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GHG emissions and firm performance: The role of CEO gender socialization

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ABSTRACT

In this paper, I examine the effect of corporate greenhouse gas emissions (GHG) on profitability. I use the gender composition of the CEOs' children as an identification strategy to investigate the impact of GHG emissions on profits. CEOs who father a daughter are associated with a 10% reduction in GHG emissions. The reduction in emissions, in turn, improves profitability. A one standard deviation decrease in GHG emissions leads to a 0.14 standard deviations increase in profitability. Examining the channels, I show that CEOs with daughters are more likely to adopt a climate-integrated business strategy and set emission-reduction targets. Emission reduction affects profitability through both information advantage (protection from negative industry shocks, and lower cost of capital), and operational efficiency (lower operating costs and energy consumption) channels.

1. Introduction

Companies are under increasing pressure from stakeholders and regulators to be environmentally sustainable, comply with environmental regulations, and reduce emissions. However, mandatory emission-reduction regulations are rare, and few emissions disclosure regulations exist worldwide. For example, the 2013 update of the Companies Act 2006 in the United Kingdom (UK) is the first mandate for companies to report greenhouse gas (GHG) emissions in their annual reports. Therefore, corporate emission-reduction initiatives are largely voluntary and hinge on how such initiatives affect profitability. Despite the increasing focus on corporate environmental impacts, the financial benefit of corporate environmental sustainability is not well established. Empirical evidence on corporate GHG emissions' financial implications and motives is inconclusive (Busch and Lewandowski, 2018). For example, Matsumura, Prakash, and Vera- Muñoz (2014) show that firms with higher GHG emissions tend to have lower firm values. On the other hand, sustainable practices can benefit the firm through improved reputation, customer loyalty, operational efficiency and product differentiation (Besley and Ghatak, 2007; Eichholtz, Kok and Quigley, 2010; Flammer, 2015). Since emissions are often inherent to profitable production technologies, corporations must be incentivised to find solutions that jointly optimise financial profits and environmental impacts.

I return to this issue in the United Kingdom (UK) context. This setting, as discussed below, allows me to provide a range of evidence missing in the literature on corporate GHG emissions and profitability. Consistent with previous evidence, I show that FTSE 350 companies with lower emissions have higher profitability. Drawing on stylised results from the economics of identity and gender socialisation theory and data on male CEOs parenting a daughter, I use an instrumental variable (IV) approach that provides a methodological innovation missing from this literature (Qi et al., 2014). As I discuss later, this approach can overcome some of the econometric challenges of endogeneity and generalizability in earlier studies. Finally, I provide novel results on two mechanisms: channels through which CEOs with daughters affect corporate GHG emissions; and channels through which GHG emissions can affect profitability. I show that when companies appoint CEOs who parent a daughter, they are more likely to adopt a climate-integrated business strategy (where long-term climate targets are part of the strategic goals) and set specific emission targets. Low emission firms have higher sales growth, are more resilient to negative industry shocks, and have lower operating costs and lower cost of capital.

UK is an interesting institutional setting for examining the role of managerial preference in the GHG emissions-profitability relationship. The Climate Change Act of 2008 forms the legal framework for climate change in the UK and makes it the first country to introduce a legally binding requirement for companies to reduce GHG emissions. Subsequently, the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 mandated listed

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companies in the UK to disclose GHG emissions in their annual reports by 2013.[1] The UK is the only country where GHG emission disclosure is a stock market listing requirement (Jouvenot and Krueger, 2019). Therefore, unlike many other European countries, historical and homogenously reported corporate emission data is more readily available from the UK. Second, the CEO should have significant discretion over corporate policies to affect environmental strategies (Wangrow et al., 2015; Wernicke, Sajko, & Boone, 2021). CEOs in the UK ranked second (after the U.S.) in managerial discretion, allowing me to focus on their discretionary impacts (Crossland & Hambrick, 2011). Finally, the most directly comparable study is in the context of the United States (Cronqvist and Yu, 2017). However, gender attitudes and roles vary across countries. For example, the US is ranked 46th on the UN's 2019 Gender Inequality Index, whereas the UK seems to have more evolved gender-related attitudes, with a rank of 31st. Combining more established GHG emission reporting standards, evolved gender norms, and greater CEO discretion over corporate strategy makes the UK a suitable setting to empirically examine my conjectures.

I use a sample of FTSE 350 companies and objectives measures of GHG emissions collected from multiple sources from 2007 - 2017.[2] Using a binary indicator for CEOs parenting a daughter as the IV, I find that financial performance is better for companies with lower GHG emissions. However, these estimates can be contaminated by reverse-causality and endogeneity concerns. More profitable companies can invest more in emission-abatement technology, and unobserved factors can simultaneously affect both GHG emissions and profitability. I address these concerns by implementing an IV strategy.

The premise of the identification strategy is that the CEO's environmental preferences affect corporate climate-related practices (Lewis, Walls and Dowell, 2014). The effect of the CEO's preference on corporate strategic choices - climate-related or otherwise - is more pronounced when a new CEO is appointed (Zhang & Rajagopalan, 2010; Fondas and Wiersema, 1997). Hence, if I can identify factors that affect CEOs' environmental preferences but don't affect their companies' financial profitability, I can use it as a source of exogeneous variation around events of CEO turnovers. I hypothesise that parenting a daughter has behavioural effects on the CEO, which makes them more likely to be conscious of the climate impacts of their firms. Given the relative scarcity of female CEOs in the UK during the sample period (18 in total), CEOs in this paper refer to male CEOs unless otherwise mentioned. It is well established that parenting a daughter affects the fathers' social and political views and makes them more pro-social (Washington, 2008; Cronqvist and Yu, 2017; Green and Homroy, 2018). Additionally, women show greater environmental concern than men (Milfont and Sibley, 2016), and daughters are especially effective in influencing parents' climate views, with the strongest effects documented in fathers (Lawson et al., 2019). Therefore, daughters' environmental views can shape the climate-related preferences of male CEOs.

Consistent with this argument, I show that the average GHG emission of a company falls after it appoints a CEO who parents a daughter by 10%. However, the gender of the CEO's children is unlikely to affect the profitability of companies, except through the climate preference of the CEO. Ensuring that the instrumental variable meets the exogeneity condition is crucial for the empirical strategy, but it is challenging to test for it directly. Later in the paper, I provide evidence to eliminate the most obvious possibilities that can violate the exogeneity condition. For example, I show that parenting a daughter doesn't affect the CEOs' risk-aversion or investment decisions. Using this identification strategy, I show that a one standard deviation decrease in GHG emissions leads to a 0.14 standard deviations increase in the ROA. This estimate is qualitatively similar to estimates reported by Konar and Cohen (2001), Edmans (2011) and Flammer (2015). These effects remain similar for Scope 2 emissions but lose statistical significance for Scope 3 emissions. A small subset of firms report scope 3 emissions; therefore, the tests with scope 3 suffer from low statistical power.

One concern with the identification strategy is that CEOs with daughters are invalidly excluded from the second-stage outcome equation. Since the econometric specifications include firm fixed effects, it is identified only on CEO changes (from without daughters to with daughters). A further concern about the identification strategy could be that since the sample period coincides with a period of increasing awareness of environmental issues, better environmental performance and CEOs with daughter appointments are both generated by the same time-varying factors that themselves generate better financial performance. While it is difficult to test the exclusion restriction directly, I do a battery of tests to address this concern. The rationale behind these tests is that if CEO-daughters are capturing effects of unobserved time-varying factors, then we can expect that this effect will weaken with better controls for time effects. I test for time-varying environmental norms in three ways. First, I include year dummies in the baseline models that absorbs idiosyncratic factors related to specific years. Second, I use a linear time-trend to control for the change in environmental policies of firms over the sample period. Finally, I examine if the baseline estimates of CEO daughters on GHG emissions are similar in different sub-periods of the sample. I show that the results are similar in the post-UK Climate Change Act (2008), post-Paris Agreement (2015), and in the two halves of the sample period (2007-2011 and 2012-2017). The effect of CEO daughters on GHG emissions remains robust to these tests, indicating that trends in environmental strategies of firms are not driving the main results.

Finally, I focus on the GHG emission - profitability relationship mechanisms. I investigate two channels. I begin by providing evidence on how CEOs with daughters affect GHG emissions. It is an important concern since GHG emissions are inherent to the production technology, which is expensive to change in the short run. Using responses of sample firms to the Climate Disclosure Project (CDP) survey, I show the firms are more likely to adopt a climate-integrated business strategy following the appointment of a CEO with daughters than before.[3] Also, firms are more likely to commit to emission-reduction initiatives after appointing CEOs with daughters than before. These channels highlight how CEOs with daughters affect organisational processes related to reducing GHG emissions.

Next, I show the channels through which emission abatement can affect profitability. I focus on two broad channels - information advantage (emission reduction adds positive information about a firm in product and capital markets) and operational efficiency (low-emission firms enjoy cost advantages). I show that companies with lower GHG emissions are more resilient to industry shocks. The resilience to negative income shock stems from having a loyal customer base that values the more environmentally conscious firms (Bénabou and Tirole, 2010; Besley and Ghatak, 2007; Porter and van Linde, 1995). Further, pro-social firms with bet-

[1] The regulation requires disclosure of Scope 1 and Scope 2 but not Scope 3 emissions.

[2] Unlike many previous studies, I do not rely solely on negative environmental events or a score-based measure of environmental performance. I use actual GHG emissions, normalised by the accepted threshold level.

[3] The specific questions in the CDP survey are: (C3.1) *"Are climate-related issues integrated into your business strategy?"* and (C4.3) "Did you have emissions reduction initiatives that were active within the reporting year?"

ter management of environmental risks can have easier access to external financing and lower cost of capital (El Ghoul et al., 2011; Cheng, Ioannou and Serafeim, 2014). Consistent with this argument, I show that British companies with low GHG emissions have lower external financing constraints than companies with higher GHG emissions. I also find that companies with lower GHG emissions are more efficient in using factors of production (Eichholtz, Kok and Quigley, 2010; Iwata and Okada, 2011). Low-emission firms have lower operating expenses and lower energy usage. These results provide suggestive evidence that emission abatement affects profitability through both information advantage and operational efficiency pathways.

This paper makes several contributions to the literature. First, I provide evidence on the GHG emission-profitability relationship in the context of the UK. Although the UK has been one of the early adopters of emission-reduction initiatives, there is little evidence of the financial implications of emission abatement for UK firms (Jouvenot and Krueger, 2019; Bolton and Kacperczyk, 2021). Some of these papers in the UK context present more descriptive evidence (Broadstock et al., 2018). A large majority of the causal evidence in this strand of literature is based on the US, while some evidence exists for Australia and Japan (Griffin et al., 2017). Since emissions disclosure has long been salient for UK firms, evidence on profitability impacts of emission reduction from this context provides novel evidence to this literature.

