Do Female CEOs Pollute Less?

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Abstract

In this paper, we document a previously unknown benefit of women's role in firm management: the enhancement of environmental protection. Through a panel data analysis, we find that firms with female CEOs produce less air and water pollution and greenhouse gas emissions, and receive fewer environmental penalties, compared to firms with male CEOs. Our difference-in-differences analysis shows that firms also reduce air and water toxic releases, greenhouse gas emissions, and receive fewer environmental penalties after experiencing a male-to-female CEO transition. Moreover, firms demonstrate higher awareness of environmental protection, reflected in their 10-K filings, when being led by female CEOs.

Keywords: Female CEOs, Pollution, Environmental Penalties
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"Woman seems to differ from man in mental disposition, chiefly in her greater tenderness and less selfishness ... Man ... delights in competition, and this leads to ambition which passes too easily into selfishness."

— Charles Darwin (1874, p. 586)

1. Introduction

Traditional economic models treat firm decision makers as representative agents (e.g., Simon, 1979). Since the past decade, researchers document more extensively the relationship between firm leaders' heterogeneous backgrounds and firms' performance and behaviors (for example, see Benmelech and Frydman, 2015 for military CEOs, Roussanov and Savor, 2014 for married CEOs, and Sunder, Sunder and Zhang, 2017 for pilot CEOs). These CEO backgrounds and characteristics may be endogenously correlated with CEOs' parental economic or family cultural conditions; however, a few studies have investigated fundamental biological differences between CEOs, such as gender. For example, Huang and Kisgen (2013) have found that female CEOs and CFOs are less overconfident in corporation financial and acquisition decisions, compared to male executives. Meanwhile, the nonfinancial effect of CEOs' gender, such as firm environmental protection, has received less attention.

We are interested in studying pollution caused by firms for several reasons. First, finding ways to reduce pollution is critically beneficial to human society and economy. It is well known that pollution harms public health (e.g., Chay and Greenstone, 2003, Ebenstein et al., 2015, IIsen, Rossin-Slater, and Walker, 2017), reduces housing prices (e.g., Currie, Davis, Greenstone and Walker, 2015), lowers labor productivity (e.g., Zivin and Neidell, 2012), and influences industrial production (e.g., Greenstone, 2002). A recent review indicates that pollution has resulted in about 16% of all deaths in the world in 2015 (Lancet, 2017).

Second, a significant part of the world's pollution is caused by firms. For example, 22% of the greenhouse gas, 30% of the total air toxicity, and a large portion of the pollutants released into the land and water are generated by industrial activities (U.S. EPA, 2018). Therefore, investigating factors associated with firms' environmental friendliness is important, given the astonishing negative effects of pollution.

Third, studies linking CEO characteristics and corporate financial indicators typically face the firm-CEO matching issue in trying to establish a causal relationship. When a firm screens the candidates for a future CEO position, it may consider whether a candidate is motivated to advance the goals that the board is hoping the firm to achieve. When a CEO candidate is interviewing for a position, s/he may also consider whether the firm board has similar goals and perspectives. Simply speaking, a firm with a female CEO may be intrinsically financially different from a firm with a male CEO, and the difference that we see on the firm operations may not be affected by its CEO.

This endogeneity concern also applies to this paper, yet the concern is minor here, compared with most other CEO studies. In comparison to financial indicators, nonfinancial outcome variables are less likely to be a major consideration in decisions regarding CEO appointments. Forbes publishes articles about the characteristics of CEOs that firms should value on an almost annual basis. We surveyed these articles[1] and none of them listed the awareness of environmental protection as a factor worthy of consideration in selecting CEOs[2].

Academic research also supports our belief. Kaplan, Klebanov and Sorensen (2012) empirically conclude that CEOs' general ability and execution skills are important for companies involved in buyout and venture capital transactions. Bolton, Brunnermeier, and Veldkamp (2012) theoretically discuss CEOs' leadership of managerial resoluteness against communication and listening skills. Moreover, many papers investigate the effects of CEO overconfidence (e.g., Heaton, 2002; Malmendier and Tate, 2005, 2009; Graham, Harvey, and Puri, 2010). Researchers have found that firm performance is crucial in evaluating CEOs' ability (Jenter and Kanaan, 2015). CEOs' social network (El-Khatib, Fogel and Jandik, 2015), age (Yim, 2013), political connection (Fan, Wong and Zhang, 2007), and financial expertise (Custódio and Metzger, 2014) are also factors worthy of consideration. To the best of our knowledge, the awareness of environmental protection is not well known as an important factor in CEO selection and evaluation, according to our survey of academic research.

In this paper, we construct a unique database by merging the firm-CEO data from ExecuComp, the pollution data from the U.S. Environmental Protection Agency (EPA), the firm financials data from Compustat, and the financial statement filings from the SEC EDGAR. Employing similar empirical strategies as those of Huang and Kisgen (2013), we conduct two sets of analyses: panel data regression and difference-in-differences (DID) analysis.

[1] An incomplete list includes: 1) *What Are The Right Criteria For Selecting A New CEO*? (Forbes, 2015); 2) *7 Personality Traits Every CEO Should Have* (Forbes, 2017); 3) *Eight Criteria For Choosing A CEO* (Forbes, 2018), etc.

[2] The factors in the top of the list include: a) organizational experience and ability to motivate; b) communication skills; c) personality (curiosity, passion, etc.); d) financial knowledge; e) vision.

In a sample of firm-year observations, both the panel data regression and DID analysis use various measures of firm pollution as dependent variables, such as total toxics releases, total toxic air emissions, and several measures of water pollution. The difference of the two analyses is their independent variables: The panel data regression uses a dummy variable that indicates if the CEO is female as the independent variable, while the DID analysis uses the male-to-female CEO transition to construct the main independent variable.

