (0.002) |
| Board independence | 0.177*** | 0.172*** |
| | (0.058) | (0.059) |
| Board busyness | -0.004 | -0.001 |
| | (0.023) | (0.024) |
| Female CEO | 0.136*** | 0.138*** |
| | (0.021) | (0.021) |
| Top5 institutions | 0.009 | 0.018 |
| | (0.030) | (0.030) |
| M/B | -0.000 | -0.000 |
| | (0.000) | (0.000) |
| Firm size | -0.003 | -0.004 |
| | (0.006) | (0.006) |
| ROA | -0.014 | -0.013 |
| | (0.017) | (0.017) |
| Leverage | -0.005 | -0.006 |
| | (0.025) | (0.026) |
| Cash holdings | 0.027 | 0.023 |
| | (0.033) | (0.033) |
| SG&A | -0.004** | -0.004* |
| | (0.002) | (0.002) |
| Industry × Year Fixed Effects | Yes | Yes |
| Firm Fixed Effects | Yes | Yes |
| Intercept | Yes | Yes |
| Obs. | 543 | 543 |
| *Adj-$R^2$* | 0.765 | 0.765 |

Panel B: CA law change, female director share, and corporate environmental performance

| | E score | | Emissions reduction score | | Innovation score | Resource use score |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Treated × Post | 0.030*** | | 0.057*** | | 0.016 | 0.016 |
| | (0.009) | | (0.015) | | (0.011) | (0.021) |
| Treated × Year 2015 | | -0.040 | | -0.039 | | |
| | | (0.028) | | (0.044) | | |
| Treated × Year 2016 | | -0.014 | | -0.010 | | |
| | | (0.024) | | (0.034) | | |
| Treated × Year 2017 | | -0.005 | | -0.011 | | |
| | | (0.006) | | (0.008) | | |
| Treated × Year 2019 | | 0.021*** | | 0.045*** | | |
| | | (0.006) | | (0.011) | | |
| Treated × Year 2020 | | 0.028** | | 0.059** | | |
| | | (0.012) | | (0.023) | | |
| Treated × Year 2021 | | 0.026* | | 0.050* | | |
| | | (0.014) | | (0.029) | | |
| Board size | 0.004 | 0.004 | 0.007* | 0.006 | -0.001 | 0.007 |
| | (0.003) | (0.004) | (0.004) | (0.004) | (0.005) | (0.005) |
| Board independence | 0.036 | 0.043 | 0.030 | 0.036 | 0.007 | 0.071 |
| | (0.039) | (0.043) | (0.057) | (0.066) | (0.014) | (0.060) |
| Board busyness | 0.027 | 0.026 | 0.065 | 0.063* | 0.009 | 0.009 |
| | (0.038) | (0.036) | (0.038) | (0.035) | (0.029) | (0.055) |
| Female CEO | 0.012 | 0.003 | -0.015 | -0.022 | 0.059** | -0.009 |
| | (0.014) | (0.018) | (0.028) | (0.030) | (0.025) | (0.027) |
| Top5 institutions | 0.167*** | 0.168*** | 0.233*** | 0.230*** | 0.151** | 0.117*** |
| | (0.039) | (0.038) | (0.052) | (0.052) | (0.055) | (0.032) |
| M/B | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.001) |
| Firm size | 0.008 | 0.008 | 0.002 | 0.002 | 0.016* | 0.006 |
| | (0.009) | (0.009) | (0.012) | (0.012) | (0.008) | (0.018) |
| ROA | -0.009 | -0.008 | -0.003 | -0.003 | -0.012 | -0.011 |
| | (0.011) | (0.011) | (0.013) | (0.012) | (0.011) | (0.018) |
| Leverage | 0.050* | 0.051** | 0.060* | 0.061* | 0.031*** | 0.060 |
| | (0.024) | (0.024) | (0.033) | (0.034) | (0.008) | (0.039) |
| Cash holdings | 0.023 | 0.020 | 0.037 | 0.037 | -0.053** | 0.085** |
| | (0.038) | (0.039) | (0.064) | (0.065) | (0.023) | (0.040) |
| SG&A | 0.002* | 0.002* | 0.000 | 0.000 | 0.001 | 0.005** |
| | (0.001) | (0.001) | (0.002) | (0.002) | (0.001) | (0.002) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 432 | 432 | 432 | 432 | 432 | 432 |
| *Adj-$R^2$* | 0.649 | 0.644 | 0.608 | 0.603 | 0.554 | 0.652 |

## Table 7
## Female directors and facility-level environmental performance

This table examines the relation between the fraction of female directors on a board and facility-level environmental performance. The sample consists of 41,280 facility-year observations for a sample of 4,514 facilities associated with 627 firms over the period 2002–2017. Panel A presents the results of female directors' impact on facility-level pollution prevention measures, where the dependent variables are *ln(#Source reduction practices + 1)* and *ln(#Source reduction practices/Sales + 1)*. Panel B shows female directors' impact on facility-level emissions, where the dependent variables are *ln(Total emissions/Sales + 1)* and *ln(On-site emissions/Sales + 1)*. We include facility fixed effects and (three-digit SIC) industry times year fixed effects. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Panel A: Female directors and facility-level pollution prevention measures