Second, I make a methodological contribution using a novel identification strategy in GHG emissions-profitability literature. I introduce an instrumental variable regression based on CEOs' socialised preference through parenting a daughter.[4] While this identification strategy has been used in other contexts, this is the first paper to use it in the context of GHG emissions and profitability (Cronqvist and Yu, 2017; Washington, 2009). Attempts to establish a causal effect of GHG emissions on profitability face severe endogeneity concerns: companies can undertake climate-related projects in anticipation of better financial performance (Lys, Naughton and Wang, 2015). The main econometric challenge is to find an exogenous shock that correlates with GHG emissions but does not directly affect financial performance. Three broad empirical approaches have been used to study the effect of environmental performance on profitability, i.e., regression analysis (Iwata and Okada, 2011), portfolio analysis (Geczy et al., 2005, Ziegler et al., 2007), and event studies (Konar and Cohen, 2001; Fischer-Vanden and Thorburn, 2011). While event-study-based results provide the most convincing causal evidence on the effects of corporate environmental strategies on profitability, these studies are in the context of low-probability extreme events (Konar and Cohen, 2001). Some studies, such as Flammer (2015), use a regression discontinuity approach to establish a causal effect. This approach limits generalizability beyond the companies around the treatment threshold. It is, therefore, difficult to generalise the value effects of corporate sustainability practices from these studies (Qi et al., 2014).

Further, I contribute to the literature on how the preference of CEOs affects corporate strategic choices. The growing literature in corporate finance highlights the importance of the manager/CEO on corporate strategy and performance (Kaplan et al., 2012; Malmendier and Tate, 2005; Bertrand and Schoar, 2003). Extant literature shows how CEOs' political preferences, experience in the labour market, and overconfidence affect corporate strategies (Di Giuli and Kostovetsky, 2014; Malmendier and Tate, 2005). The importance of focusing on CEOs' family values is only recently getting recognition and prominence (Duchin, Simutin and Sosyura, 2021). This paper introduces the CEO's family context as a source of variation in the values (and allied environmental preferences) that inform CEOs' discretionary choices.

Finally, I highlight mechanisms through which corporate emissions can affect profitability—the channels through which GHG emissions and firm profits are not well established in the literature. For example, Ambec and Lanoie (2008) propose that more socio-environmentally sustainable firms have better access to loyal customers through differentiating products and have lower operating costs and costs of debt, but systematic evidence on this is sparse. I add to this literature by studying a range of potential pathways. This paper's results show that low-emission firms' profitability improves through both information advantage and operational efficiency channels. In doing so, I present a broader framework to examine the mechanisms of the emissions-profitability relationship.

The rest of the paper unfolds as follows: section 2 discusses the background and hypothesis development, section 3 presents the data and the sample, section 4 discusses the results, and section 5 concludes.

2. Background and hypotheses

2.1. GHG emissions and financial performance

One of the central issues in corporate green practices is the concern that investments in environmental technologies that reduce emissions can be detrimental to the financial performance by increasing short-term costs and crowding out more productive investments (Palmer, Oates and Portney, 1995; Fisher-Vanden and Thorburn, 2011). For example, Sarkis and Cordeiro (2001) and Wagner et al. (2001) show a negative relationship between corporate environmental performance and financial performance. On the other hand, some studies show that better environmental performance can improve corporate financial performance (Konar and Cohen, 2001; King and Lenox, 2002). Cohen, Fenn, and Naimon (1995) find that stock returns in the environmental leader's portfolio equal or exceed that of companies with poor environmental records. Better environmental performance can also decrease operating costs and increase the competitiveness of the products (Iwata and Okada, 2011). In most cases, the environmental impact of firms is measured by GHG emissions. While focusing on GHG emissions does not capture firms' full environmental impact, it has a few advantages (Iwata and Okada, 2011). A company's yearly GHG emissions are easier to quantify, and a well-established protocol exists to measure such emissions. Further, even when companies do not report GHG emissions, they can be imputed with a reasonable degree of accuracy. Given the increasing focus on emission disclosures and the climate impact of firms, investors may perceive better environmental performance (measured as lower GHG emissions) positively (Bolton and Kacperczyk, 2021).

Hypothesis 1. Firms with lower GHG emissions have higher profitability than firms with higher GHG emissions.

The direction of association between environmental and financial performance has been widely debated in the finance and accounting literature (Lys et al., 2015; Cronqvist and Yu, 2017). A major concern in this literature is reverse-causality and how unobservable characteristics can drive the association of profitability and green policies. Empirical evidence on this has been inconclusive. However, there are only a few direct and causal pieces of evidence on the impact of corporate emissions on profitability (e.g., Eccles et al., 2014; Flammer, 2015). A commonly used method to circumvent this is event studies around adverse environmental events. Using positive (negative) environmental news about

[4] Instrumental variable regressions have been used to establish causal relationships between emissions and credit ratings (Safiullah et al., 2021), and technological innovation on air pollution (Chen et al., 2022).

companies like environmental awards or oil spills, Klassen and McLaughlin (1996) show positive (negative) effects on firm value. Fischer-Vanden and Thorburn (2011) examine the announcement returns for membership to voluntary corporate environmental initiatives and find evidence of a negative impact on short-term profitability. In a similar spirit, some studies focus on the returns to the portfolio of stocks of companies with and without explicit environmental commitments, but the results are inconclusive (Geczy et al., 2005, Ziegler et al., 2007). In these studies, the underlying assumption is that the effect of observable variables that affect the adoption of environmental commitments are already priced in. However, environmental responsibilities may correlate with unobservable firm (or managerial) characteristics that may not be fully impounded into the stock prices.

These studies provide valuable evidence on how markets react to discrete environmental events but limit the ability to generalise these results beyond the specific context. Konar and Cohen (2001) use GHG emissions data to examine the effect on firms' intangible assets but do not seek to provide a causal interpretation of their results. Flammer (2015) studies corporate social responsibility using a regression discontinuity approach and finds positive abnormal returns for adopting close call CSR-proposals. The recent literature suggests that environmental performance may have important implications for financial performance and firm value. Expressly, it warrants a causal mechanism to be established using an objective measure of firm performance.

2.2. Preference of CEOs and corporate strategy

Whether and how CEOs affect corporate strategy has been a long-standing debate among management, finance, and corporate-governance scholars (Hambrick, Finkelstein, and Mooney, 2005; Kaplan, Klebanov, Sorensen, 2012). For example, a strand of the literature focuses on how CEOs' career experiences affect corporate strategic choices like research and development and political activities (Benmelech and Frydman, 2015; Schoar and Zuo, 2017). A key theme of this strand of research is that the experiences in the labour market - such as military experience or entering the labour market during economic downturns - shape the decision-making of CEOs.

Further, others have investigated the demographic and behavioural factors that affect CEOs' decision-making. For example, Chen, Ma, and Schumacher (2020) show that firms led by female CEOs are more socially responsible, while Gupta, Nadkarni and Mariam (2019) focus on CEOs' personality traits. CEOs' cultural heritage and early-life exposure to negative events also shape how they lead their firms (Nguyen, Hagendorff and Eshraghi, 2018; Bernile, Bhagwat and Rau, 2017).

Relatively underrepresented in the literature is the role of familial influence on a CEO's professional life. Recent studies have investigated how the family dynamics during CEO's childhood affect their later-career decision making (Duchin, Simutin and Sosyura, 2021). Others have studied how the experience of parenting, particularly daughters, affects the CEO's decision-making (Dahl, Deszö and Ross, 2012; Cronqvist and Yu, 2017; Green and Homroy, 2018). For example, Cronqvist and Yu (2017) show that CEOs who parent daughters lead more pro-social firms. While the paper's focus is corporate social responsibility ratings in general, the strongest results are for environmental ratings. The underlying theoretical framework comes from the economics of identity literature which proposes that children (and daughters in particular) affect parental socio-political preferences (Washington, 2008; Oswald and Powdthavee, 2010). Therefore, fathers internalise the socialised gender norms of their daughters (Akerlof and Kranton, 2000; Warner & Steel, 1999).

More specifically, concerning pro-climate values, conservation psychology literature highlights the importance of children in shaping parents' dispositions towards climate change. Anecdotally, Pierre-André de Chalendar, CEO of St Gobain, said in 2019, *"Today, it's incredible—I cannot go to a meeting of Saint-Gobain executives without hearing this question: you know, when I go back home at night [I'm asked]: 'Mom and Dad, what is your company doing for the planet?"* This is backed up by academic evidence. Lawson et al. (2019) provide experimental evidence from an educational intervention designed to build climate change concern among parents via their middle-school-aged children. Daughters were especially effective in influencing parents' climate views, with the strongest effects documented in fathers. Therefore, daughters appear to be a special channel through which climate-related preferences are shaped in fathers.

Building on this literature, if CEOs parent a daughter, they are more likely to have greater concerns for the climate impact of their business and take actions to reduce GHG emissions. However, employees tend to be appointed CEOs in their later careers when they have already started a family. Therefore, a meaningful examination of how male CEOs' socialized climate preferences from daughters impacts corporate GHG emissions must be around events of the CEO change. Such an approach will allow a comparison of GHG emissions of the *same* firm when a CEO who parents only sons is replaced by a CEO who parents at least one daughter.

Hypothesis 2. GHG emission of a firm falls following the appointment of a CEO parenting a daughter who replaces a CEO parenting only sons.

2.3. Channels through which GHG emissions impact profitability

The impact of GHG emission abatement on profitability has been studied extensively, but investigations into the mechanisms driving this effect are fewer. While the causal relationship between environmental performance and firm profitability is an important question, the channels through which this effect operates are critical to understanding voluntary corporate sustainability initiatives. Conceptually emission abatement can affect financial performance through two broadly defined (and non-mutually exclusive) channels: (a) informational advantage channel and (b) operational efficiency channel.

The informational advantage channel predicts that market participants perceive emission abatement positively. Therefore, stakeholders will incorporate emission abatement as positive information in transactions with the firms. Through this channel, emission abatement enhances the image of the firm and profitability increases due to an increase in earnings (higher sales turnover) or easier financing of its investments (lower cost of capital). For example, consumers are increasingly focusing on sustainable consumption lower emissions will gain customers and investors with a preference for environmental sustainability. Consumers who care more about the climate will be loyal to low-emission firms and shield them from negative industry shocks relative to competitors (Ambec and Lanoie, 2008; Besley and Ghatak, 2007).

Therefore, I hypothesize that low-emission firms will have higher sales growth and greater profit resilience to negative industry shocks.

Hypothesis 3A1. Low-emission firms will have higher sales growth than high-emission firms.

Hypothesis 3A2. Low-emission firms will have higher profitability than competitors in times of negative industry shocks.