In a panel data analysis, we found that firms with female CEOs cause less air and water pollution, produce less greenhouse gas emissions, and receive a fewer number of environmental penalties compared to firms with male CEOs. Our DID analysis reveals, that firms reduce air and water pollution releases, and greenhouse gas emissions, and receive fewer environmental penalties after experiencing male-to-female CEO transitions. We also look more closely into a firm's awareness of environmental protection and find that firms mention more emission-related words in their 10-K filings after transitioning to female CEOs.

Although we employ the DID approach that can mitigate some endogeneity concerns as Huang and Kisgen (2013) suggest, and we use the environmental outcome variables that are not strongly correlated with the factors of CEO appointment consideration, we do not claim this relationship to be entirely free from endogeneity concerns. We are also aware that the female CEOs may be different from females in non-executive roles, as Adams (2015) noted, and do not imply that simply having any female person as the CEO will surely reduce a firm's pollution. In this study, we merely document that firms with female CEOs cause less pollution than those with male CEOs, and firms experiencing male-to-female CEO transition decrease their pollution releases. We believe that even as a correlation, the link between the female executives' status in firms and the reduction of firm pollution is important as a novel finding.

We believe that our paper contributes to at least two branches of the literature in addition to the pollution abatement studies. First, our findings provide additional evidence to prove that economic agents have heterogeneity and it matters (Eswaran, 2014). Men and women are different: women are more socially-orientated (selfless), whereas men are more individually-orientated (selfish) (Eckel and Grossman, 1998). This difference is also confirmed by the findings that women, compared to men, trust their teammates more in cooperation (Kuhn and Villeval, 2014), are more likely to volunteer and accept requests to volunteer for less promotable tasks (Babcock, Recalde, Vesterlund and Weingart, 2017), are less likely to negotiate for a higher wage in the workplace (Gneezy, Leibbrandt and List, 2015), show less willingness to participating in competition (Niederle and Vesterlund, 2007, Flory, Leibbrandt and List, 2014) and make different decisions in corporate boards (Adams and Funk, 2012; Apesteguia, Azmat and Iriberri, 2012). Our finding that firms reduce total pollution after experiencing a male-to-female CEO transition also shows the socially-orientated tendency of female leadership.

Second, our findings contribute to the growing literature on the role of female members on firm boards. With the vast increase in female participation in the labor force (Goldin, 2006, Fernández, 2013) and the rise in the number of female professionals (Black and Juhn, 2000), the average proportion of women directors on the boards of S&P 1500 firms has increased steadily (Kim and Starks, 2016). The process of hiring female managers and employees is also of researchers' interest (Bohnet, Van Geen and Bazerman, 2015; Fernandez-Mateo and Fernandez, 2016). As for the effects, although the mandatory assigned quota for female directors may lead to lower firm value in the short term (Ahern and Dittmar, 2012), the presence of female leader has been proven to help the firms operate longer (Weber and Zulehner, 2010), help avoid operations-related lawsuits (Adhikari, Agrawal and Malm, 2018), improve stock price informativeness (Gul, Srinidhi and Ng, 2011), achieve higher board attendance record (Adams and Ferreira, 2009), improve the boards' quality of advice (Kim and Starks, 2016), and improve the firms' environmental protection as found in this study. Despite the operational and nonfinancial benefits, women are still more underrepresented in firms in the science, technology, engineering, and mathematics (STEM), natural resources, and finance sectors (Adams and Kirchmaier, 2016).

The remainder of this paper is organized as follows: Section 2 describes the sample construction and data sources. Section 3 presents the empirical specification and results. Section 4 concludes.

2. Sample Construction and Data Sources

2.1. CEO Turnover Data

To construct our samples, we first downloaded all observations from the Standard and Poors' Execucomp database from 1992 to 2017. Execucomp provides detailed information on salary, bonus, position, and other profile characteristics of senior executives. There are 286,016 firm-executive-year level observations, including 48,827 executives and 3,685 firms. We then searched all over the observations and obtained 47,089 observations that include information about 7,787 CEOs.[3]

In a further step, we marked turnover events based on the CEO employment records. Whenever we found that the person's name in the CEO position changed during the course of observation of year t, we marked year t - 1 as the turnover year. For example, our sample

[3] We identify CEOs based on the variable "PCEO - Current CEO". This variable identifies the executive who holds the CEO position for all or most of the most recent years on file for that company. If the variable "PCEO - Current CEO" is missing, we use the variables "BECAMECEO" and "LEFTOFC" to infer, whether the executive holds the CEO position in the corresponding year. These two variables record the exact dates of when the manager starts and finishes (if applicable) managing a firm.

documents showed that Steven P. Jobs held the CEO position of Apple Inc. from 1998 to 2011 and that Timothy D. Cook took the CEO position from 2012. In this case, 2011 was regarded as the turnover year. We manually checked that Cook was appointed the chief executive of Apple Inc. on August 24, 2011, which supported the correctness of our identification. Eventually, we were able to identify 4,186 turnover events.

2.2. Emission and Penalties Data

Following the procedure described by Shive and Forster (2019), we obtained plant-year level emission and penalties data from the EPA website. To link plants and their parental firms, we first downloaded the Toxics Release Inventory (TRI) data from 1987 to 2014 with 2,525,090 plant-year level observations. The dataset covers 49,157 plants and 13,480 (parent) firms. We then converted this dataset into a firm-year level dataset with six measures of total air and water toxics releases. Since there is no firm-level identifier for the TRI dataset, we manually matched the TRI firm names to the Compustat firm names. We later appended other emission and penalties variables in these data.

From the Greenhouse Gas Reporting Program (GHGRP), we obtained each firm's plant emission of *Carbon Dioxide (CO2),* and we calculated each firm's *# of CO2 Emission Plant*. From the Clean Air Markets Division (CAMD) we obtained each firm's emission of *Nitric Oxide (NO)* and *Sulfur Dioxide (SO2)*. These variables were available starting from 2008. We also obtained and constructed six variables measuring the number of penalties and five penalties amount measures from the EPA ECHO database. We used logarithms of all these measures in order to avoid the potential skewness problem yet using raw data provided similar results (not reported). We finally merged the CEO turnover data and the emission data, based on their public identifiers, GVKEY and CUSIP number.