| | ln(#Source reduction practices + 1) | | ln(#Source reduction practices/Sales + 1) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female director ratio | 0.106* | 0.107* | 0.163* | 0.145* |
| | (0.061) | (0.061) | (0.090) | (0.086) |
| Credit score | | 0.000 | | 0.000 |
| | | (0.000) | | (0.000) |
| ln(Sales) | | 0.001 | | -0.107** |
| | | (0.007) | | (0.049) |
| ln(#Employees) | | -0.004 | | 0.027 |
| | | (0.008) | | (0.050) |
| Board size | -0.001 | -0.001 | -0.002 | -0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| Board independence | 0.011 | 0.012 | -0.057 | -0.047 |
| | (0.049) | (0.049) | (0.045) | (0.045) |
| Board busyness | -0.029 | -0.028 | -0.024 | -0.019 |
| | (0.018) | (0.018) | (0.020) | (0.022) |
| Female CEO | -0.031 | -0.032 | -0.038** | -0.048* |
| | (0.025) | (0.025) | (0.016) | (0.027) |
| Top5 institutions | 0.018 | 0.018 | -0.002 | 0.005 |
| | (0.037) | (0.037) | (0.041) | (0.040) |
| M/B | 0.000 | 0.000 | -0.001 | -0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Firm size | -0.011 | -0.012 | -0.028* | -0.032** |
| | (0.012) | (0.012) | (0.015) | (0.014) |
| ROA | 0.095*** | 0.094*** | 0.047 | 0.044 |
| | (0.035) | (0.035) | (0.037) | (0.037) |
| Leverage | 0.054 | 0.054 | 0.013 | 0.011 |
| | (0.036) | (0.036) | (0.046) | (0.045) |
| Cash holdings | -0.018 | -0.017 | -0.027 | 0.012 |
| | (0.055) | (0.055) | (0.083) | (0.080) |
| SG&A | 0.023 | 0.022 | 0.093 | 0.057 |
| | (0.083) | (0.083) | (0.075) | (0.066) |
| Facility Fixed Effects | Yes | Yes | Yes | Yes |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| Obs. | 41,280 | 41,280 | 41,280 | 41,280 |
| *Adj-$R^2$* | 0.483 | 0.483 | 0.383 | 0.398 |

Panel B: Female directors and facility-level emissions

| | ln(Total emissions/Sales + 1) | | ln(On-site emissions/Sales + 1) | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female director ratio | -0.015* | -0.023** | -0.017** | -0.021*** |
| | (0.008) | (0.010) | (0.007) | (0.007) |
| Credit score | | 0.000 | | 0.000 |
| | | (0.000) | | (0.000) |
| ln(Sales) | | -0.061* | | -0.021** |
| | | (0.037) | | (0.011) |
| ln(#Employees) | | 0.040 | | 0.002 |
| | | (0.039) | | (0.012) |
| Board size | 0.001 | 0.001* | 0.000 | 0.001 |
| | (0.001) | (0.001) | (0.000) | (0.000) |
| Board independence | 0.000 | 0.001 | 0.009 | 0.012* |
| | (0.015) | (0.015) | (0.007) | (0.007) |
| Board busyness | 0.001 | 0.002 | 0.002 | 0.004 |
| | (0.004) | (0.004) | (0.003) | (0.003) |
| Female CEO | 0.017 | 0.016** | 0.016 | 0.014* |
| | (0.011) | (0.008) | (0.011) | (0.007) |
| Top5 institutions | 0.009 | 0.013 | 0.004 | 0.005 |
| | (0.010) | (0.010) | (0.006) | (0.006) |
| M/B | -0.000 | -0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | -0.002 | -0.003 | 0.001 | -0.000 |
| | (0.004) | (0.004) | (0.002) | (0.002) |
| ROA | 0.007 | 0.008 | -0.000 | -0.001 |
| | (0.009) | (0.009) | (0.005) | (0.006) |
| Leverage | 0.003 | 0.003 | 0.003 | 0.003 |
| | (0.005) | (0.007) | (0.004) | (0.004) |
| Cash holdings | -0.016 | 0.002 | -0.002 | 0.006 |
| | (0.014) | (0.016) | (0.006) | (0.007) |
| SG&A | -0.004 | -0.019 | -0.006 | -0.014 |
| | (0.009) | (0.013) | (0.008) | (0.010) |
| Facility Fixed Effects | Yes | Yes | Yes | Yes |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| Obs. | 41,280 | 41,280 | 41,280 | 41,280 |
| *Adj-$R^2$* | 0.655 | 0.690 | 0.781 | 0.796 |

## Table 8
## Director qualifications, committee roles, and governance roles

This table examines whether female directors are different from their male counterparts in terms of qualifications, committee roles, and governance roles. Panel A presents the two-sample t-test comparing female and male directors in age, board tenure, and educational background. Panel B presents the two-sample t-test comparing female and male directors in skill sets and industry and finance experience. Panel C presents the two-sample t-test comparing female and male directors in board leadership and committee affiliations. Panel D presents the regression analysis to explain board leadership roles and committee affiliations controlling for director characteristics and (three-digit SIC) industry times year and firm fixed effects. Panel E presents the regression analysis to examine the relation between the fraction of female directors on a board and its having ESG-linked compensation policy for executives, ESG-related committee, and ESG reporting controlling for firm characteristics and (three-digit SIC) industry times year and firm fixed effects. Definitions of the variables are provided in the Appendix. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Panel A: Director age, tenure, and educational background

| | Group mean for directors | | Diff. in mean t-test |
|---|---|---|---|
| | Female | Male | |
| | (1) | (2) | (3) |
| Age | 59.640 | 62.850 | -3.211*** |
| Tenure | 5.983 | 8.380 | -2.397*** |
| Field_business | 0.463 | 0.485 | -0.022*** |
| Field_law | 0.138 | 0.135 | 0.004* |
| Field_medicine | 0.028 | 0.026 | 0.002** |
| Field_STEM | 0.400 | 0.460 | -0.060*** |
| # Fields | 1.029 | 1.105 | -0.076*** |
| Highest degree | 1.828 | 1.739 | 0.089*** |
| Obs. (for Tenure, no missing values) | 36,897 | 169,340 | |