Investors increasingly price carbon risks and exclude high-emission firms from their portfolios (Griffin, Lont and Sun, 2017).

Low-emission firms can broaden their investor base by attracting socially-responsible investors, which should lower their cost of capital (Bolton and Kacperczyk, 2021; Krueger, Sautner and Starks, 2020). Therefore, low emission firms are likely to have a lower cost of equity financing and lower reliance on precautionary cash holdings (El Ghoul et al., 2011; Cheng, Ioannou and Serafeim, 2014; Almeida, Campello and Weisbach, 2004). In that case, these firms can easily finance their investments in productive capacity and innovative projects, which, in turn, affects long-term profitability.

Hypothesis 3B1. Low-emission firms will have a lower cost of equity capital than high-emission firms.

Hypothesis 3B2. Low-emission firms will have lower cash holdings than firms with high GHG emissions.

The operational efficiency channel predicts that large capital investments in green technologies accrue cost savings over the years (Downer et al., 2021). For example, low-emission production technologies are often modern equipment and systems that ensure more efficient use of the factors of production. It leads to reduced costs from material usage and waste disposal. These technologies are also more energy-efficient, lowering energy costs (Gillingham and Stock, 2018). Consequently, firms with low GHG emissions are likely to have lower operating costs (Eichholtz, Kok and Quigley, 2010; Iwata and Okada, 2011). Therefore, we hypothesize that low-emission firms will have lower operating expenses and energy costs.

Hypothesis 3C1. Low-emission firms will have lower operating expenses than firms with high GHG emissions.

Hypothesis 3C2. Low-emission firms will have lower energy costs than firms with high GHG emissions.

3. Data and variables

3.1. Sampling and data sources

I apply the following sample selection criteria to identify companies in the UK. The sample companies are constituents of the FTSE 350 index from 2007 to 2017. I begin with the FTSE 350 index constituents for every year from 2007–2017 (inclusive). To qualify for inclusion in the final sample, companies must have been a part of the FTSE 350 index for two consecutive years. Information on financial and environmental performance measures must have been available for those years. These requirements led to an unbalanced panel of 309 companies comprising 3,188 firm-year observations. I provide a breakdown of the sample by industry according to the UK Standard Industrial Classification of Industrial Activities in Appendix 4.

I draw on several data sources for the empirical analysis. Data on CEO compensation and board composition is obtained from BoardEx. I collected data on CEOs' families and children from BoardEx World of CEOs *Beta*, which provides detailed biographies of CEOs. I also cross-referenced and augmented information on CEOs' families from public sources such as the *Wall Street Journal, Financial Times, The Economist*, and *Forbes*. Thomson Reuters Eikon provides financial data of companies. I triangulate information on GHG emissions from several sources. First, I obtained corporate emissions data from the European Pollutant Release and Transfer Register (E-PRTR). I also used emissions data from Eikon (reported in field ENERDP 123) as an alternative source. Finally, I obtained GHG emissions data reported by companies in the Carbon Disclosure Project (CDP) survey. I also obtained information on firms' emission-reduction mechanisms and climate-integrated business strategies from the CDP. I present the variable descriptions with sources in Appendix 1 and summary statistics in Table 1. The observations noted in Table 1 are firm-years for *Firm Characteristics* and *Governance Characteristics* and individual CEOs (and CEO-years) for *CEO Characteristics*.

3.1.1. Independent variable

Unlike many previous studies, I do not rely on negative environmental events or a score-based measure of environmental performance (e.g., KLD; see Cronqvist & Yu, 2017; Wernicke et al., 2021). Instead, I use actual GHG emissions normalised by the accepted threshold levels from three different sources. In all cases, I use Scope 1 CO_2e emissions.

First, E-PRTR provides annual pollution data for over 30,000 facilities within the sample period. I used a multi-level matching process to aggregate the emission data provided by E- PRTR at the facility level to the company level. I started from the information on the parent company for each facility and aggregated the data at the parent-company level. When some of these parent companies were subsidiaries of listed companies, I matched them to the sample of FTSE 350 companies using Osiris (Bureau van Dijk) data. To ensure that the emissions data are comparable, I only considered facilities based in Europe.

I then standardized GHG emissions by the thresholds for their impact on human health and the environment set by the European Commission, which scales the reporting threshold for CO_2 at 100 million kgs/year. This standardization process gave us a common denominator for comparing GHG emissions across companies. Based on this approach, I constructed a variable, *GHG-Normalized*, which ranges from 2 to 60, with higher scores denoting greater GHG emissions. The mean GHG emission of sample companies is 12, and the standard deviation is 27. I detail the standardisation process in Appendix 2. In alternate specifications, I use the Global Warming Potential as the scaling variable instead of the impact on human health and the environment. I use the GWP values for the 100-year time horizon from the IPCC fifth assessment report (2014).[5]

As a second measure of emissions, I use the information from Thomson Reuters Eikon in the ENERDP123 data field. I use natural logs of the reported CO_2e emissions to construct a variable, *Ln GHG Emissions-Eikon*, with a mean of 10.39 and a standard deviation of 3.23. The emissions data constructed from granular E-PRTR information (*GHG-Normalized*) using the normalisation has a higher coverage of GHG data: I have 3,188 firm-year observations of *GHG-Normalized* but only 2,453 observations for *Ln GHG Emissions-Eikon.*

Finally, I use information from CDP to create a third measure of GHG emissions. In the CDP survey, companies are asked to self-report information on their GHG emissions in question C6.1: "*What were your organisation's gross global Scope 1 emissions in metric tons CO2e?*". I used the natural logarithm of the reported GHG emissions to construct *Ln GHG Emissions-CDP.* The mean and standard deviation of *Ln GHG Emissions-CDP* are 10.13 and 3.46, respectively. CDP survey data is only available for 2010–2017; I have a 16% lower number of observations (2,060) than *GHG Emissions-Eikon*. The three measures of GHG emissions are positively and statistically significantly correlated with each other with correlation coefficients of 0.86 (*GHG-Normalized and Ln GHG Emissions-CDP),* 0.78 (*GHG-Normalized and Ln GHG Emissions-Eikon),* and 0.75 (*Ln GHG Emissions-CDP and Ln GHG Emissions-Eikon).*

[5] The GWP values are taken from the IPCC website and I show the results in Appendix 18. The baseline effect of CEO-Daughters on GHG emissions and of GHG emissions on ROA remains unchanged.

Table 1
Summary statistics. This table summarises the sample of FTSE 350 companies for 2007-2017. I provide descriptive statistics of the firm, corporate governance, and CEO characteristics. The Observations for CEO characteristics relates to number of CEOs while that of Firm and Governance characteristics relates to firm-years. The variables are defined in Appendix 1.

Variable	Observations	Mean	Median	St. Deviation
Firm Characteristics				
GHG (Normalized)	3,188	12.435	6.924	28.199
Ln GHG Emissions - Eikon	2,453	10.336	8.521	3.218
Ln GHG Emissions- CDP	2,060	10.138	9.186	3.461
Ln GHG Emissions- CDP Scope 2	1,812	11.327	10.803	4.301
Ln GHG Emissions- CDP Scope 3	432	14.025	13.224	4.667
Return on Assets (ROA)	3,188	7.382	5.117	6.292
Market to Book Value (MTBV)	3,188	2.353	1.457	2.423
Firm Size (Ln Sales)	3,188	17.602	10.731	0.945
Volatility	3,188	0.037	0.044	0.019
%Shareholding-Family	3,188	0.033	0	0.144
%Shareholding-Institutions	3,188	0.218	0.136	0.098
HHI	3,188	0.227	0.216	0.184
Ln (1+Capital Expenditure)	3,188	0.291	0.113	0.188
Debt-to-Equity Ratio (DE Ratio)	3,188	0.247	0.025	0.031
Ln (Firm Age)	3,188	3.052	2.937	1.915
Capital Intensity	3,188	2.578	1.924	1.322
Governance Characteristics				
Board Size	3,188	7.335	6.109	3.616
% Independent Directors	3,188	53.003	50.148	21.121
CEO Duality	3,188	0.126	0.000	0.222
Board Oversight	3,188	0.729	1	0.444
Law Expert	3,188	0.379	0	0.338
CEO Characteristics				
CEO Daughter	352	0.605	1	0.263
No. of CEOs' Children	352	2.803	2.202	2.065
No. of CEOs' Daughter	352	1.497	1	1.853
Female CEOs	352	0.057	0	0.115
CEO Experience (Years)	352	5.083	7.349	9.564
CEO Age (Years)	352	61.160	57.766	9.724
Conservative Donor	352	0.784	1	0.117

3.1.2. Dependent variable

The main outcome variable is profitability, measured by the return on assets (ROA). The mean (median) *Return on Assets*, measured by operating profits before depreciation, interest, and taxes (EBITDA) and divided by lagged total assets, is 7.3% (5.1%).[6] I use Tobin's Q approximated by the market to book value (MTBV is defined as the sum of the book value of debt and market value of equity, divided by the book value of assets) as an alternate financial performance measure. The mean (median) MTBV is 2.9 (1.7), respectively.

3.1.3. Instrumental variable

Inquiry into the private lives of CEOs has data challenges, as information about a CEO's offspring is not reliably archived. I have used a novel database called BoardEx World of CEOs *Beta*. This database is available on a trial basis to researchers before being integrated into the commercially licensed BoardEx platform. It contains biographical profiles of CEOs, with details of their families, including children. Using this database, I could identify the genders of the children of 352 out of 460 male CEOs (77%) in the sample, adopting a binary sex-assigned-at-birth classification. The range of CEO family information is similar to that of Green and Homroy (2018) and greater than Cronqvist and Yu (2017; Panels C and D), who had approximately 60% coverage. Nevertheless, to see whether the missing data was a cause for concern, I examined at this stage whether firms for which I have CEO-children data differed systematically from those without this information. The latter were excluded from the sample.[7]

The main focus is the children of male CEOs (Cronqvist & Yu, 2017; Dahl et al., 2012). On average, male CEOs of British companies father 2.8 children and 1.5 daughters. To ascertain the fidelity of the information on CEO children, I used machine-learning algorithms to extract information on CEOs' families from publicly available sources such as the *Financial Times*, *Fortune*, and *Forbes*. These algorithms use a combination of the CEOs' names, company names, and strings like "daughters", "children", "family", and "marriage". I parse the publicly available news articles on CEOs to identify the names of CEOs' children and, where available, the birth order. With the list of names, I run a second algorithm to determine the gender of the children from the pronouns used in the public reports and press articles. The distribution of children and daughters for both male and female CEOs is provided in Table 2. Approximately 3% of the male CEOs do not father a child. Based on this data, I constructed a binary indicator, *CEO Daughter*, which equals 1 if the CEO is a male and has fathered at least one daughter.[8] On average, 60% of the male CEOs in my sample parent at least one daughter. This is the instrumen-

[6] In alternate specifications, I add R&D expenditures to EBITDA to control for the potential downward bias in the operating cash flow for companies with high R&D intensity (Eberhart, Maxwell and Siddique, 2004).