2.3. Firm Financials

For each observation in our merged sample, we constructed seven firm-year level control variables using Compustat financial information, including the *Total Assets (log)*, *Leverage*, *ROA*, *Market-to-Book*, *Operating Cash Flow / Total Assets*, *Sale Growth*, and *Cash Flow Volatility*. The Compustat information is obtained from firms' financial statements, mainly including balance sheets, income statements and cash flow statements. They are widely recognized as main firm financial performance indicators and therefore controlling them absorbs the time-varying firm performance' effects on pollutants' emission level. See Table 1 for detailed definition.

2.4. SEC Form 10-K Data

To measure firms' awareness of environment protection, we used the number and frequency of the emission-related words in the SEC 10-K filings. 10-K annual reports are the primary source of information for investors, providing a comprehensive overview of the company's business and financial condition. These reports and how investors perceive corporate disclosures have been widely studied. For instance, the number of words per sentence, the number of syllables per word (Li, 2008), and the file size of 10-K (Loughran and McDonald, 2014) are shown to be related to firm performance.

For each firm in our sample, we collected its text files of the SEC 10-K filings from EDGAR, and then counted the total number of emission-related words in them, including air emission, water emission, and other emission-related words, and the frequency of them per every 1,000,000 words. On average, emission-related words appeared 8.2 times in an SEC 10-K filing.

3. Empirical Specification and Results

3.1. Empirical Specification of Panel Regressions

We used the following empirical specification in our panel regressions:

$$Env_{i,t} = \alpha + \beta * Female_{i,t} + \chi_{i,t} + \Phi_i + \Phi_t + \epsilon_{i,t} \quad (1)$$

The dependent variable $Env_{i,t}$ is one of the toxics releases, emissions, penalties measures or environmental awareness measures of firm i in year *t*. $Female_{i,t}$ indicates whether the firm *i* has a female CEO during year *t*. It is a dummy variable that equals one if the firm has a female CEO during a given year and equals zero otherwise. We controlled for seven firm-year level financial characteristics in $\chi_{i,t}$, described in Section 2.3. We included the fixed effects of firm and year in all regressions, and the firm fixed effects also absorbed the fixed effects of industry and area (state or MSA). Standard errors were clustered by firm. We list the detailed definitions for all used variables in Table 1. Summary statistics are presented in Table 2.

3.2. Empirical Specification of DID Regressions

Simple comparisons of the pollution indicators of the firms with male and female CEOs are likely to be undermined by comoving trends in the pollution indicators. In order to gain insight into the causal effects, we studied the influence of female CEOs on emissions under the DID framework, as conducted by Huang and Kisgen (2013). In this setting, CEO transitions are plausibly regarded as quasi-natural experiments to evaluate treatment effects in the absence of truly experimental data. In our identification strategy, the treatment group consists of the firms that experience male-to-female CEO transitions, whereas the control group consists of the firms with other types of CEO transitions (e.g., male-to-male).

The DID identification strategy is one of the most important methods for empirical studies in accounting and economics to evaluate the treatment effects. Card and Krueger (1994) have assessed the employment effects of a raise in minimum wage in New Jersey, using a neighboring state, Pennsylvania, to identify the variation in employment that New Jersey would have experienced in the absence of a raise in minimum wage. Other applications of DID include studies on the effects of immigration on native wages and employment (Card, 1990), the effects of temporary disability benefits on time out of work after an injury (Meyer, Viscusi and Durbin, 1995), and the effect of anti-takeover laws on firms' leverage (Garvey and Hanka, 1999) among many other studies.

The sample for these tests has firm-year observations from five years before to five years after a CEO transition, excluding the year of the transition. Our main DID regression is:

$$Env_{i,t} = \alpha + \beta_1 * Post_{i,t} + \beta_2 * Post_{i,t} * Female_{i,t} + \chi_{i,t} + \Phi_i + \Phi_t + \epsilon_{i,t} \qquad (2)$$

where $Env_{i,t}$ is one of the toxics releases, emissions, penalties measures or environmental awareness measures of firm *i* in year *t*. $Post_{i,t}$ indicates, whether year *t* is after the year of a CEO transition and equals one, if the observation is after the transition and zero otherwise. The interaction term, $Post_{i,t} * Female_{i,t}$, is an indicator variable for whether year t is after the year of a male-to-female CEO transition. We also controlled for the same firm-year level financial characteristics $\chi_{i,t}$, firm and year dummies Φ_i and Φ_t as in Equation (1). The firm dummies also absorb the fixed effects of industry and area (state or MSA).

4. Empirical Results

4.1. Toxics Releases

Table 3 lists the OLS panel regressions and DID regressions that link CEO gender, male-to-female transition, and toxics releases. The sample is at the firm-year level. Columns with the independent variable *Female* report the results of panel regressions under the specification of Equation (1), while columns with the independent variable *Post* and the interaction term *Post * Female* report the results of DID regressions using Equation (2).

4.1.1. Total Toxics Releases

In columns (1) and (2), the dependent variable is *Total Toxics Releases*, defined as the sum of the total quantity of the toxic chemicals released on-site at all facilities of the firm, and the total quantity of toxic chemical reported as transferred to off-site locations for release or disposal. In the EPA TRI Basic dataset, it is calculated as the sum of rows #40 through #53, row #55, and rows #57 through #76.

The estimated coefficients for *Female* are negative and significant in column (1), suggesting a negative correlation between a female CEO and the firm's total toxics releases.