Panel B: Director skill sets

| | Group mean for directors | | Diff. in mean t-test |
|---|---|---|---|
| | Female | Male | |
| | (1) | (2) | (3) |
| Skill_academic | 0.171 | 0.120 | 0.051*** |
| Skill_community | 0.113 | 0.050 | 0.063*** |
| Skill_environment | 0.035 | 0.015 | 0.020*** |
| Skill_government | 0.214 | 0.151 | 0.063*** |
| Skill_risk management | 0.077 | 0.039 | 0.038*** |
| Skill_technology | 0.148 | 0.131 | 0.017*** |
| # Skills | 0.749 | 0.500 | 0.249*** |
| Industry experience | 0.230 | 0.414 | -0.184*** |
| Finance experience | 0.287 | 0.301 | -0.014*** |

Panel C: Board leadership and committee affiliations

| | Group mean for directors | | Diff. in mean t-test |
|---|---|---|---|
| | Female | Male | |
| | (1) | (2) | (3) |
| Chairman of the Board | 0.015 | 0.120 | -0.105*** |
| Lead director | 0.023 | 0.051 | -0.028*** |
| Audit committee | 0.492 | 0.426 | 0.065*** |
| Compensation committee | 0.366 | 0.355 | 0.010*** |
| ESG committee | 0.053 | 0.030 | 0.023*** |

| | | | |
|---|---|---|---|
| Nomination committee | 0.312 | 0.268 | 0.044*** |

Panel D: Regression analysis explaining board leadership and committee affiliations

| | Chairman of the Board | Lead director | Audit committee | Compensation committee | ESG committee | Nomination committee |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Female | -0.086*** | -0.018*** | 0.089*** | 0.043*** | 0.015*** | 0.066*** |
| | (0.002) | (0.002) | (0.007) | (0.007) | (0.002) | (0.006) |
| Age | -0.003*** | 0.002*** | 0.010*** | 0.008*** | 0.000*** | 0.006*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Tenure | 0.012*** | 0.003*** | -0.010*** | -0.002*** | -0.000** | -0.001* |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Field_business | -0.009** | 0.012*** | 0.100*** | 0.005 | -0.006*** | -0.003 |
| | (0.004) | (0.003) | (0.006) | (0.006) | (0.002) | (0.005) |
| Field_law | -0.004 | 0.014*** | -0.012 | 0.000 | -0.001 | 0.064*** |
| | (0.007) | (0.005) | (0.012) | (0.010) | (0.004) | (0.009) |
| Field_medicine | -0.031*** | -0.025*** | -0.128*** | -0.056*** | -0.004 | 0.035** |
| | (0.009) | (0.006) | (0.018) | (0.019) | (0.004) | (0.016) |
| Field_STEM | 0.014*** | 0.003 | 0.003 | -0.006 | -0.002 | -0.007 |
| | (0.004) | (0.003) | (0.006) | (0.005) | (0.002) | (0.005) |
| Highest degree | -0.002 | 0.001 | -0.028*** | 0.010** | 0.004** | 0.008** |
| | (0.003) | (0.002) | (0.005) | (0.004) | (0.002) | (0.004) |
| Skill_academic | -0.039*** | 0.004 | 0.035*** | 0.003 | 0.004 | 0.039*** |
| | (0.005) | (0.004) | (0.010) | (0.008) | (0.003) | (0.007) |
| Skill_community | -0.022*** | 0.001 | -0.012 | 0.002 | 0.008** | 0.012 |
| | (0.006) | (0.005) | (0.012) | (0.011) | (0.003) | (0.009) |
| Skill_environment | 0.009 | -0.014* | -0.022 | -0.002 | 0.018** | 0.023 |
| | (0.012) | (0.007) | (0.020) | (0.017) | (0.007) | (0.015) |
| Skill_government | 0.006 | 0.002 | -0.053*** | -0.003 | 0.006** | 0.035*** |
| | (0.005) | (0.004) | (0.008) | (0.008) | (0.002) | (0.006) |
| Skill_risk management | -0.023*** | -0.010** | 0.053*** | -0.042*** | -0.002 | -0.025** |
| | (0.007) | (0.005) | (0.013) | (0.012) | (0.003) | (0.010) |
| Skill_technology | 0.005 | -0.007** | -0.070*** | -0.005 | 0.010*** | -0.001 |
| | (0.005) | (0.003) | (0.009) | (0.008) | (0.003) | (0.007) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Firm Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 192,844 | 192,844 | 192,844 | 192,844 | 192,844 | 192,844 |
| *Adj-$R^2$* | 0.061 | 0.049 | 0.069 | 0.148 | 0.376 | 0.270 |