[7] In univariate results reported in the Appendix 19, I do not find meaningful differences in fundamental firm characteristics between these two groups.

[8] I also use a measure for female CEOs mothering a daughter as part of the empirical strategy.

Table 2
Distribution of CEO children and daughters. In this table, I present the distribution of CEO children and CEO daughters for the sample of FTSE 350 CEOs. Columns 1 and 2 show the distribution of children and daughters of male CEOs, and columns 3 and 4 show the distribution of children and daughters of female CEOs.

	Male CEO's Children (1)	Male CEO's Daughters (2)	Female CEO's Children (3)	Female CEO's Daughters (4)
0	2.92%	39.55%	0.05%	20.00%
1	8.72%	40.02%	51.21%	48.34%
2	47.30%	16.92%	42.73%	31.66%
3	31.36%	2.14%	6.01%	0.00%
4+	9.80%	1.37%	0.00%	0.00%

tal variable used to examine the causal effect of GHG emissions on profitability.

3.1.4. Control variables

I adjust for several sources of heterogeneity across companies that may affect corporate environmental performance. A key correlate of corporate sustainability practices is the board of directors (De Villiers, Naiker, & Van Staden, 2011; Homroy & Slechten, 2019). Therefore, I control for corporate governance characteristics such as *Board Size* (total number of directors on the board), *Board Independence* (% non-executive directors on the corporate board), an indicator termed *CEO Duality* (meaning that the CEO and chairman are the same person), and an indicator for the presence of a legal expert on the board (*Law Expert*). On average, a board has seven directors and 1.04 legal experts. I use the information on corporate boards' oversight of emission reduction from the CDP survey. The survey question C1.1 asks companies, "*Is there board-level oversight of climate-related issues within your organisation?*" I create a dummy *Board Oversight* which equals 1 if companies report that they have board-level oversight of climate-related issues: 79% of the sample companies do so.

Second, corporate green practices correlate with the company's ownership structure (Johnson & Greening, 1999). Therefore, I control for the proportion of shares held by institutional investors (*%Shareholding-Institutions*) and family ownership (*%Shareholding-Family)*. The mean (median) institutional shareholding is 22% (13%), and the mean (median) family shareholding is 3.3% (0%). I also control for a range of CEO characteristics like *CEO Age, CEO experience*, and *Conservative Donor* (a dummy = 1 if the CEO predominantly donates to the Conservative party).

Finally, I include an array of firm-level covariates: profitability (*Return on Assets*), natural log of total sales (*Firm Size)*, operating risk (*Volatility*), and financial leverage (*Debt-to-Equity Ratio*). Additionally, I control for technology adoption using the natural log of firm age (*Firm Age*) and sales and operating revenues scaled by shareholders' equity (*Capital Intensity*). Competitive pressures can affect corporate strategy. Therefore, I control for the industry classification of the companies using the 2-digit UK Standard Industrial Classification (UK SIC). However, companies do not routinely change industry classification, even though time-varying industry conditions may affect strategic choices.[9] Therefore, I control for a time-varying industry competitiveness measure (HHI). The mean (median) *Firm Size, Debt-to-Equity Ratio, Capital Intensity* and *Firm Age* are 17 (10), 0.247 (0.025), 2.578 (1.924), and 3.05 (2.93), respectively.

[9] I also show that the results are similar to including an indicator for firms in the business-to-business industry groups. B2B dummy equals 1 for companies whose primary UK SIC codes are between 10-33 and 41-43.

4. Empirical methods and results

4.1. Effect of GHG emissions on firm performance

4.1.1. OLS and fixed effects regressions

I begin by estimating a simple Ordinary Least Square model with a full suite of firm, industry, and governance controls of the following type:

$$ROA_{it} = \beta_0 + \beta_1 \ln GHG_{it-1} + \beta_2 X_{it-1} + f_t + \varepsilon_{it} \quad (1)$$

where X_{it-1} is the vector of all control variables, lagged by one period, and f_t are year dummies.

However, the OLS estimates are likely to suffer from time-invariant omitted variable bias. For example, some companies may be more climate-conscious than others for idiosyncratic reasons. As long as the climate-consciousness of companies remains constant over time, such variations can be subsumed by firm fixed effects. I estimate the following firm fixed effects model:

$$ROA_{it} = \beta_0 + \beta_1 \ln GHG_{it-1} + \beta_2 X_{it-1} + f_t + \lambda_i + \varepsilon_{it} \quad (2)$$

where X_{it-1} is the vector of all control variables, f_t are year dummies, and λ_i are the firm-fixed effects.

The baseline results on the effects of environmental performance on profitability are presented in Table 3. I present the OLS and the firm-fixed effects regression estimates in panels A and B, with ROA as the dependent variable.[10] I present results using all three measures of GHG emissions as the main independent variables. The OLS results show that firms with lower GHG emissions are associated with higher profitability. The fixed effects regressions show similar effects: the profitability improves with a decrease in GHG emissions within a firm. Regarding the economic effects of the firm-fixed effects regressions, a one standard deviation decrease in GHG emissions is associated with a 0.32 standard deviations increase in ROA.[11]

4.1.2. Instrumental variable regressions

However, the fixed effects approach does not consider any time-varying factors influencing emissions and firm profitability. To address this concern, I use instrumental variable (IV) regressions. The instrumental variable needs to be correlated with GHG emissions but does not affect profitability directly except through emissions. The underlying theory of the instrumental variable used in this paper comes from the economics of identity literature, as discussed in Section 2. I use a binary indicator of (male) CEOs parenting a daughter as the instrumental variable in a 2-stage least squares model:

$$GHG_{it-1} = \alpha_i + \beta CEO - Daughters_i + \lambda J_{it} + f_t + \lambda_i + \epsilon_{it} \quad (3a)$$

$$ROA_{it} = \alpha_i + f_t + \beta \; \widehat{GHG_{it-1}} + \kappa J_{it} + f_t + \lambda_i + \epsilon_{it} \quad (3b)$$

GHG_{it-1} is the measures of GHG emissions, $\widehat{GHG_{it-1}}$ is the predicted value of GHG_{it-1} from Eq. 3a, $CEO - Daughters_i$ is an indicator for the (male) CEO fathering a daughter. J_{it} is a vector of all company, board and industry characteristics discussed in Section 3. λ_i and f_t are firm and year fixed effects. It is important to discuss the implications of the estimated coefficient of $CEO - Daughters_i$ in this model. Since I don't observe child-birth events for CEOs in the sample, the fixed effects models are identified by CEO turnovers. The model is identified in cases where a CEO who parents a daughter is replaced by a CEO who parents only sons,

[10] The results are similar when I use MTBV to measure financial performance.

[11] The economic impact is calculated by multiplying the standard deviation of GHG-Normalized (6.294) with the coefficient on GHG-Normalized from column 4 of Table 3 (0.266) and dividing the product by the standard deviation of ROA (5.117).

Table 3
Effect of GHG emissions on profitability - OLS and firm fixed effects estimates. In this table, I provide the estimates for the effect of GHG emissions on profitability. I present the OLS and firm-fixed effects estimates in panels A and B. The dependent variable in all specifications is Return on Assets (ROA), and the independent variables are defined in Appendix 1. Within each panel, the first, second and third columns present results with GHG emissions data sourced from E-PRTR, Eikon and Carbon Disclosure Project (CDP), respectively. In panel A, robust standard errors are in brackets, and in panel B, standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	Panel A: OLS			Panel B: Firm Fixed Effects		
	ROA			ROA		
	(1)	(2)	(3)	(4)	(5)	(6)
GHG-Normalized	-0.381***			-0.266***		
	(0.082)			(0.047)		
Ln GHG-Eikon		-0.464***			-0.380***	
		(0.084)			(0.057)	
Ln GHG_CDP			-0.479***			-0.319***
			(0.095)			(0.062)
Firm Size	0.127**	0.133**	0.145**	0.117**	0.125**	0.131**
	(0.050)	(0.042)	(0.049)	(0.055)	(0.052)	(0.057)
Volatility	0.018	0.010	0.016	0.004	0.009	0.008
	(0.013)	(0.009)	(0.011)	(0.006)	(0.009)	(0.006)
%Shareholding - Family	0.276	0.218	0.224	0.003	0.006	0.008
	(0.313)	(0.210)	(0.200)	(0.003)	(0.007)	(0.005)
%Shareholding-Institutions	0.054**	0.058**	0.051**	-0.005**	-0.010**	-0.009**
	(0.026)	(0.028)	(0.026)	(0.002)	(0.004)	(0.004)
Firm Age	0.119	0.098	0.106	0.022	0.019	0.008
	(0.088)	(0.076)	(0.101)	(0.016)	(0.014)	(0.006)
Capital Intensity	0.067**	0.061**	0.065**	0.039**	0.030**	0.044**
	(0.025)	(0.023)	(0.024)	(0.017)	(0.015)	(0.020)
HHI	0.131	0.109	0.118	0.029	0.018	0.021
	(0.117)	(0.110)	(0.112)	(0.023)	(0.020)	(0.024)
Board Size	0.228	0.137	0.141	0.032	0.020	0.026
	(0.190)	(0.124)	(0.131)	(0.024)	(0.016)	(0.019)
% Non-Executive Directors	0.069*	0.053	0.057	0.017**	0.007**	0.011**
	(0.035)	(0.028)	(0.030)	(0.008)	(0.003)	(0.005)
% Female Directors	0.021	0.018	0.024*	0.007	0.009	0.001
	(0.017)	(0.011)	(0.013)	(0.005)	(0.007)	(0.003)
CEO Duality	0.145	0.138	0.136	0.002	0.000	0.001
	(0.119)	(0.130)	(0.137)	(0.003)	(0.006)	(0.001)
Board Oversight	0.239**	0.203**	0.220**	0.041**	0.030**	0.033**
	(0.101)	(0.097)	(0.102)	(0.015)	(0.013)	(0.013)
Law Expert	-0.014	-0.011	-0.014	–	–	–
	(0.008)	(0.007)	(0.009)			
CEO Experience (Years)	0.009*	0.006	0.009	–	–	–
	(0.005)	(0.004)	(0.007)			
CEO Age (Years)	0.031	0.036	0.044	–	–	–
	(0.020)	(0.024)	(0.029)			
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes	No	No	No
Firm Fixed Effects	No	No	No	Yes	Yes	Yes
Observations	3,188	2,453	2,060	3,188	2,453	2,060
Adjusted R^2	0.332	0.344	0.305	0.305	0.311	0.294

and vice-versa. There are 153 such instances out of the 299 CEO turnover events within the sample period. The following section discusses how this identification strategy allows me to explore the mechanisms.