The coefficient indicates that a female CEO is associated with an 8.6% decline in the *Total Toxics Releases*.[4] The interaction term, *Post * Female* enters negatively and significantly in column (2), suggesting that after replacing their male CEOs with female CEOs, firms will significantly reduce their total toxics releases. The coefficient indicates that replacing a male CEO with a female CEO is associated with a 11.3% decline in the *Total Toxics Releases*.[5]

4.1.2. Air Toxics Releases

In columns (3) and (4), the dependent variable, *Total Toxic Air Emissions*, is generated by adding the contents of the total fugitive air emissions and total stack air emissions. The estimated coefficients for *Female* and the interaction term *Post * Female* both enter negatively and significantly, suggesting lower toxic air emissions after replacing a male CEO with a female CEO. These coefficients indicate that a female CEO is associated with a 5.3% (panel regression) and 7.5% (DID regression) decline in the *Total Toxic Air Emissions*, respectively.[6]

4.1.3. Water Toxic Releases

From column (5) to (12), we used four measures of water pollution. The dependent variable of columns (5) and (6) is *Total Discharges to Stream A*, defined as the total release to the first reported stream or water body. The dependent variable of columns (7) and (8) is *Total Number of Receiving Streams*, the total number of streams reported by all facilities of

[4] 8.6% is calculated as -0.5005 (coefficient) / 5.801 (mean of the dependent variable)
[5] 11.3% is calculated as -0.6584 (coefficient) / 5.801 (mean of the dependent variable)
[6] 5.3% is calculated as -0.5952 (coefficient) / 11.133 (mean of the dependent variable); 7.5% is calculated as -0.8376 (coefficient) / 11.133 (mean of the dependent variable)

the firm as receiving toxic chemical releases. In columns (9) - (10), the dependent variable is *Total Surface Water Discharge*, the total of all individual stream release fields. *Total Underground Injection*, the dependent variable of columns (11) - (12), is the total of both Classes I and II well injections from all facilities of the firm. In all regressions, the estimated coefficients for *Female* and the interaction term *Post * Female* enter negatively and significantly, suggesting lower water pollution after replacing a male CEO with a female CEO.

The results of columns (5) - (12) are not only statistically significant but also economically sizable. As shown, we do find a significantly negative association between female CEOs and the water pollution. We also show that the effects of female CEOs are economically tangible. In terms of the panel regressions, the coefficients indicate that a female CEO is associated with a 23.2%, 12.0%, 22.8%, and 18.8% decline in the *Total Discharges to Stream A*, *Total Number of Receiving Streams*, *Total Surface Water Discharge*, and *Total Underground Injection*, respectively.[7] As for the DID regressions, the coefficients indicate that replacing a male CEO with a female CEO is associated with a 19.1%, 13.7%, 19.5%, and 30.7% decline in the *Total Discharges to Stream A*, *Total Number of Receiving Streams*, *Total Surface Water Discharge*, and *Total Underground Injection*, respectively.[8]

4.2. Greenhouse Gas Emissions and Air Pollution

[7] 23.2% is calculated as -1.0327 (coefficient) / 4.448 (mean of the dependent variable); 12.0% is calculated as -0.4261 (coefficient) / 3.559 (mean of the dependent variable); 22.8% is calculated as -1.0074 (coefficient) / 4.416 (mean of the dependent variable); 18.8% is calculated as -0.1266 (coefficient) / 0.675 (mean of the dependent variable);

[8] 19.1% is calculated as -0.8494 (coefficient) / 4.448 (mean of the dependent variable); 13.7% is calculated as -0.4862 (coefficient) / 3.559 (mean of the dependent variable); 19.5% is calculated as -0.862 (coefficient) / 4.416 (mean of the dependent variable); 30.7% is calculated as -0.2074 (coefficient) / 0.675 (mean of the dependent variable);

Table 4 reports the impact that female CEOs cause on firms' greenhouse gas emissions and pollution with *Nitric Oxide (NO)* and *Sulfur Dioxide (SO2)*. The dependent variables are *Carbon Dioxide (CO2)* in columns (1) and (2), and *# of CO2 Emission Plant* in columns (3) and (4). The estimated coefficients for *Female* and the interaction term *Post * Female* enter negatively and significantly in all regressions. In terms of the economic significance, the coefficients indicate that a female CEO is associated with a 18.0% decline in the *Carbon Dioxide (CO2)* emission and replacing a male CEO with a female CEO is associated with a 26.8% decline.[9]

The dependent variables are *Nitric Oxide (NO)* in columns (5) and (6), and *Sulfur Dioxide (SO2)* in columns (7) and (8). Although the estimated coefficients for *Female* enter negatively, yet insignificantly, the estimates of *Post * Female* enter negatively and significantly.

4.3. Environmental Penalties

Table 5 presents the effects of having female CEOs on the number of EPA penalties, whereas Table 6 presents their effects on the penalties amount. The dependent variables include total penalties (*# of Penalties*, *Total Penalty Amount*), penalties charged at the federal level (*# of Fed Penalties*, *Fed Penalty Amount*), penalties charged by state and local authorities (*# of State Local Penalties*, *State Local Penalty*), number of plants that have been charged with environmental penalties (*# of Plants with Penalty*), compliance actions (*# of Compliance Action*, *Compliance Action Cost*), and cost recovery demanded by the EPA (*# of Cost Recovery Awarded Cases*, *Amount of Cost Recovery Awarded*). In all 12 regressions in

[9] 18.0% is calculated as -0.0474 (coefficient) / 0.264 (mean of the dependent variable); 26.8% is calculated as -0.0707 (coefficient) / 0.264 (mean of the dependent variable)

Table 5, as well as 10 regressions in Table 6, the estimated coefficients for *Female* and the interaction term *Post * Female* enter negatively and significantly.