Panel E: Female directors and executive compensation, ESG committee, and ESG reporting

| | Compensation policy including ESG metric | ESG (executive) committee | ESG reporting |
|---|---|---|---|
| | (1) | (2) | (3) |
| Female director ratio | 0.123** | 0.138** | 0.155*** |
| | (0.058) | (0.061) | (0.060) |
| Board size | -0.000 | 0.006** | 0.008*** |
| | (0.003) | (0.003) | (0.003) |
| Board independence | 0.029 | -0.194*** | -0.186*** |
| | (0.055) | (0.064) | (0.059) |
| Board busyness | -0.028 | -0.010 | -0.112*** |
| | (0.039) | (0.042) | (0.041) |
| Female CEO | 0.041 | 0.001 | -0.003 |
| | (0.041) | (0.036) | (0.037) |
| Top5 institutions | -0.057 | -0.050 | -0.067 |
| | (0.041) | (0.041) | (0.044) |
| M/B | -0.000 | -0.000 | -0.000 |
| | (0.001) | (0.001) | (0.001) |
| Firm size | 0.007 | 0.041*** | 0.053*** |
| | (0.012) | (0.013) | (0.012) |
| ROA | 0.017 | -0.016 | -0.029 |
| | (0.024) | (0.022) | (0.023) |
| Leverage | 0.014 | -0.079** | -0.054* |
| | (0.037) | (0.032) | (0.032) |
| Cash holdings | 0.000 | 0.037 | 0.096** |
| | (0.046) | (0.044) | (0.042) |
| SG&A | -0.001 | 0.003 | -0.002 |
| | (0.005) | (0.004) | (0.004) |
| Industry × Year Fixed Effects | Yes | Yes | Yes |
| Firm Fixed Effects | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes |
| Obs. | 19,551 | 19,551 | 19,551 |
| *Adj-$R^2$* | 0.706 | 0.673 | 0.640 |

## Internet Appendix for "The Eco Gender Gap in Boardrooms"

## Table IA1
## Difference between treated and control firms before and after California's SB 826

This table shows the changes in both the fraction of female directors and corporate environmental outcomes between the treated and control firms before and after the enactment of California's SB 826. The treated firms are public firms without female directors in 2018 and headquartered (and stayed) in California. We find the closest control firm for each treated firm by matching on (three-digit SIC) industry, firm size, and *E score*. *Pre-event* represents the pre-event window (2015 to 2018). *Post-event* represents the post-event window (2019 to 2021).

| | Female director ratio | | | E score | | |
|---|---|---|---|---|---|---|
| | Treated | Control | Diff. | Treated | Control | Diff. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Pre-event | 0.019 | 0.017 | 0.003 | 0.016 | 0.014 | 0.001 |
| Post-event | 0.209 | 0.130 | 0.078*** | 0.052 | 0.039 | 0.013* |

## Table IA2
## Additional summary statistics

This table provides additional summary statistics for variables used in Section 6. Panel A provides the summary statistics for directors' board leadership roles and committee affiliations based on a sample of 206,237 director-year observations over the period 2002–2021. Panel B provides the summary statistics for firms' ESG-linked compensation policy, ESG-related committees, and ESG reporting based on a sample of 19,879 firm-year observations over the period 2002–2021. Definitions of the variables are provided in the Appendix.

Panel A: Directors' board leadership roles and committee affiliations

| | Obs. | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Chairman of the Board | 206,237 | 0.101 | 0.301 | 0 | 1 |
| Lead director | 206,237 | 0.046 | 0.209 | 0 | 1 |
| Audit committee | 206,237 | 0.438 | 0.496 | 0 | 1 |
| Compensation committee | 206,237 | 0.357 | 0.479 | 0 | 1 |
| ESG committee | 206,237 | 0.034 | 0.180 | 0 | 1 |
| Nomination committee | 206,237 | 0.276 | 0.447 | 0 | 1 |

Panel B: ESG-linked compensation policy, ESG-related committee, and ESG reporting

| | Obs. | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Compensation policy including ESG metric | 19,879 | 0.251 | 0.434 | 0 | 1 |
| ESG (executive) committee | 19,879 | 0.284 | 0.451 | 0 | 1 |
| ESG reporting | 19,879 | 0.277 | 0.447 | 0 | 1 |

## Table IA3
## Female directors and corporate environmental performance: including different fixed effects

This table examines the relation between the fraction of female directors on a board and corporate environmental performance by including different fixed effects. The dependent variable is *E score*, the average of emissions reduction score, resource use score, and innovation score from Refinitiv. Our variable of interest is *Female director ratio*, the number of female directors scaled by board size. In addition to firm, year, and (three-digit SIC) industry times year fixed effects, we further include the following fixed effects: headquarters state times year fixed effects and incorporation state times year fixed effects. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