The first and second stage IV estimates are presented in Table 4. Column 1 provides the within-firm effect on GHG emissions of replacing a male CEO who parents only sons with a male CEO who parents a daughter. In column 1, I show that when such CEO changes occur, the average GHG emissions of the firm fall by 9.88%. Panels B and C replicate the IV results with different measures of GHG emissions. Column 3 shows the estimates using log GHG emissions data from the Carbon Disclosure Project, and column 5 shows the estimates using log GHG emissions data from Thomson Reuters Eikon. The results are qualitatively similar to those in column 1. These results empirically verify hypothesis 2 that male CEOs fathering a daughter is associated with lower GHG emissions. Using a similar method, Cronqvist and Yu (2017) find that CSR scores of firms are 9% higher when the CEO has a daughter. The instrument passes the 5% threshold value for weak instruments (Stock and Yogo, 2005). The Cragg-Donald Wald F-statistics are 17.67 (and 14.54 and 19.22 in panels B and C, respectively). The critical values of 5% and 10% maximal IV relative bias (relative to the OLS estimates) are 12.38 and 10.27, respectively. These results support hypothesis 2 and the *relevance* criteria for a valid IV.

In the second stage, the effect of environmental performance on profitability is statistically significantly stronger than the fixed effects estimate. A one standard deviation reduction in GHG emissions leads to a 0.14 of a standard deviation increase in ROA in terms of the economic effect.[12] It is helpful to benchmark this effect with the literature. Konar and Cohen (2001) find that a 10% decrease in toxic emissions increases market value by $34 million (or 0.03 of a standard deviation). A similar magnitude is reported by Edmans (2011) and Flammer (2015).

[12] The economic impact is calculated by multiplying the standard deviation of GHG-Normalized (6.294) with the coefficient on GHG-Normalized from column 2 of Table 4 (0.144) and dividing the product by the standard deviation of ROA (5.117).

Table 4

Effect of GHG emissions on profitability - Instrumental variable estimates. In this table, I provide the estimates for the effect of GHG emissions on profitability using instrumental variable regressions. I use a binary indicator for CEO Daughter as the instrumental variable. In panels A, B and C, I present the estimates with GHG emissions data sourced from E-PRTR, Eikon and Carbon Disclosure Project (CDP), respectively. The first and second columns present the first and the second stage estimates within each panel. All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	Panel A		Panel B		Panel C	
	GHG-Normalized (1)	ROA (2)	Ln GHG-Eikon (3)	ROA (4)	Ln GHG-CDP (5)	ROA (6)
CEO Daughter	-0.988*** (0.235)		-1.022*** (0.268)		-0.969*** (0.221)	
$\widehat{GHG - Normalized}$		-0.144*** (0.053)				
$\ln \widehat{GHG - Eikon}$				-0.175*** (0.036)		
$\ln \widehat{GHG - CDP}$						-0.202*** (0.061)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,188	3,188	2,453	2,453	2,060	2,060
First-Stage F-Stats	17.67		14.54		19.22	

Table 5

Tests for the exogeneity condition of the instrumental variable. In this table, I present the results of tests for the exogeneity requirement of the CEO Daughter instrumental variable. The dependent variable in column (1) is the normalized GHG emissions from E-PRTR and presents the OLS estimates for the effect of CEO Daughters in feminized industries. Columns (2) -(6) present firm fixed effects estimates where the dependent variables are a binary indicator for female directors on the board, the natural logarithm of (1+Capital Expenditures, the natural logarithm of Selling, General and Administrative (SG&A) expenditures, the debt-to-capital and the debt-to-equity ratios, respectively. All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	GHG -Normalized (1)	Female Directors (2)	Ln (1+Capex) (3)	Ln(1+SG&A) (4)	DC Ratio (5)	DE Ratio (6)
CEO Daughter	-1.112*** (0.394)	0.108 (0.069)	0.069 (0.053)	0.038 (0.025)	0.017 (0.022)	0.013 (0.011)
CEO Daughter* Feminized Industry	0.078 (0.049)					
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	Yes	Yes	Yes	Yes	Yes
Observations	3,188	3,188	3,188	3,188	3,188	3,188
R^2	0.187	0.243	0.239	0.227	0.199	0.212

Therefore, notwithstanding the small magnitude of the gain in profitability from reducing emissions, it is still economically meaningful. Overall, these results provide causal evidence that environmental performance enhances firm performance.

For the IV strategy to be valid, it is important to ascertain that CEOs with daughters do not affect profitability through other channels. For example, Cronqvist and Yu (2017) show that CEOs who parents daughters spend more on CSR and have more diverse boards. Both diverse boards and CSR expenses can affect profitability and contaminate the results. The concern is that the effect of the daughter on the CEO's behaviour may affect profitability through other channels in more feminised industries (higher proportion of females in the workforce): CEOs with daughters can foster company policies that aid women and enhance the productivity of the workforce. Table 5 shows that CEOs with daughters have no differential effect on profitability in more feminised industries.[13] In column 2, I show that the appointment of CEOs with daughters in the United Kingdom has no statistically significant impact on board gender diversity (measured as having at least one female director on the board). This result likely reflects the already existing regulatory pressures in the UK for board gender diversity relative to the US. See, for example, the targets set by the Davies Report (2011) for increasing female representation on British boards. Therefore, the behavioural preference of CEOs with daughters to appoint female directors doesn't differentiate firms in this setting.

Additionally, I investigate if CEOs with daughters are associated with higher risk-aversion and different kinds of corporate strategies. Following Green and Homroy (2018), I use two measures of corporate strategic choices: CapEx and selling, general and administrative expenditure (SG&A). The reason for choosing these two measures is that these expenses will reflect expenses on employee welfare and production that can affect profitability directly. The measures for risk-aversion used are the debt-to-capital ratio (DC Ratio) and debt-to-equity ratio (DE Ratio).[14] These measures reflect if CEOs with daughters undertake more risky strate-

[13] I use the industry-level data on the share of women in employment from OECD annual labour force statistics.

[14] For example, financing a business's day-to-day operations through debt has an intrinsic level of risk because potential bankruptcy costs rise with debt. As a re-

Table 6
Tests for time trends in corporate environmental policies. In this table, I present the results of tests for time trends in corporate environmental policies. The dependent variable in all columns is the normalized GHG emissions from E-PRTR. Column 1 presents the baseline results with a linear time trend instead of industry dummies. Columns (2) -(5) present results for different sub-periods: post-UK Climate Change Act (years 2009-2017), post-Paris Agreement (years 2015-2017), and the two halves of the sample period (2007-2011 and 2012-2017). All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	Linear Time Trends	Post Climate Change Act (2008)	Post Paris Agreement (2015)	2007-2011	2012-2017
	GHG-Normalized				
	(1)	(2)	(3)	(4)	(5)
CEO Daughter	-0.932***	-0.993***	-0.971***	-0.904***	-0.992***
	(0.218)	(0.249)	(0.255)	(0.223)	(0.022)
Control Variables	Yes	Yes	Yes	Yes	Yes
Linear Time Trend	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	No	Yes	Yes	Yes	Yes
Observations	3,188	3,060	694	1,724	2,088
R^2	0.181	0.190	0.196	0.170	0.201

gies directly affecting profitability. The results are presented in Table 5. I find no statistically meaningful effect of CEO Daughters on risk aversion and other corporate strategies. These rules out the most apparent channels that can invalidate the exogeneity requirement.

Since the sample period coincides with increasing awareness of environmental issues and regulatory pressures in the UK, better environmental performance and CEOs with daughter appointments can both be affected by these unobserved factors. One such factor could be the evolving pressures for corporate environmental policies. It is difficult to test the exclusion restriction directly, but I attempt to mitigate the concern about time-varying environmental norms. The baseline models reported in Table 4 include year dummies that absorb idiosyncratic factors related to specific years. These dummies will likely pick up discrete environmental policies or stakeholder pressures firms face in certain years. In Table 6, I provide alternative tests for the time trends in corporate environmental policies that can confound the CEO-Daughter effect. To better capture the trend in environmental sustainability pressures, I use a linear time-trend to estimate the baseline model. In these tests, we examine if the CEO-daughter effect is weakened when we change the control for time-variable factors and whether the said effect varies in different sub-periods of our sample. In column 1, I show that adding the time-trend instead of the year dummies does not alter the main results. Second, I examine if the baseline estimates are similar in different sub-periods of the sample. In columns 2-5, I show that the results are similar in the post-UK Climate Change Act (2008), post-Paris Agreement (2015), and in the two halves of the sample period (2007-2011 and 2012-2017). These results show that the CEO-daughter effect on GHG emissions is robust to the different ways of treating the time factors.

4.2. Mechanisms

4.2.1. Channels through which CEOs with daughters affect GHG emissions

How do CEOs with daughters affect GHG emissions? It is important to examine the channels of effect and ensure that the results are not picking up spurious effects. Significant GHG emissions change results only from a change in business strategy and production technology (Trinks et al., 2020). Therefore, if a CEO aims to reduce GHG emissions, it must reflect in some business strategy and production technology indicators.

I use the information on firm-level climate actions from CDP surveys to explore the channels through which CEOs with daughters affect GHG emissions. I estimate linear probability models of the following type:

$$Climate\ Actions_{it} = \beta_0 + \beta_1 CEO - Daughter_i + \beta_2 X_{it} + f_t + \lambda_i + \varepsilon_{it} \quad (4)$$

Eq. (4) is identified by CEO changes. Since the $Climate\ Actions_{it}$ are binary indicators, these estimates are linear probability estimates where β_1 shows the average change in climate actions for periods when a firm is led by a CEO with daughters from periods when a firm is led by a CEO who parents only sons. The control variables used are *Firm Size, Volatility, Leverage, Firm Age, Capital Intensity, %Shareholding-Institutions, %Shareholding-Family, CEO Age, CEO Tenure, Board Size,* and *Board Independence.*

I use two binary indicators of $Climate\ Actions_{it}$ in two separate regressions. First, I use an indicator, *Business Strategy,* which equals 1 if climate-related issues are integrated into the company's business strategy (CDP Survey Question CC2.2). For this question (and its sub-questions), firms provide details about how aspects of climate responsibility are integrated into their long-term business strategies. In Appendix 3, I provide two example responses.

Second, I use another binary indicator for emission reduction targets, *Emission Target,* which equals 1 if a company has adopted emission reduction targets (CDP Survey Question CC3.1). The linear probability and logit estimates reported in Table 7 show that firms are more likely to adopt a climate-integrated business strategy and set emission reduction targets following the appointment of CEOs with daughters. These results show direct pathways through which CEOs with daughters can affect corporate emissions.