The results are not only statistically significant but also economically sizable. As shown, we do find a significantly negative association between female CEOs and the environmental penalties. We also show that the effects of female CEOs are economically tangible. In terms of the panel regressions, the coefficients indicate that a female CEO is associated with a 56.4% and 58.4% decline in the *# of Penalties* and *Total Penalty Amount*, respectively.[10] As for the DID regressions, the coefficients indicate that replacing a male CEO with a female CEO is associated with a 69.3% and 61.8% decline in the *# of Penalties* and *Total Penalty Amount*, respectively.[11]

4.4. Awareness of Environment Protection

The above empirical analyses showed that a female CEO significantly reduces her firm's overall emissions and releases in terms of *Total Toxics Releases*, *Total Toxic Air Emissions*, and several measures of water pollution. Apart from the measurable indicators, we were also interested in determining whether a female CEO raises her firm's awareness of environmental protection. We employed textual analysis and used the number and frequency of emission-related words in a firm's SEC 10-K filings to measure this awareness.

[10] 56.4% is calculated as -0.1174 (coefficient) / 0.208 (mean of the dependent variable); 58.4% is calculated as -1.1283 (coefficient) / 1.931 (mean of the dependent variable)
[11] 69.3% is calculated as -0.1442 (coefficient) / 0.0208 (mean of the dependent variable); 61.8% is calculated as -1.193(coefficient) / 1.931 (mean of the dependent variable)

In Table 7, columns (1) - (2) and (5) - (6) report panel regressions results. These results suggest, that there is a positive correlation between having a female CEO and the firm's awareness of environmental protection. The *Number of Emission-related Words* in the 10-K form will be marginally higher by 21.46, if the firm has a female CEO in the given year, as shown in column (1). In terms of the *Frequency of Emission-related Words*, we can draw similar results from column (5) - (6). Thus, for firm-years with female CEOs, firms are more likely to mention "Emission" in their 10-K forms.

In the DID analyses presented in columns (3) - (4) and (7) - (8), the interaction term, *Post * Female*, enters positively and significantly. As shown in column (3), the *Number of Emission-related Words* in the 10-K form will marginally increase by 26.48 after the firm experiences a male-to-female CEO transition. Similar results could be drawn from column (7) - (8), where *the Frequency of Emission-related Words* is the dependent variable of interest. In terms of the economic significance, the coefficient indicates that replacing a male CEO with a female CEO is associated with a 66.1% increase in *the Frequency of Emission-related Words*.[12] The results of Table 7 imply a positive impact of female CEOs on firms' awareness of environmental protection.

5. Conclusion

In addition to the previously documented gains of having more female leadership in firms, we present another important benefit that has positive externalities to society: enhancing environmental protection. We find that when being led by female CEOs, firms

[12] 66.1% is calculated as 3.607 (coefficient) / 5.455 (mean of the dependent variable)

pollute less, receive less environmental penalties, and have a higher awareness of environmental protection.

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Table 1 Sample Construction and Variable Definition

This table presents how we construct the sample and the definitions of the dependent, independent, and control variables.

	Sample Construction
Firm-Year Sample	Each firm-year observation contains the firm characteristics, the CEO characteristics, the turnover event, the toxics release records, the greenhouse gas emissions records, the environment-related enforcement and penalties records, and the financial indicators of a firm in a given year. CEO characteristics and turnover data are constructed from Execucomp. Toxic emissions data are constructed from Environmental Protection Agency (EPA) Toxics Release Inventory (TRI). Greenhouse gas emissions and air pollution data are constructed from EPA Clean Air Markets Database (CAMD) and EPA Greenhouse Gas Reporting Program (GHGRP). Environment-related enforcements and penalties data are constructed from EPA Enforcement and Compliance History Online (ECHO) system, which incorporates Federal enforcement and compliance (FE&C) data from the Integrated Compliance Information System (ICIS). Firm characteristics data are constructed from Compustat. The sample contains 18,250 firm-year level observation between 1992 and 2014.
	Dependent Variables
Total Toxics Releases	Natural logarithm of (1 + Total toxics releases). Total toxics releases equal the sum of the total on-site release and the total off-site release. Data are obtained from EPA TRI Basic. In kilopound.
Total Toxic Air Emissions	Natural logarithm of (1 + Total toxic air emissions). Total toxic air emissions are calculated by adding the contents of the total fugitive air emissions and total stack air emissions. Data are obtained from EPA TRI Plus. In kilopound.
Total Discharges to Stream A	Natural logarithm of (1 + Total discharges to stream A). Total discharges to stream A is calculated as the total release to the first reported stream/water body. Data are obtained from EPA TRI Plus. In kilopound.
Total Number of Receiving Streams	Natural logarithm of (1 + Total number of streams). Total number of receiving streams is calculated as the total number of streams reported by all facilities of the firm as receiving toxic chemical releases. Data are obtained from EPA TRI Plus.
Total Surface Water Discharge	Natural logarithm of (1 + Total surface water discharge). Total surface water discharge is calculated as the total of all individual total stream release fields. Data are obtained from EPA TRI Plus. In kilopound.
Total Underground Injection	Natural logarithm of (1 + Total underground injection). Total underground injection is calculated as the total of both Classes I and II well injections from all facilities of the firm. Data are obtained from EPA TRI Plus. In kilopound.
Carbon Dioxide (CO2)	Natural logarithm of (1 + Carbon dioxide (CO2) emission). CO2 emission data (in Metric Tons) are obtained from CAMD and GHGRP.
# of CO2 Emission Plant	Natural logarithm of (1 + # of plants with CO2 emission record). Data are obtained from CAMD and GHGRP.
Nitric Oxide (NO)	Natural logarithm of (1 + Nitric Oxide (NO) emission). NO emission data (in metric tons CO2 equivalent) are obtained from CAMD.