| | E score | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Female director ratio | 0.108*** | 0.104*** | 0.080*** | 0.071*** | 0.061** |
| | (0.024) | (0.025) | (0.026) | (0.023) | (0.026) |
| Board size | 0.005*** | 0.005*** | 0.004*** | 0.003*** | 0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Board independence | -0.126*** | -0.114*** | -0.144*** | -0.093*** | -0.119*** |
| | (0.028) | (0.027) | (0.029) | (0.025) | (0.027) |
| Board busyness | 0.008 | -0.000 | -0.005 | -0.016 | -0.016 |
| | (0.017) | (0.017) | (0.018) | (0.015) | (0.017) |
| Female CEO | 0.009 | 0.007 | 0.009 | -0.009 | -0.004 |
| | (0.014) | (0.014) | (0.015) | (0.014) | (0.016) |
| Top5 institutions | -0.033* | -0.025 | -0.031 | -0.031* | -0.032* |
| | (0.018) | (0.018) | (0.019) | (0.017) | (0.019) |
| M/B | -0.000 | -0.000 | 0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.021*** | 0.021*** | 0.024*** | 0.023*** | 0.025*** |
| | (0.005) | (0.005) | (0.005) | (0.005) | (0.005) |
| ROA | -0.010 | -0.016 | 0.003 | -0.018* | -0.007 |
| | (0.009) | (0.010) | (0.010) | (0.010) | (0.010) |
| Leverage | -0.036** | -0.044*** | -0.029* | -0.020 | -0.018 |
| | (0.015) | (0.015) | (0.016) | (0.013) | (0.015) |
| Cash holdings | 0.033* | 0.034* | 0.031 | 0.025 | 0.024 |
| | (0.017) | (0.018) | (0.019) | (0.017) | (0.020) |
| SG&A | 0.003 | 0.004 | 0.004 | -0.002 | -0.002 |
| | (0.004) | (0.004) | (0.004) | (0.002) | (0.002) |
| Firm Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effects | Yes | | | | |
| Industry × Year Fixed Effects | | | | Yes | Yes |
| Headquarters state × Year Fixed Effects | | Yes | | Yes | |
| Incorporation state × Year Fixed Effects | | | Yes | | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Obs. | 21,488 | 21,352 | 19,145 | 21,338 | 19,108 |
| *Adj-$R^2$* | 0.821 | 0.827 | 0.825 | 0.852 | 0.844 |

## Table IA4
## Female directors and corporate environmental performance: additional robustness checks

This table examines the relation between the fraction of female directors on a board and corporate environmental performance with additional robustness checks. Column (1) analyzes the possible nonlinear effect of the number of women on a board by introducing indicator variables representing one or more women, two or more women, and three or more women on a board. Columns (2) and (3) use the sample with directors' ancestral data to examine the possible effect of a board's national cultural values. Columns (4) and (5) use the sample with directors' donation history data to examine the possible effects of a board's political leaning. We include (three-digit SIC) industry times year fixed effects and firm fixed effects. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

| | E score | | | | |
|---|---|---|---|---|---|
| | | Sample with ancestral data | | Sample with donation data | |
| | (1) | (2) | (3) | (4) | (5) |
| Female director count ≥ 1 | 0.008 | | | | |
| | (0.005) | | | | |
| Female director count ≥ 2 | 0.019*** | | | | |
| | (0.005) | | | | |
| Female director count ≥ 3 | 0.011** | | | | |
| | (0.005) | | | | |
| Female director ratio | | 0.111*** | 0.108*** | 0.081** | 0.090** |
| | | (0.028) | (0.027) | (0.037) | (0.038) |
| Board IDV | | | 0.003 | | |
| | | | (0.103) | | |
| Board UAI | | | -0.042 | | |
| | | | (0.074) | | |
| Board PDI | | | -0.114 | | |
| | | | (0.119) | | |
| Board MAS | | | 0.063 | | |
| | | | (0.099) | | |
| Board Republican share | | | | | 0.022 |
| | | | | | (0.020) |
| Board polarization | | | | | -0.065** |
| | | | | | (0.030) |
| Board size | 0.003** | 0.004*** | 0.004*** | 0.003* | 0.003* |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Board independence | -0.126*** | -0.140*** | -0.140*** | -0.164*** | -0.159*** |
| | (0.028) | (0.028) | (0.028) | (0.031) | (0.031) |
| Board busyness | 0.008 | -0.001 | -0.001 | -0.006 | -0.005 |
| | (0.017) | (0.017) | (0.017) | (0.021) | (0.021) |
| Female CEO | 0.012 | 0.011 | 0.010 | 0.017 | 0.018 |
| | (0.014) | (0.015) | (0.015) | (0.018) | (0.018) |
| Top5 institutions | -0.032* | -0.029 | -0.030 | -0.019 | -0.020 |
| | (0.018) | (0.020) | (0.020) | (0.024) | (0.024) |
| M/B | 0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.021*** | 0.028*** | 0.028*** | 0.027*** | 0.027*** |
| | (0.005) | (0.005) | (0.005) | (0.007) | (0.007) |

| | | | | | |
|---|---|---|---|---|---|
| ROA | -0.010 | -0.003 | -0.003 | 0.011 | 0.011 |
| | (0.009) | (0.010) | (0.010) | (0.013) | (0.013) |
| Leverage | -0.035** | -0.032** | -0.033** | -0.031 | -0.030 |
| | (0.014) | (0.016) | (0.016) | (0.021) | (0.021) |
| Cash holdings | 0.033* | 0.035* | 0.035* | 0.031 | 0.030 |
| | (0.017) | (0.019) | (0.019) | (0.024) | (0.024) |
| SG&A | 0.003 | 0.004 | 0.004 | 0.007 | 0.007 |
| | (0.004) | (0.004) | (0.004) | (0.006) | (0.006) |
| Year Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Firm Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| Obs. | 21,488 | 20,372 | 20,372 | 15,451 | 15,451 |
| *Adj-$R^2$* | 0.822 | 0.811 | 0.811 | 0.810 | 0.811 |