4.2.2. Channels through which GHG emissions affect profitability

This section empirically tests the operational efficiency and informational advantage channels through which environmental performance can affect profitability.

4.2.2.1. Information advantage channel. One benefit of corporate sustainability is that they enhance customer loyalty (Bénabou and Tirole, 2010). It follows that firms with better environmental performance will attract consumers with environmental preferences. It implies that low-emission firms will have higher sales and higher resilience to adverse demand shocks (hypothesis 3a).

First, I estimate cross-sectional regression with annual sales turnover growth as the dependent variable and an indicator for

sult, firms with a higher debt-to-capital ratio are inherently riskier prospects, as a downturn in sales could lead to potential solvency issues.

Table 7
Channels through which CEOs with daughters affect GHG emissions. In this table, I show the channels through which CEOs with daughters affect GHG emissions. Panel A shows the linear probability estimates, and panel B shows the marginal effects of logistic regressions. The dependent variable in columns 1 and 2 are binary indicators for Climate Integrated Business Strategy and Emission Reduction Targets, sourced from the Carbon Disclosure Project survey (CDP). All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

Panel A	Climate Integrated Business Strategy (1)	Emission Reduction Targets (2)
CEO Daughter	0.507***	0.434***
	(0.188)	(0.128)
Control Variables	Yes	Yes
Year Dummies	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	1,956	1,956
R^2	0.324	0.291
Panel B	**Climate Integrated Business Strategy (1)**	**Emission Reduction Targets (2)**
CEO Daughter	0.214***	0.269***
	(0.066)	(0.091)
Control Variables	Yes	Yes
Year Dummies	Yes	Yes
Firm Fixed Effects	Yes	Yes
Observations	1,956	1,956

low-emission firms as the main independent variable. Low_GHG_{it} equals 1 if the GHG emission of the focal firm is lower than the industry average and 0 otherwise. The control variables used are *Firm Size, Volatility, Leverage, Firm Age, Capital Intensity, %Shareholding-Institutions, %Shareholding-Family, Board Size,* and *Board Independence.*

$$\Delta Sales\ Turnover_{it,t+1} = \beta_0 + \beta_1 Low\_GHG_{it} + \beta_2 X_{it} + f_t + \lambda_i + \varepsilon_{it} \tag{5a}$$

In column 1 of Table 8, I show that low-emission firms have higher sales growth than high-emission firms.

Next, I test the demand resilience of low-emission firms. I use an indicator for negative demand shock by a dummy variable, $Negative\ Shock_{t,t+1}$, which indicates that the three-digit UK-SIC industry group of the company experienced at least a 10% fall in sales in the preceding 12 months. The main explanatory factor is the interaction term $Low\_GHG_{it} * Negative\ Shock_{t,t+1}$. The dependent variable is the change in ROA between periods *t* and *t+1*.

I estimate the following fixed effects model with the same set of controls as Eq. (5a):

$$\Delta ROA_{it,t+1} = \beta_0 + \beta_1 Low\_GHG_{it} * Negative\ Shock_{t,t+1} + \beta_2 X_{it} + f_t + \lambda_i + \varepsilon_{it} \tag{5b}$$

I present the results in column 2 of Table 8. The adverse effect of a fall in industry demand is partially mitigated for firms with better environmental performance: the coefficient of the interaction term is positive/negative and statistically significant. While I cannot test for customer loyalty directly, the results suggest that firms with better emission records are less adversely affected by adverse industry shocks.

Further, I test the lower cost of equity capital and lower financing constraint hypothesis 3b. First, I follow El Ghoul et al. (2011) to calculate the cost of equity capital using four different models: the Claus and Thomas (2001) model (CT), the Gebhardt et al. (2001) model (GLS), the Ohlson and Juettner-Nauroth (2005) model (OJ) and the Easton (2004) model (ES).[15] I subtract the 10-year UK treasury bond yields to get each model's estimated cost of equity. To construct these measures, we use data on analyst forecasts from I/B/E/S. I estimate cross-sectional regression with the cost of capital measures as the dependent variables and the Low_GHG_{it} indicator as the main independent variable. The control variables used are *Firm Size, Volatility, Leverage, Firm Age, Market to Book Ratio, Market Beta, Capital Intensity, %Shareholding-Institutions, %Shareholding-Family, Board Size,* and *Board Independence.*

$$Cost\ of\ Equity_{it} = \beta_0 + \beta_1 Low\_GHG_{it-1} + \beta_2 X_{it} + f_t + \varepsilon_{it} \tag{6a}$$

I present the results in columns 3-6. The coefficient of Low_GHG_{it-1} is negative and statistically significant at the 1% level. It implies that low-emission firms have a lower cost of equity than high-emitters.

Finally, I examine the cash-flow sensitivity of cash for low-emitter firms. I estimate a model where the dependent variable changes the cash holdings ratio over total assets between years *t* and *t+1*. I regress this on the indicator for low GHG emissions and the interaction of Low_GHG_{it} and cash flow (*Cash Flow*), where cash flow is measured contemporaneously with the change in cash holdings (*Cash Holdings*). I estimate the following regression:

$$\Delta Cash\ Holdings_{it,t+1} = \beta_0 + \beta_1 Low\_GHG_{it} * Cash\ Flow_{t,t+1} + \beta_2 X_{it} + f_t + \lambda_i + \varepsilon_{it} \tag{6b}$$

The control variables used are *Firm Size, Volatility, Leverage, Firm Age, Capital Intensity, %Shareholding-Institutions, %Shareholding-Family, Board Size,* and *Board Independence.* The interaction coefficient (Low_GHG_{it} * *Cash Flow*) is negative and statistically significant at 5% levels, suggesting that better environmental performance does not hoard more precautionary cash when cash flow increases. It is a direct implication of better external financing opportunities for these firms.[16] I present the results in column 7.

4.2.2.2. Operating efficiency channel. I test hypothesis 3c by estimating the cross-sectional effect of below-average GHG emissions on the operating expenses, controlling for firm characteristics. The control variables used are *Firm Size, Volatility, Leverage, Firm Age, Capital Intensity, %Shareholding-Institutions, %Shareholding-Family, Board Size,* and *Board Independence.*

$$Operating\ Expenses_{it} = \beta_0 + \beta_1 Low\_GHG_{it} + \beta_2 X_{it} + f_t + \varepsilon_{it} \tag{7}$$

The coefficient on the Low_GHG_{it} dummy is negative and statistically significant at the 10% level, suggesting that, on average, firms with better environmental performance have lower operating costs. I present the results in column 8 of Table 8.

Finally, I estimate a similar cross-sectional regression with expenditure on energy as the dependent variable. I obtained information on energy costs from responses to CDP question 11.1: "What percentage of your total operational spend in the reporting year was on energy?". In column 9 of Table 8, I show that low-emission firms have lower expenditure on energy.

Together, these results shed some light on the potential mechanisms for the negative effect of GHG emissions and financial performance. Profitability effects of emission reduction result from lower operating costs, improved access to external financing, and insulation from industry shock through customer loyalty. It is important to note that these results do not show causal effects of

[15] For an overview of these models, please see El Ghoul et al. (2011).

[16] I check for the robustness of the result using the more general Kaplan and Zingales (1997) approach to measure financial constraints. This approach uses a linear combination of cash flow to total capital, debt-to-capital, market-to-book, dividends-to-capital, and cash holdings-to-capital to measure financing constraint. The results are qualitatively similar and omitted for brevity.

Table 8

Channels through which GHG emissions affect profitability. This table shows the channels through which GHG emissions affect profitability. Panel A shows the results for the information advantage hypothesis, and panel B shows the results for the operational efficiency hypothesis. The dependent variables are shown on top of each column. All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	Panel A: Information Advantage							Panel B: Operational Efficiency	
	$\Delta Sales_{it,t+1}$	$\Delta ROA_{it,t+1}$	r_{CT}	r_{GLS}	r_{OJ}	r_{ES}	$\Delta Cash\ Holdings_{it,t+1}$	Ln(Operating Expenses)	% Energy Expenses
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Low GHG	0.109**	0.077**	-0.043**	-0.021**	-0.039**	-0.040**	0.064**	-0.118**	-0.166**
	(0.048)	(0.032)	(0.018)	(0.010)	(0.016)	(0.014)	(0.030)	(0.051)	(0.073)
Negative Shock * Low GHG		0.172**							
		(0.068)							
Cash Flow * Low GHG							-0.121**		
							(0.055)		
Cash Flow							0.073**		
							(0.029)		
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	No	No	No	No	Yes	No	No
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Dummies	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes
Observations	2,804	2,804	3,188	3,188	3,188	3,188	2,477	3,188	1,984
R^2	0.290	0.311	0.214	0.232	0.210	0.253	0.281	0.327	0.304

emission reduction on operating expenses but provide indicative evidence of the channels through which emission reduction affects profitability.

4.3. Robustness and extensions

I conduct a range of additional tests to ensure the robustness of the main results. These tests attempt to check the sensitivity of the baseline results to different variable specifications and empirical strategies.

a. Scope 2 and scope 3 emissions

Increasingly, regulators are focusing not only on firms' own emissions but also on the environmental impacts of their upstream and downstream value chains. The concern is that firms can offshore their emissions to build a green reputation. Therefore, I examine the effect of male CEOs parenting a daughter on Scope 2 (purchased electricity, steam, heating, and cooling for own use) and Scope 3 (purchased goods and services, business travels, waste disposal, transportation and distribution and investments).

For this analysis, I use the natural logarithm of the emissions data reported in CDP. Approximately 88% of the sample firms within CDP coverage report their Scope 2 emissions in question 8.3a: "Please provide your gross global Scope 2 emissions figures in metric tonnes CO2e". The mean scope 2 emissions of firms in my sample are 12.33. However, there is much smaller coverage of scope 3 emissions reported in question 11.1: "Please account for your organization's Scope 3 emissions, disclosing and explaining any exclusions". This information is available for only 21% of the sample firms. The mean scope 3 emissions is 14.02. A large fraction of the firms in my sample have global operations, and collecting emissions data from the widespread network is still evolving. An MSCI report from 2020 highlights the challenges corporations face in collecting reliable emission data from their upstream and downstream activities (Baker, 2020).

Table 9 presents the first and the second stage IV regressions. I show that CEOs with daughters are associated with lower scope 2 and scope 3 emissions. However, the result for scope 3 emissions is statistically weak, likely driven by the lower power of the test with a small subsample. In the second stage, reduction in scope 2 emissions is associated with higher profitability, but the effect of scope 3 emissions on ROA is not statistically significant at conventional levels.