Sulfur Dioxide (SO2)	Natural logarithm of (1 + Sulfur Dioxide (SO2) emission). SO2 emission data (in metric tons CO2 equivalent) are obtained from CAMD.
# of Fed Penalties	Natural logarithm of (1 + # of federal enforcement cases with federal penalty record). Federal penalties are the penalties assessed or agreed to for federal enforcement action. Data are obtained from ICIS-FE&C.
# of State Local Penalties	Natural logarithm of (1 + # of federal enforcement cases with state or local penalty record). State\local penalties are the penalties for local government or state settlements, or the penalties allocated to a state/local entity from a federal enforcement settlement with state\local participation. Data are obtained from ICIS-FE&C.
# of Compliance Action	Natural logarithm of (1 + # of compliance action). Compliance action is one of the categories of ICIS activity. ICIS activity includes information request, inspection, compliance action/determination, and enforcement. Data are obtained from ICIS-FE&C.
# of Cost Recovery Awarded Cases	Natural logarithm of (1 + # of federal enforcement cases with cost recovery awarded for the Enforcement Action). EPA incur costs to stabilize and/or clean up Superfund sites, and the costs are then recovered from the entities associated with the site. Data are obtained from ICIS-FE&C.
# of Penalties	Natural logarithm of (1 + # of federal enforcement cases with penalty record). The penalties include both federal penalties and state\local penalties. Data are obtained from ICIS-FE&C.
# of Plants with Penalty	Natural logarithm of (1 + # of plants with either federal or state\local penalty record). Data are obtained from ICIS-FE&C.
Fed Penalty Amount	Natural logarithm of (1 + Federal penalty amount). Federal penalty amount is the total amount assessed or agreed to for enforcement action. This value is the derived sum of federal penalties at all settlements at a case. Data are obtained from ICIS-FE&C.
State Local Penalty	Natural logarithm of (1 + State\local penalty amount). State\local penalty amount is the amount for local government or state settlements, or the amount allocated to a state/local entity from a federal enforcement settlement with state\local participation. Data are obtained from ICIS-FE&C.
Compliance Action Cost	Natural logarithm of (1 + Compliance action cost). Compliance action cost is the sum of compliance action amounts. It is the settlement-level sum of the dollar values of injunctive relief and the physical or nonphysical costs of returning to compliance. Injunctive relief represents the actions a regulated entity is ordered to undertake to achieve and maintain compliance, such as installing a new pollution control device to reduce air pollution or preventing emissions of a pollutant in the first place. Data are obtained from ICIS-FE&C.
Amount of Cost Recovery Awarded	Natural logarithm of (1 + Amount of cost recovery awarded). Amount of cost recovery awarded is the amount of cost recovery ordered or agreed to be repaid by the responsible party or parties and due to the Superfund in accordance with either an administrative or judicial settlement. Data are obtained from ICIS-FE&C.
Total Penalty Amount	Natural logarithm of (1 + Total penalty amount). Total penalty amount includes both the federal penalty amount and the state\local penalty amount. Data are

	obtained from ICIS-FE&C.
Number of Emission-related Words	The number of emission-related words in SEC 10-K form, including air emission, water emission and other emission-related words.
Frequency of Emission-related Words	The number of emission-related words in SEC 10-K form in every 1,000,000 words.
	Independent Variables
Female	This dummy equals one if the firm has a female CEO and equals zero otherwise.
Post	This dummy equals one if this year is within 5 years from a CEO transition. It equals zero if this year is within 5 years before a CEO transition
Post * Female	This dummy is an interaction term between Female and Post. It equals one if this year is within 5 years from a male-to-female CEO transition. It equals zero if this year is within 5 years from other types of CEO transition (e.g. male-to-male) or within 5 years before a CEO transition.
	Control Variables
Total Assets (log)	Natural logarithm of (1 + Firm's total assets). Obtained from Compustat.
Leverage	Liabilities divided by total assets. Obtained from Compustat.
ROA	Earnings before interest, taxes, and depreciation (Compustat Item 13) divided by lagged total assets. Constructed from Compustat.
Market-to-Book	Market-to-Book: the ratio of market value of assets (Compustat Item 9 + Compustat Item 34 + Compustat Item 199 * Compustat Item 25 + Compustat Item 10 - Compustat Item 35) to book value of assets (Compustat Item 6). Constructed from Compustat.
Operating Cash Flow / Total Assets	Operating cash flow divided by total assets. Constructed from Compustat.
Sale Growth	Sales in the current year divided by sales in the past year. Obtained from Compustat.
Cash Flow Volatility	The standard deviation of cash flows in the past five years. Obtained from Compustat.

Table 2. Summary Statistics

	Obs	Mean	Std. Dev	5%	Median	95%
			Dependent Variables			
Total Toxics Releases	9,527	5.801	3.777	0.001	5.757	12.321
Total Toxics Air Emissions	8,953	11.133	5.007	0	12.001	18.262
Total Discharges to Stream A	9,379	4.448	5.640	0	0	15.656
Total Number of Receiving Streams	9,557	3.559	2.461	0	3.555	7.724
Total Surface Water Discharge	9,551	4.416	5.651	0	0	15.681
Total Underground Injection	9,357	0.675	3.095	0	0	2.944
Carbon Dioxide (CO2)	3,161	0.264	0.812	0	0	2.364
# of CO2 Emission Plant	3,171	0.378	0.773	0	0	2.303
Nitric Oxide (NO)	3,100	0.001	0.008	0	0	0
Sulfur Dioxide (SO2)	3,131	0.003	0.022	0	0	0
# of Fed Penalties	10,325	0.087	0.299	0	0	0.693
# of State Local Penalties	10,315	0.145	0.421	0	0	1.099
# of Compliance Action	10,327	0.055	0.237	0	0	0.693
# of Cost Recovery Awarded Cases	10,305	0.002	0.033	0	0	0
# of Penalties	10,316	0.208	0.501	0	0	1.386
# of Plants with Penalty	10,321	0.231	0.475	0	0	1.099
Fed Penalty Amount	10,327	0.993	3.159	0	0	10.187
State Local Penalty Amount	10,312	1.321	3.396	0	0	10.127
Compliance Action Cost	10,328	0.654	2.749	0	0	6.621
Amount of Cost Recovery Awarded	10,307	0.032	0.646	0	0	0
Total Penalty Amount	10,314	1.931	4.084	0	0	11.290
Number of Emission-related Words	5,018	8.738	36.049	0	1	42
Frequency of Emission-related Words	5,018	5.455	14.778	0	0.331	27.739
			Independent Variables			
Female	10,331	0.014	0.116	0	0	0
Post	6,519	0.391	0.488	0	0	1
			Control Variables			
Total Assets (log)	10,331	7.933	1.582	5.570	7.833	10.605
Leverage	10,220	0.267	0.150	0.032	0.257	0.525
ROA	10,327	0.143	0.079	0.045	0.137	0.265
Market-to-Book	10,328	1.400	0.982	0.532	1.139	3.087
Operating Cash Flow / Total Assets	10,330	0.096	0.067	0.001	0.094	0.204
Sale Growth	10,324	0.286	18.152	0.188	0.067	0.468
Cash Flow Volatility	10,229	214.162	864.371	2.367	42.140	828.938