## Table IA5
## Female directors and corporate environmental performance: using KLD and ASSET4 data

This table examines the relation between the fraction of female directors on a board and corporate environmental performance using two other ESG data sets: the KLD and ASSET4 data sets. Panel A performs the same regression analysis as Tables 3 and 5 by including (three-digit SIC) industry times year fixed effects and firm fixed effects in different columns. Panel B performs the same 2SLS regression analysis as Table 4. Definitions of the variables are provided in the Appendix. Standard errors (in parentheses) are clustered at the firm level. ***, **, * correspond to statistical significance at the 1, 5, and 10 percent levels, respectively.

Panel A: OLS regressions

| | E score_KLD | | E score_ASSET4 | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Female director ratio | 0.087*** | 0.049* | 0.234*** | 0.069** |
| | (0.020) | (0.026) | (0.038) | (0.034) |
| Board size | 0.004*** | 0.003*** | 0.010*** | 0.002 |
| | (0.001) | (0.001) | (0.002) | (0.001) |
| Board independence | -0.077*** | -0.127*** | -0.113*** | -0.106*** |
| | (0.014) | (0.021) | (0.032) | (0.028) |
| Board busyness | 0.032*** | -0.018 | 0.089*** | -0.014 |
| | (0.011) | (0.014) | (0.018) | (0.014) |
| Female CEO | -0.006 | -0.002 | 0.005 | -0.005 |
| | (0.012) | (0.015) | (0.017) | (0.020) |
| Top5 institutions | -0.046*** | -0.019 | -0.082*** | -0.023 |
| | (0.015) | (0.017) | (0.026) | (0.023) |
| M/B | 0.001*** | 0.000 | 0.001 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.024*** | -0.020*** | 0.064*** | 0.017*** |
| | (0.002) | (0.005) | (0.004) | (0.006) |
| ROA | 0.022** | 0.002 | 0.018 | -0.009 |
| | (0.010) | (0.009) | (0.019) | (0.015) |
| Leverage | -0.007 | 0.013 | -0.026 | 0.005 |
| | (0.011) | (0.014) | (0.019) | (0.019) |
| Cash holdings | 0.011 | 0.020 | 0.124*** | 0.004 |
| | (0.011) | (0.013) | (0.025) | (0.023) |
| SG&A | 0.003* | 0.003* | -0.007* | -0.004 |
| | (0.002) | (0.002) | (0.004) | (0.004) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Firm Fixed Effects | | Yes | | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| Obs. | 23,364 | 22,850 | 12,825 | 12,595 |
| *Adj-$R^2$* | 0.299 | 0.530 | 0.446 | 0.804 |

Panel B: 2SLS regressions

| | Female director ratio | E score_KLD | Female director ratio | E score_ASSET4 |
|---|---|---|---|---|
| | First stage | Second stage | First stage | Second stage |
| | (1) | (2) | (3) | (4) |
| Gender Equality Index | 0.066*** | | 0.085*** | |
| | (0.019) | | (0.024) | |
| Affirmative Action | 0.048*** | | 0.064*** | |
| | (0.007) | | (0.010) | |
| Female director ratio | | 1.056*** | | 1.131*** |
| | | (0.208) | | (0.287) |
| Board size | 0.004*** | 0.000 | 0.004*** | 0.007*** |
| | (0.001) | (0.001) | (0.001) | (0.002) |
| Board independence | 0.043*** | -0.124*** | 0.076*** | -0.190*** |
| | (0.011) | (0.020) | (0.016) | (0.039) |
| Board busyness | 0.029*** | 0.004 | 0.030*** | 0.061*** |
| | (0.007) | (0.015) | (0.009) | (0.021) |
| Female CEO | 0.117*** | -0.122*** | 0.109*** | -0.093** |
| | (0.010) | (0.030) | (0.009) | (0.038) |
| Top5 institutions | -0.001 | -0.053*** | -0.014 | -0.079*** |
| | (0.011) | (0.019) | (0.015) | (0.030) |
| M/B | 0.000* | 0.001** | -0.000 | 0.001 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Firm size | 0.009*** | 0.015*** | 0.009*** | 0.056*** |
| | (0.001) | (0.003) | (0.002) | (0.005) |
| ROA | 0.008 | 0.020 | 0.029*** | -0.002 |
| | (0.008) | (0.013) | (0.011) | (0.023) |
| Leverage | -0.008 | -0.001 | -0.010 | -0.018 |
| | (0.008) | (0.014) | (0.010) | (0.022) |
| Cash holdings | 0.001 | 0.001 | -0.004 | 0.118*** |
| | (0.009) | (0.014) | (0.012) | (0.027) |
| SG&A | -0.005** | 0.007*** | -0.001 | -0.006 |
| | (0.002) | (0.003) | (0.002) | (0.004) |
| Industry × Year Fixed Effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| First-stage F-statistic | 29.55*** | | 30.01*** | |
| Overidentificaiton test (Hansen's J statistic) | | 2.138 | | 0.001 |
| Obs. | 22,981 | 22,981 | 12,561 | 12,561 |