These results indicate that CEOs with daughters implement strategies to reduce scope 2 and scope 3 emissions (as discussed in Section 4.3.1). As challenges to collecting homogeneous emission data from supply chain partners ease and scope 3 reporting becomes more widespread, the weak results we report for scope 3 emissions can gain statistical power.

b. Tests for Validity of the CEO-Daughter IV

For the IV estimates to be unbiased, giving birth to a daughter must be a random event, and the daughter needs to be born before the appointment as a CEO. There could be other sources of bias: fertility stopping rules, sex-selective adoption, children borne out of wedlock, stepchildren, etc. Some of these issues are discussed in this subsection.

First, is the effect observed driven by CEOs having daughters or having children more generally? It is plausible that having more children would induce CEOs to care more about the future because they have more offspring to parent. In Appendix 5, I test the effect of family size versus the presence of a daughter versus CEOs with no children. The results indicate that the CEOs without children do not exhibit a statistically significant effect on GHG levels; neither does the number of children more generally. The CEO-daughter effect remains fairly stable and statistically significant, suggesting that this effect is more persistent than family size effects.

Second, is the CEO-daughter effect different from a general CEO parenthood effect? Results reported in Appendix 6 suggest that CEOs who are parents (based on a binary variable of having children or not, more generally) indeed exhibit lower GHGs emissions than non-parents. However, further scrutiny of this effect suggests that it is driven by the presence of at least one daughter. Thus, relative to CEOs with no children, CEOs with daughters are associated with lower GHG emissions, whereas CEOs who only parent sons have an effect that is not statistically distinguishable.

Third, the gender socialisation effect may increase with the number of daughters. I calculated the proportion of daughters and re-estimated the full multivariate models. The corresponding coefficients in Appendix 7 show that the association between the proportion of CEO daughters and GHG emissions is statistically indistinguishable from the binary measure. Thus, there is no conclusive indication that the proportion of daughters matters; rather,

Table 9
Scope 2 and scope 3 emissions - Instrumental variable estimates. In this table, I provide the estimates for the effect of Scope 2 and Scope 3 GHG emissions on profitability using instrumental variable regressions. I use a binary indicator for CEO Daughter as the instrumental variable. In panels A and B, I present the estimates with Scope 2 and Scope 3 GHG emissions using Carbon Disclosure Project (CDP) data. The first and second columns present the first and the second stage estimates within each panel. All specifications include the full set of control variables in Table 3 and are defined in Appendix 1. The standard errors clustered at the firm level are in brackets. ***, **, and * denote statistical significance at 1%, 5% and 10%, levels, respectively.

	Panel A		Panel B	
	Ln GHG -CDP Scope 2 (1)	ROA (2)	Ln GHG -CDP Scope 3 (3)	ROA (4)
CEO Daughter	-0.422***		-0.191*	
	(0.126)		(0.104)	
$\ln \widehat{GHG - CDP\ Scope}\ 2$		-0.173**		-0.082
		(0.080)		(0.055)
$\ln \widehat{GHG - CDP\ Scope}\ 3$				
Control Variables	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,812	1,812	432	432
First-Stage F-Stats	11.21		3.37	

the CEO-daughter effect reflects more of a state than a matter of degrees.

Fourth, does the birth-order matter? Studies on birth order and fertility stopping decisions allude to the possibility that family size and birth order may be contingent on the sex of the first-born. For example, parents may have overt or latent preferences for the particular sex of their children, which could be more generally reflective of their preferences). In Appendix 8, I test whether the sex of the first child influences (a) the number of subsequent children and (2) the number of sons after the first child. I find no evidence of gender-sequencing effects in response to the sex of the first child in the sample. Given this, to the extent that children's sex is randomly distributed, and if the CEO–daughter effect reflects a state (as previously evidenced), then the socialisation effects should be most pronounced if the daughter is a CEO's first-born. The complementary results summarised in Appendix 9 indeed suggest that the CEO-daughter effect is most pronounced when the daughter is a CEO's first-born (an effect replicated in the contingency analyses as well). Thus, the CEO-daughter effect appears to be more of a treatment than a dosage effect.

c. Female CEOs

Further, I examine whether the effect of the daughter effect on climate concerns applies to female CEOs. In my sample, we only have 18 female CEOs. Appendix 10 shows the cross-sectional estimate of female CEOs and female CEOs' daughters on emissions. Companies with female CEOs have lower emissions than companies with male CEOs. However, there is no added effect of female CEOs who mother a daughter on emissions. It shows that the CEO-daughter effect emerges as a meaningful channel through which values typically socialised in women may be visible in male CEOs who father daughters.

d. Heterogeneous treatment effect and CEO network

Finally, I examine the effect of CEO daughters on GHG emissions in subsamples of firms with the highest and lowest GHG emissions. For this test, I create subsamples *Emission_High* = 1 and *Emissions_Low* = 1 when the GHG emission is in the top-quartile and bottom quartile of the GHG emissions distribution. If CEOs are endogenously sorted, I expect more environmentally oriented CEOs to sort into the *Emissions Low* group. Therefore, any effect of Male CEO-Daughter is likely to be more pronounced in the low emissions group. The results indicate that the Male-CEO Daughter is the strongest in the *Emissions High* Group. The stronger marginal impact in the high emissions group further supports that female socialisation in male CEOs with daughters affects GHG emissions, particularly where the emissions are *already* higher. This result, I argue, indicates that the baseline result is driven more by female socialization, particularly in companies with high GHG emissions, than endogenous sorting. I present the results in Appendix 11.[17]

Next, I explore the network of CEOs before the appointment. The endogenous association is more likely to be a concern when an external CEO appointment happens at a firm with which the CEO already had a prior connection. Therefore, I construct a dummy = 1 for externally appointed CEOs who have been non-executive directors at the same firm at any point in time before the CEO appointment. This test mitigates the concern that endogenously sorted CEO appointments contaminate the main results. Using this control also does not materially alter the result.

e. Alternate instrumental variable

I explore an alternative identification strategy to examine the robustness of the results. I use the mean GHG emissions of peer firms (*Peer-Emissions*) as the instrumental variable. The underlying logic is that a firm's GHG emissions may be affected by the level of GHG emissions by the direct industry peers, but GHG emissions of industry peers do not significantly affect the focal firm's financial performance. I identify peers as companies working in the same 2-digit UK SIC codes. The results, reported in Appendix 13, show that peer-firms GHG emissions have a positive and statistically significant effect on a focal firm's GHG emissions. Lower GHG emissions increase profitability in the second stage. However, the first-stage F-statistics is 8.49, lower than the threshold of 9.37 for a 20% bias relative to OLS. Therefore, I can't reject the null hypothesis of a weak instrument at conventional statistical levels.

How do the two IV strategies compare? While both the IVs can satisfy the relevance criteria, the concern in both cases is the exclusion restriction. In the case of *CEO-Daughter*, the concern is that CEOs who parent a daughter can also make choices (other than emission reduction) that affect profitability. It would violate the exogeneity requirement of a strong IV. I have attempted

[17] The baseline results hold when I drop firms in the financial and insurance sectors which has the lowest scope 1 emissions. The results are presented in Appendix 12.

to eliminate some more obvious threats in this regard. For the *Peer-Emissions*, any omitted variables at the individual firm level are likely aggregated up at the group level (Gormley and Matsa, 2013). Certain industries face more regulatory or institutional ownership pressure that drives down emissions, and institutional owners and regulators' focus is typically on the most profitable industry groups. In such cases, unobserved industry-level factors (regulatory focus or institutional ownership pressures) can simultaneously drive both GHG emissions and profitability.

f. Excess returns

In an efficient market, a tangible variable unambiguously beneficial to firm value will be rapidly capitalised and not lead to any excess returns. In the case of low-GHG emissions, there is a trade-off between long-term and short-term profits, and therefore the net effect on market returns is unclear (Edmans, 2011). I construct a rolling annual portfolio of low GHG companies (if the GHG emission of the focal firm is at least 20 per cent lower than the 2-digit industry average). I estimate the monthly excess return on the portfolio of these stocks over a benchmark using the Carhart (1997) four-factors and Newey-West (1987) standard errors. The results in Appendix 14 show that this portfolio earns a monthly excess return of 0.09% over the risk-free rate (yield on the UK 10-year government bond). This result shows that a portfolio of low GHG emission companies earns an annualised excess return of 1.1% over the risk-free rate.

Similarly, I construct a rolling annual portfolio of stocks of firms whose CEOs parent a daughter and estimate the monthly excess return on this portfolio. I find no statistically significant difference in the annualized excess returns of these companies over the risk-free rate. This result corroborates earlier results that firms led by CEOs with daughters have similar risk-profile to other firms.

g. ETS and other climate-related regulations

Finally, the regulatory environment, like the European Union Emission Trading System (EU ETS), may affect the relationship between emission abatement and profitability. Some industries, like mining, metals, energy etc., are more likely than others to be affected by such regulations (Oestreich and Tsiakas, 2015). For example, Veith et al. (2009) and Scholtens and van der Groot (2014) show higher profits for sectors affected by the EU ETS. Additionally, there have been considerable policy initiatives regarding climate change in the UK within my sample period. For example, a 2013 amendment to the Companies Act (2006) made it mandatory for listed companies to disclose GHG emissions in their annual reports (Jouvenot and Krueger, 2019; Bolton and Kacperczyk, 2021). Since these are industry-level factors affecting certain years, I re-estimate the models with industry-year fixed effects to test (a) the effect of GHG emissions on firm performance and (b) the effect of CEO daughters on GHG emissions. The results remain qualitatively similar to the baseline estimates.

Additionally, I provide results using an indicator for ETS-affected industries. The indicator equals 1 for firms in the following industries: Manufacturing-Industrial, Construction, Energy and Utilities. In this regression, naturally, I drop the industry dummies. The ETS-dummy is positively and statistically significantly related to ROA, reconciling my result with the existing literature. Of course, we can't use firm fixed effects in these specifications because a firm once treated by EU-ETS continues to remain so. The results are reported in Appendix 15.

h. Internal vs external appointments

I examine if externally appointed male CEOs with daughters affect GHG differently than internally selected counterparts. The underlying argument is that externally appointed CEOs are less affected by the firm's culture, so factor in different elements (perhaps also pre-existing environmental performance) in their choice to join a new position. More generally, externally appointed CEOs are likely to drastically affect companies' strategies (Karaevli, 2007; Zhang & Rajagopalan, 2010). I run the baseline models separately for internally and externally appointed CEOs. I use the information on BoardEx on *Time in Role* and *Time in Company*. I create an indicator *External Appointments*, which I code as 1 if the number of years the CEO has spent in the role is the same as the number of years in the company, 0 otherwise. Forty-six per cent of the CEOs in the sample are externally appointed. Against these considerations, I still find statistically significant and economically meaningful effects of male CEOs' daughters on GHG emissions when controlling for an external appointment dummy. The impact of *CEO-Daughter* is stronger for externally appointed CEOs. The results are reported in Appendix 16.