Table 3. Total, Air and Water Toxics Releases

The table presents the relation between the CEO gender, change of gender from CEO turnover, and firm's total, air and water toxics release. The sample is at the firm-year level. Each observation contains a firm's characteristics. Columns with independent variable *Female* report the results of panel regression. Columns with independent variable *Post* and the interaction term report the results of DID regressions. The dependent variables are listed in the table headers, including *Total Toxics Releases*, *Total Toxic Air Emissions*, and four measurements of Toxic Water Releases. We have three independent variables of interest. *Female* is a dummy variable that equals one if the firm has a female CEO in a firm-year observation. *Post * Female* is a dummy variable that equals one if this year is after the year of male-to-female CEO transition. *Post* is a dummy variable that equals one if this year is after the year of CEO transition. In all regressions, we control for *Total Asset (log), Leverage, ROA, Market-to-Book, Operating Cash Flow / Total Assets, Sale Growth, Cash Flow Volatility*, and the fixed effects of firm and year. Standard errors are clustered by firm. Robust t-statistics are in parentheses. ***, ** and * denotes 1%, 5% and 10% statistical significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	TOTAL		AIR		WATER							
	Total Toxics Releases		Total Toxic Air Emissions		Total Discharges to Stream A		Total Number of Receiving Streams		Total Surface Water Discharge		Total Underground Injection	
Female	-0.5005**		-0.5952*		-1.0327*		-0.4261**		-1.0074*		-0.1266*	
	(-2.0901)		(-1.9479)		(-1.9496)		(-1.9695)		(-1.9341)		(-1.7990)	
Post * Female		-0.6584**		-0.8376*		-0.8494*		-0.4862**		-0.8620*		-0.2074**
		(-2.0727)		(-1.9421)		(-1.7864)		(-2.0501)		(-1.8302)		(-1.9863)
Post		-0.1085**		-0.1283		0.0806		-0.0611		0.0774		0.0212
		(-1.9773)		(-1.4274)		(0.7678)		(-1.1284)		(0.7492)		(0.4600)
Firm-year Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,527	6,159	8,953	5,736	9,379	6,072	9,557	6,192	9,551	6,180	9,357	6,034
R-squared	0.921	0.934	0.877	0.898	0.905	0.920	0.884	0.898	0.908	0.923	0.864	0.932

Table 4. Greenhouse Gas Emissions and Air Pollution

The table presents the relation between the CEO gender, change of gender from CEO turnover, and the firm's greenhouse gas emissions and air pollution. The sample is at the firm-year level. Each observation contains a firm's characteristics. Columns with independent variable *Female* report the results of panel regression. Columns with independent variable *Post* and the interaction term report the results of DID regressions. The dependent variables are listed in the table headers, including *Carbon Dioxide (CO2)*, *# of CO2 Emission Plant*, *Nitric Oxide (NO)*, and *Sulfur Dioxide (SO2)*. We have three independent variables of interest. *Female* is a dummy variable that equals one if the firm has a female CEO in a firm-year observation. *Post * Female* is a dummy variable that equals one if this year is after the year of male-to-female CEO transition. *Post* is a dummy variable that equals one if this year is after the year of CEO transition. In all regressions, we control for *Total Asset (log), Leverage, ROA, Market-to-Book, Operating Cash Flow / Total Assets, Sale Growth, Cash Flow Volatility*, and the fixed effects of firm and year. Standard errors are clustered by firm. Robust t-statistics are in parentheses. ***, ** and * denotes 1%, 5% and 10% statistical significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Carbon Dioxide (CO2)		# of CO2 Emission Plant		Nitric Oxide (NO)		Sulfur Dioxide (SO2)	
Female	-0.0474**		-0.4058**		-0.0068		-0.0142	
	(-2.1856)		(-2.3890)		(-1.0459)		(-1.0323)	
Post * Female		-0.0707***		-0.2933**		-0.0005**		-0.0021**
		(-2.7276)		(-2.1416)		(-2.1340)		(-2.1598)
Post		0.0171		0.0245		0.0003***		0.0022**
		(0.4375)		(0.5232)		(2.6528)		(2.5739)
Firm-year Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,161	1,764	3,171	1,773	3,100	1,702	3,131	1,733
R-squared	0.863	0.883	0.785	0.795	0.829	0.886	0.811	0.869