## Appendix IA1
## Introduction to the EPA's TRI database

*A. The Toxics Release Inventory (TRI) database*

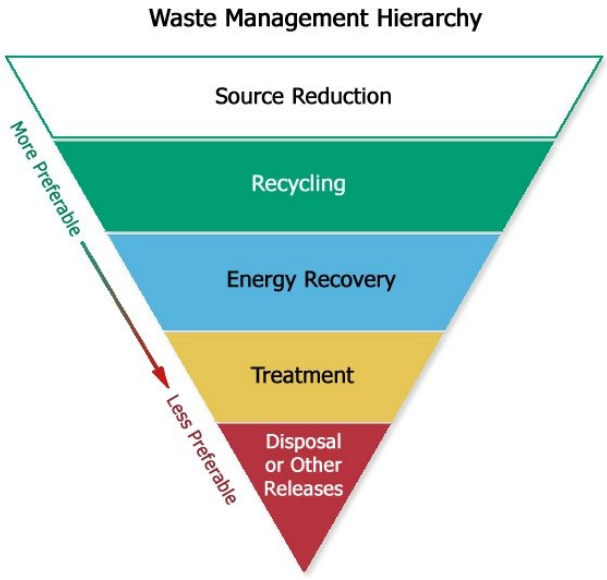
The TRI program was established by the EPA due to the Emergency Planning and Community Right-to-Know Act (EPCRA) in 1986. The TRI reporting started with the 1987 reporting year (first TRI reports due July 1st, 1988), and has continued to the present. In terms of coverage, we find more comprehensive coverage since 1991. By August 2022, the TRI toxic chemical list contains 775 individually listed chemicals and 33 chemical categories. Facilities satisfying the following criteria are required to report to the TRI database: (1) in the mining, utility, manufacturing, publishing, hazardous waste, or federal industry; (2) manufacturing, processing, or otherwise using a TRI-listed chemical in quantities above certain threshold levels set by the EPA in a given year; and (3) having ten or more full-time equivalent employees.

Each TRI-reporting facility reports the production and ultimate outlets of each chemicals (see: https://www.epa.gov/toxics-release-inventory-tri-program/common-tri-terms). "Production wastes" denote the amount of all chemicals produced along with the production process. The outlets of these wastes include recycling, energy recovery, treatment, and releases (definitions are provided in the above link).
The releases include air releases, water release, and land release (also defined in the above link).

After collecting all facility-level releases data from the EPA website (https://www.epa.gov/toxics-release-inventory-tri-program), we use the link between facility id (TRIFD) to Compustat GVKEY established by Chen et al. (2022) that is based on matching facility names and parental company names.

*B. The P2 database*

The Pollution Prevention Act (P2 Act) approved by the Congress in 1990 authorized the EPA to gather and disseminate information on pollution prevention activities (also known as source reduction activities). It is under the TRI database (in File Type 2A: https://www.epa.gov/toxics-release-inventory-tri-program/tri-basic-plus-data-files-calendar-years-1987-present). Facilities that are covered in the TRI database are also required to disclose any source reduction practices implemented at their facilities to reduce production wastes in the reporting year. Source reduction practices denote the first layer of the waste management hierarchy (see the figure below): Once potential production wastes are reduced, firms do not need to recycle, recover, treat, and release them. Facilities report these newly implemented source reduction practices by selecting one or more predefined codes (W-codes) that describe specific practices within the eight categories (e.g., process modifications, substitution of raw materials, which are listed below).



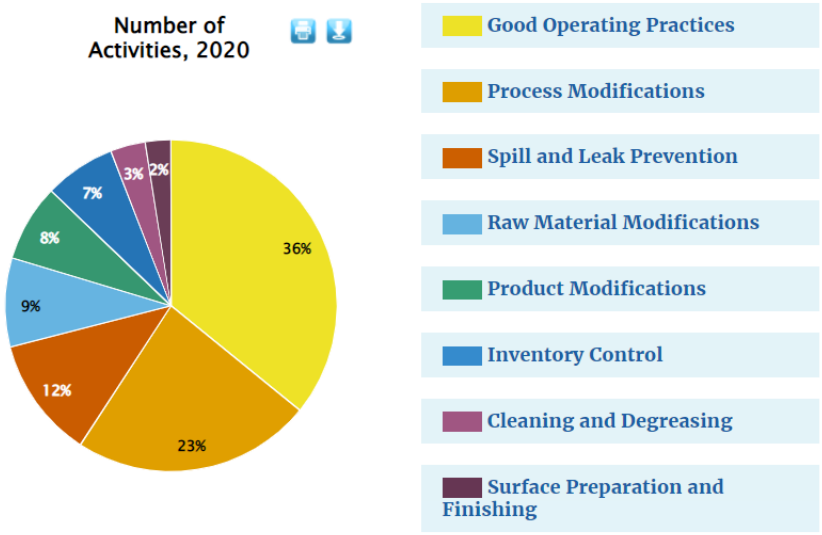

Source: https://www.epa.gov/trinationalanalysis/pollution-prevention-and-waste-management

The information collection of source reduction practices is authorized by the Pollution Prevention Act (PPA) of 1990 that expanded the EPA's authority to collect information beyond release quantities as specified in EPCRA Section 313 to include information specific to source reduction and preferred waste management techniques as described under Section 6607 of the PPA (Gaona 2018). This initiative gave the public a broader lens by which to evaluate and track firms' performance in their management of TRI-listed chemicals.