5. Conclusion

The focus of the current climate policies relies heavily on the voluntary reduction of corporate GHG emissions. Without binding regulations, these policies' success depends on the companies' net financial benefit from improving their environmental performance. In this paper, I examine the relationship between corporate GHG emissions and financial performance using a sample of FTSE 350 companies. I use the information on CEOs' parenting daughters to provide causal evidence on whether improving emissions improves profitability. These results show statistically significant gains in profitability for lower GHG emissions: when GHG emissions decrease by one standard deviation, profitability increases by 0.14 of a standard deviation.

Examining the channels, I show that CEOs with daughters are more likely to adopt a climate-integrated business strategy and set emission-reduction targets than CEOs who parent only sons. Further, I show that firms with better within-industry environmental performance are better insulated against negative industry shock and have lower financing and operating costs.

This paper adds to the literature on corporate environmental practices and their shareholder value effects. The results highlight a behavioural channel that drives corporate sustainability actions, ultimately benefiting the shareholders. Absent regulations, I highlight a novel channel that can make firms more environmentally responsible.

It is essential to recognise the context within which the results of this paper hold. The identifying variation in this study comes from events of CEO turnover, which includes a change in the gender composition of the CEO's children. In addition, the sample of companies is drawn from the relatively more market-oriented institutional setting of the United Kingdom, where the CEO significantly impacts corporate strategy. The external validity of these results on a sample of companies from different institutional settings is an avenue for future research.

CRediT author statement

Swarnodeep Homroy is the sole author of the paper **"GHG Emissions and Firm performance: The role of CEO Gender Socialization"** and is responsible for conceptualization, data collection, data analysis and writing the final manuscript.

Declaration of Competing Interest

The author declares no conflict of interest.

Appendix 1. Variable definitions

Variable	Definition	Source
Ln GHG Emissions- CDP	Natural logs of values reported in "What were your organisation's gross global Scope 1 emissions in metric tons CO2e?	CDP Survey Question C6.1
Ln Scope 2 Emissions - CDP	Natural log of values reported in "Please provide your gross global Scope 2 emissions figures in metric tonnes CO2e"	CDP Survey Question C8.3a
Ln Scope 3 Emissions - CDP	Natural log of values reported in "Please account for your organization's Scope 3 emissions, disclosing and explaining any exclusions"	CDP Survey Question C14.1
Ln GHG Emissions - Eikon	Natural logs of GHG emissions	Thomson Reuters Eikon
GHG (Normalized)	GHG Emissions scaled by the threshold for adverse effect on human health	European Pollutant Release and Transfer Register
Return on Assets (ROA)	Net Income/Total Assets	Thomson Reuters Eikon
Market to Book Value (MTBV)	Market value of equity/Book value of total assets	Thomson Reuters Eikon
Firm Size (Ln Sales)	Natural log of annual sales turnover	Thomson Reuters Eikon
Volatility	Volatility in monthly stock prices over the preceding 12 months	Thomson Reuters Eikon
Capital Intensity	Sales and operating revenue divided by stockholders' equity.	Thomson Reuters Eikon
%Shareholding-Family	Fraction of shares held by a family or founding family	Thomson One
%Shareholding-Institutions	Fraction of shares held by institutional investors	Thomson One
HHI	Authors' calculations of the sum of squares of the market share of each firm in an industry	Thomson Reuters Eikon
Ln (1+Capital Expenditure)	Natural log of (1+Capital Expenditure) in a year	Thomson Reuters Eikon
Debt-to-Equity Ratio (DE Ratio)	Total Debt/Shareholders Equity	Thomson Reuters Eikon
Ln (Firm Age)	Natural log of the gap between the founding year and the current calendar year	Thomson Reuters Eikon
Board Size	Number of directors on the corporate board	BoardEx
% Independent Directors	Fraction of Board Size composed of Independent Directors	BoardEx
% Female Directors	Fraction of Board Size composed of Female Directors	BoardEx
CEO Duality	Dummy = 1 if the CEO is also the Chair of the Board	BoardEx
Board Oversight	Dummy =1 if the answer to "Is there board-level oversight of climate-related issues within your organisation?" is Yes	CDP Survey Question C1.1
Climate Integrated Business Strategy	Dummy = 1 if the answer to "Is climate change integrated into your business strategy?" is Yes	CDP Survey Question C2.2
Emission Reduction Targets	Dummy = 1 if the answer to "Did you have an emissions reduction or renewable energy consumption or production target that was active (ongoing or reached completion) in the reporting year?) is Yes	CDP Survey Question 3.1
Energy Consumption	Percentage reported in response to "What percentage of your total operational spend in the reporting year was on energy?"	CDP Survey Question 11.1
Law Expert	Dummy = 1 if at least one director on the board has obtained an LLM or an LLB degree	BoardEx
CEO Daughter	Dummy = 1 if the CEO has at least one daughter	BoardEx World of CEOs beta
No. of CEO Children	Total number of children of a CEO	BoardEx World of CEOs beta
Proportion of CEO Daughter	Fraction of daughters in the number of CEOs' children	Authors' Calculation
First-born CEO Daughter	Dummy =1 if the eldest child of a CEO is a daughter	Lexis-Nexis, Forbes, Financial Times, Wall Street Journal, BoardEx World of CEOs beta
Female CEOs	Dummy = 1 if the CEO gender is "Female"	BoardEx
CEO Experience (Years)	Number of years of tenure of the CEO in a company	BoardEx
CEO Age (Years)	Age of the CEO as of the calendar year	BoardEx
Conservative Donor	Dummy = 1 if at least 51 per cent of the CEO's political donations are made to the Conservative Party.	UK Electoral Commission
Industry Dummies	Based on 2-digit UK SICs	Companies House, UK

Appendix 2. GHG emissions algorithm for E-PRTR

To measure firms' environmental performance, I use firms' GHG emission data from the E-PRTR (Website: http://prtr.ec.europa.eu/). The E-PRTR is the Europe-wide register that provides annual data on the amounts of pollutants released to air, water, and land from 93 key pollutants (e.g., heavy metals, pesticides, greenhouse gases, and dioxins) as well as off-site transfers of waste and of pollutants in wastewater from 108,228 industrial facilities in the EU Member States, Iceland, Liechtenstein, Norway, Serbia, and Switzerland over the period 2007–2017. The main advantage of the register is that data are comparable across countries and pollutants because data collection and reporting are standardised over all the pollutants in all countries. A facility is defined as an operation unit of a firm focused on a narrowly defined process like packaging, bottling, etc.

The original dataset downloaded from the E-PRTR website contains 370,037 observations. Each line of the dataset reports data on one particular pollutant released/transferred by one facility in one year, as well as information about the category of the pollutant (greenhouse gas, pesticide, etc.) and information about the facility (e.g., address, activity sector, parent company, etc.). Therefore, I may have several observations for the same facility within a year if this facility releases or transfers various types of pollutants per year. For example, the facility with ID = 9 (Saint-Gobain Glass Polka Sp. Z o. o.) has three lines for the year 2011 in the dataset because this facility released two types of pollutants (NOx and Cadmium) and reported hazardous waste disposal in 2011.

As I am interested in one specific pollutant, I aggregate only Scope 1 GHG pollutants defined on the E-PRTR website: water vapour, carbon dioxide (CO_2), ozone (O_3), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC's) and sulphur hexafluoride (SF_6). The E-PRTR database do not include embedded GHG emissions from imports of resources, inputs Each pollutant is reported in the E-PRTR if the emitted amount exceeds a reporting threshold. The reporting thresholds are set up by the European Commission based on their impact on human health and the environment.[18] Therefore, I normalise the emitted amount according to the reporting threshold and then sum these normalised amounts of GHG pollutants for each facility.

I finally reshaped the dataset to have only one observation per facility per year. The dataset has now 283,466 lines. Each line contains information on the facility (address, parent company, and economic activity code) and the amount of pollutant by category. From this dataset, I extract all the facilities belonging to UK firms featured in the FTSE350 and aggregate pollution data at the firm level, as explained in the Data Section of the paper.

Appendix 3. Sample responses on climate integrated business strategies - CDP

A. British American Tobacco - 2017

"Climate change is identified as a key business risk on the Group's Risk Register and is integrated into the business strategy and budget cycle. We have a target to reduce our Scope 1, 2 and 3 CO2e emissions by 55% by 2025 and 80% by 2050 against our 2000 baseline of 1.52 tCO2e per million cigarettes equivalent.1) The internal process for collecting and reporting information on climate change to influence the strategy: Operating companies, in which we hold an equity stake equal or in excess of 50% are required to report environmental performance. The biggest in terms of CO2 footprint factories, GLTs and TMD organizations report on a quarterly basis, the medium – on semi-annual, the smallest – on annual. Frequent monitoring helps us understand and monitor the impacts our direct operations (including Scope 3 Freight) have on the natural environment. The data collected is used in tracking performance against our short; medium and longer term carbon intensity targets and informs the need for targeted investment(s).2) The following aspects of climate change have influenced the strategy: Need for adaptation: Our ability to mitigate and or adapt to climate change through the use of business tools and risk management processes enables the business to build resilience and take advantage of opportunities across the supply chain."

B. Reckitt Bekinser 2013

"The processClimate change issues are integrated into our business strategy. In early 2012 we initiated a project to identify the key sustainability megatrends likely to impact our business and during this process reviewed over 90 studies from key research, strategy and policy organizations. We identified six global megatrends like rising energy costs and emission constraints, increasing water scarcity and increasing pressure on natural resources & waste to name a few. We are responding to these global developments with a strategy for more sustainable innovation, called better business. We are focusing on the areas where we can make the biggest difference – the need for better health and hygiene behaviour and the increasing scarcity of water. We will continue to focus on minimizing carbon emissions across the lifecycle of our products, including Scope 3 emissions. And by 2020 we aim to achieve 1/3 reduction in both our carbon footprint and our water impact per dose of product."

[18] See Article 5 of the E-PRTR Regulation No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC.

Appendix 4. Industry distribution of the sample and GHG emissions

In this table, I present the industry distribution of the sample based on the UK SIC codes. I also present the average GHG emissions of companies in each industry group, scaled by the European Commission reporting threshold for CO2 in 100 million kgs/year. See Appendix 2 for details on the normalisation process.

Industry Group	Number of Companies	UK SIC Codes	GHG-Normalized
Technology	14	62	4.84
Telecommunications	6	61	6.67
Healthcare	13	84	8.41
Financials- Banks	27	64	2.19
Financials - Insurance	20	66	2.48
Professional Services	32	70	10.65
Real Estate	24	68	5.87
Consumer Discretionary	59	45	14.22
Consumer Staples	20	47	20.76
Manufacturing - Industrials	55	10-33	23.35
Construction	22	41-43	13.58
Energy	8	46, 61, 62,	16.71
Utilities	9	35, 36	15.33

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