Table 5. Number of Penalties

The table presents the relation between the CEO gender, change of gender from CEO turnover, and the number of federal enforcement cases with different kinds of penalties. The sample is at the firm-year level. Each observation contains a firm's characteristics. Columns with independent variable *Female* report the results of panel regression. Columns with independent variable *Post* and the interaction term report the results of DID regressions. The dependent variables are listed in the table headers, including *# of Fed Penalties, # of State Local Penalties, # of Compliance Action, # of Cost Recovery Awarded Cases, # of Penalties,* and *# of Plants with Penalty*. We have three independent variables of interest. *Female* is a dummy variable that equals one if the firm has a female CEO in a firm-year observation. *Post * Female* is a dummy variable that equals one if this year is after the year of male-to-female CEO transition. *Post* is a dummy variable that equals one if this year is after the year of CEO transition. In all regressions, we control for *Total Asset (log), Leverage, ROA, Market-to-Book, Operating Cash Flow / Total Assets, Sale Growth, Cash Flow Volatility*, and the fixed effects of firm and year. Standard errors are clustered by firm. Robust t-statistics are in parentheses. ***, ** and * denotes 1%, 5% and 10% statistical significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	# of Fed Penalties		# of State Local Penalties		# of Compliance Action		# of Cost Recovery Awarded Cases		# of Penalties		# of Plants with Penalty	
Female	-0.0690**		-0.0698**		-0.0287**		-0.0014**		-0.1174**		-0.1088**	
	(-2.3866)		(-2.1693)		(-2.2235)		(-2.1745)		(-2.2907)		(-2.4762)	
Post * Female		-0.0720**		-0.0796**		-0.0514**		-0.0018**		-0.1442**		-0.1178**
		(-2.1855)		(-2.4896)		(-2.2470)		(-2.2234)		(-2.2511)		(-2.2667)
Post		0.0099		0.0111		-0.0012		-0.0008		0.0153		0.0015
		(1.1275)		(1.0203)		(-0.1672)		(-0.7846)		(1.1435)		(0.1398)
Firm-year Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,325	6,513	10,315	6,505	10,327	6,515	10,305	6,501	10,316	6,504	10,321	6,509
R-squared	0.388	0.410	0.559	0.582	0.320	0.333	0.097	0.127	0.578	0.599	0.606	0.633

Table 6. Amount of Penalties

The table presents the relation between the CEO gender, change of gender from CEO turnover, and the amount of different kinds of penalties related to environmental protection. The sample is at the firm-year level. Each observation contains a firm's characteristics. Columns with independent variable *Female* report the results of panel regression. Columns with independent variable *Post* and the interaction term report the results of DID regressions. The dependent variables are listed in the table headers, including *Fed Penalty Amount, State Local Penalty Amount, Compliance Action Cost, Amount of Cost Recovery Awarded,* and *Total Penalty Amount*. We have three independent variables of interest. *Female* is a dummy variable that equals one if the firm has a female CEO in a firm-year observation. *Post * Female* is a dummy variable that equals one if this year is after the year of male-to-female CEO transition. *Post* is a dummy variable that equals one if this year is after the year of CEO transition. In all regressions, we control for *Total Asset (log), Leverage, ROA, Market-to-Book, Operating Cash Flow / Total Assets, Sale Growth, Cash Flow Volatility*, and the fixed effects of firm and year. Standard errors are clustered by firm. Robust t-statistics are in parentheses. ***, ** and * denotes 1%, 5% and 10% statistical significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Fed Penalty Amount		State Local Penalty Amount		Compliance Action Cost		Amount of Cost Recovery Awarded		Total Penalty Amount	
Female	-0.8402**		-0.5564**		-0.3189**		-0.0274**		-1.1283**	
	(-2.2366)		(-2.1740)		(-2.3473)		(-2.1557)		(-2.3197)	
Post * Female		-0.8046**		-0.8633***		-0.4841**		-0.0438**		-1.1930**
		(-2.1444)		(-2.7567)		(-2.2502)		(-2.2311)		(-2.2283)
Post		0.1120		0.0182		-0.0326		-0.0003		0.0849
		(1.1219)		(0.1953)		(-0.3582)		(-0.0123)		(0.7092)
Firm-year Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster by Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10,327	6,515	10,312	6,500	10,328	6,516	10,307	6,501	10,314	6,502
R-squared	0.310	0.334	0.458	0.486	0.266	0.285	0.091	0.109	0.461	0.487

Table 7. Environmental Awareness

The table presents results on the relation between the CEO gender and the firm's attention to toxic emissions. The sample is at the firm-year level. Each observation is a firm's characteristics. The dependent variables of interest are the *Number of Emission-related Words* and the *Frequency of Pollution-related Words*. As described in Table 1, *Number of Emission-related Words* is the number of emission-related words in SEC 10-K form, including air emission, water emission and other emission-related words. *Frequency of Emission-related Words* is the number of emission-related words in SEC 10-K form in every 1,000,000 words. We have three independent variables of interest. *Female* is a dummy variable that equals one if the firm has a female CEO in a firm-year observation. *Post * Female* is a dummy variable that equals one if this year is after the year of male-to-female CEO transition. *Post* is a dummy variable that equals one if this year is after the year of CEO transition. In columns with an even number, we control for *Total Asset (log), Leverage, ROA, Market-to-Book, Operating Cash Flow / Total Assets,* and *Sale Growth*. In each regression, we also control for the fixed effect of firm and year. Clustered robust t-statistics are in parentheses. ***, ** and * denotes 1%, 5% and 10% statistical significance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Number of Emission-related Words				Frequency of Emission-related Words			
Female	21.46***	21.24***			3.229**	3.607**		
	(5.67)	(5.39)			(1.97)	(2.17)		
Post * Female			26.48***	26.75***			4.813**	5.343**
			(5.26)	(5.04)			(2.19)	(2.32)
Post			-0.194	0.105			0.0289	0.0800
			(-0.15)	(0.08)			(0.05)	(0.13)
Firm-year Controls		Yes		Yes		Yes		Yes
Firm Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5,018	4,696	3,183	3,000	5,018	4,696	3,183	3,000
R-squared	0.600	0.601	0.586	0.586	0.537	0.541	0.551	0.553