The reported information is summarized in TRI File Type 2A – these activities can be classified into the following eight categories: raw material modifications, product modifications, cleaning and degreasing, surface preparation and finishing, process modifications, spill and leak prevention, inventory control, and good operating practices (detailed definitions are provided at https://www.epa.gov/toxics-release-inventory-tri-program/pollution-prevention-p2-and-tri).

The following pie chart illustrates the frequencies of eight categories of source reduction practices:

For 2020, a total of 1,188 facilities (6% of all TRI facilities) reported initiating 2,779 new source reduction activities. Good operating practices, process modifications, and spill and leak prevention were the activities reported most frequently. Click on the legend or graph to see examples of source reduction activities; reported codes are included in parentheses.



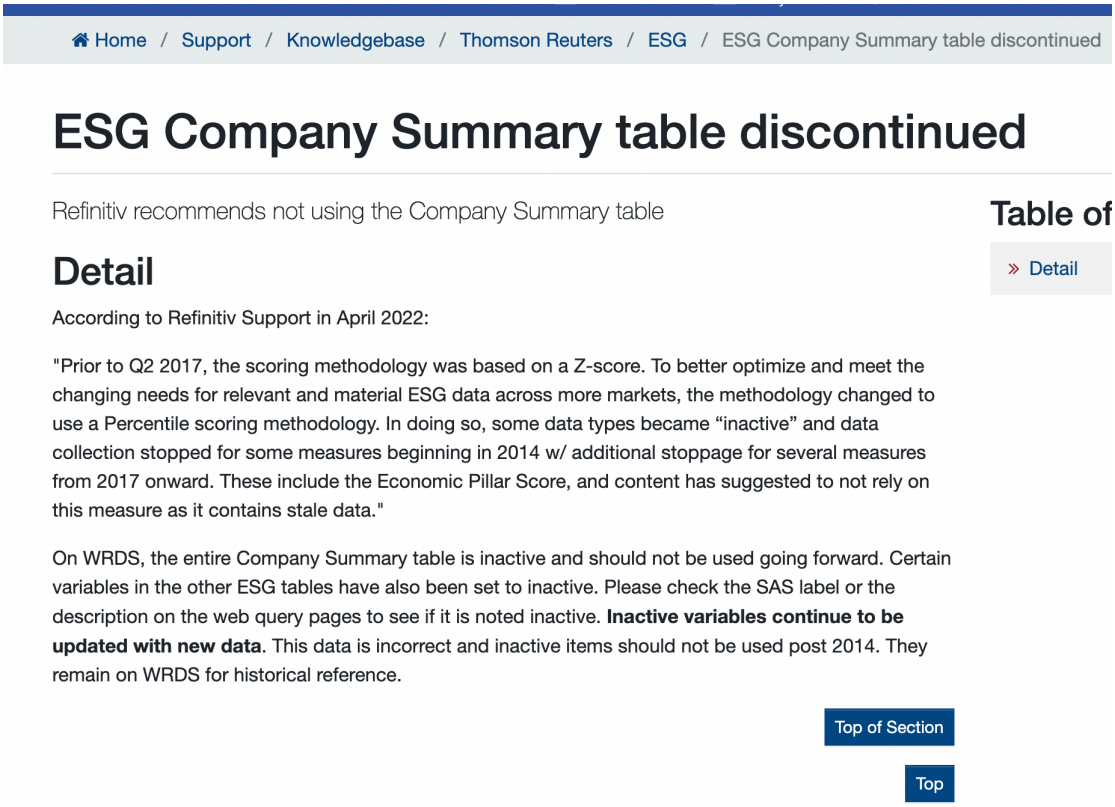

Source: https://www.epa.gov/toxics-release-inventory-tri-program/pollution-prevention-p2-and-tri

References:

Gaona, Sandra D., 2018. The utility of the toxic release inventory (TRI) in tracking implementation and environmental impact of industrial green chemistry practices in the United States, in: *Green Chemistry*, edited by: H. E. M. Saleh, and M. Koller, IntechOpen, DOI: 10.5772/intechopen.70716.

## Appendix IA2
## Comparing Refinitiv ESG with ASSET4

The excerpt from WRDS provides a brief comparison between Refinitiv and ASSET4 in their scoring approach.



Home / Support / Knowledgebase / Thomson Reuters / ESG / ESG Company Summary table discontinued

# ESG Company Summary table discontinued

Refinitiv recommends not using the Company Summary table

Table of

» Detail

## Detail

According to Refinitiv Support in April 2022:

"Prior to Q2 2017, the scoring methodology was based on a Z-score. To better optimize and meet the changing needs for relevant and material ESG data across more markets, the methodology changed to use a Percentile scoring methodology. In doing so, some data types became “inactive” and data collection stopped for some measures beginning in 2014 w/ additional stoppage for several measures from 2017 onward. These include the Economic Pillar Score, and content has suggested to not rely on this measure as it contains stale data."

On WRDS, the entire Company Summary table is inactive and should not be used going forward. Certain variables in the other ESG tables have also been set to inactive. Please check the SAS label or the description on the web query pages to see if it is noted inactive. **Inactive variables continue to be updated with new data**. This data is incorrect and inactive items should not be used post 2014. They remain on WRDS for historical reference.

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