Efficiency-Based Carbon Pricing: Reassessing Firms' Environmental Impact

Stefano Bonini* Meghana Vaidya† Shuang Wu‡

March 31, 2022

Abstract

We model the firm's objective as a function of output and environmental ethics. Purely profit-driven production is at the cost of greater emission charges, leading firms to endogenize the optimal emission-output level. Firms with higher environmental ethics have higher marginal output and emit less because of the higher emission cost. More importantly, we argue that the one-size-fits-all carbon pricing is not optimal. Instead, carbon emissions should be priced based on the efficiency of the emission. Given a fixed carbon cap, switching to efficiency-based carbon pricing adds value to social welfare. Such an increase in value positively relates to the overall emission reduction. We provide empirical evidence to support the theory.

*Stevens Institute of Technology, sbonini@stevens.edu
†Stevens Institute of Technology, mvaidya@stevens.edu
‡Stevens Institute of Technology, swu33@stevens.edu

1 Introduction

Climate change weaves through our daily lives and is the most discussed socioeconomic crisis today[1]. The EPA reported a 47% increase in greenhouse gases between 1990 and 2015 globally[2]. Greenhouse effect, a phenomenon detected in 1800s[3] has started getting attention from the governments and organizations in current times with IPCC[4] suggesting reducing the emissions globally by 50% to limit the global warming at 1.5°C above pre-industrial levels. However, no one has yet discovered how to strategically and steadily decrease carbon emissions without squeezing economic activity.

To find such a solution, we need to understand two components: the incentives of firms to be environmentally responsible and the elasticity of firms' financial performance to the commitment. The two components are difficult to disentangle as adopting pro-environment practices is endogenous to firms' objectives. Furthermore, there is no explicit linkage between environmental conscience and profitability. These challenges make it difficult to uncover the role and the value of environmental conscience – is it an inner reward with little material returns, or is it a value-enhancing strategy of firms to respond to the evolving customer preference and behavior?

In this paper, we attempt to theoretically and empirically investigate the role of environmental ethics in shaping firms' decisions on emission and output. We introduce a new approach to better understand the impact of firms' environmental ethics on their emission levels. Before touching on the theory, let us consider a simple example. There are two firms, firm A emitting 800 thousand short tons of CO_2 equivalent and firm B emitting 1 million short tons of CO_2 equivalent. These numbers suggest that firm A is environmentally more cautious than firm B. Now, firm A achieves a profit of 100 million USD and profit for firm B is 500 million USD. Thus we can say that for the same level of emission firm B is more

[1] Discussed in Stern (2006); Akey and Appel (2021); Bartram et al. (2021) and so on
[2] https://www.epa.gov/climate-indicators/climate-change-indicators-global-greenhouse-gas-emissions
[3] https://www.nationalgeographic.com/environment/article/greenhouse-gases
[4] Intergovernmental Panel on Climate Change

profitable ($500 per ton of CO_2 versus $125 for A), or more *efficient*. This shows the absolute value of emission as a one-sided measure of a firms' environmental ethics. We thus propose a new approach and construct a variable called "scaled profit" to measure the efficiency of pollution and define it as the ratio of firms' profit to total emission. A higher value of scaled profit suggests that the firm achieves a higher profit with the same pollution level.

We construct a model where firms' objective is the output net of environmental costs. We assume that carbon (emission) is one of the inputs in firms' output function, positively impacting output. On the other hand, carbon emission is associated with a cost. Firms endogenize the optimal output-emission given heterogeneous environmental ethics. We show that the firms with higher environmental ethics ("green firm" thereafter) have higher efficiency of emission/output.

We extend the model to feature the prevalent cap-and-trade regime[5] and compare social welfare under the uniform carbon pricing and our proposed efficiency-based carbon pricing. With the same emission reduction, the efficiency-based carbon pricing can help achieve the social optimum by adjusting firms' intrinsic costs of emission and nudging the green firm to consume more carbon to achieve higher output.

The intuition is the following: under the uniform carbon pricing regime, the green firm emits less and is likely to sell the extra carbon certificates to the brown firm for companies of similar asset size. Switching to efficiency-based carbon pricing means efficient production is "rewarded" with a lower carbon price given the same carbon cap. Facing a lower cost on emissions, the green firm's incentive of selling decreases, shifting the optimal output to the right. The basic idea of the differential carbon pricing is that it is more economically sound to induce the green firm to consume instead of selling the allocated carbon because it creates more value concerning a higher output than the brown firm.

The value of switching from uniform carbon pricing to differential carbon pricing depends on the production gain from the green firm's additional consumption of carbon relative to the

[5]https://www.c2es.org/content/market-based-state-policy/

social loss from the brown firm's further costly reduction in emission. We find that this value increases with the emission reduction goal set by the government. In other words, efficiency-based carbon pricing adds more value upon a greater reduction in emission intensity.

The model hints at the government's role in allocating scarce carbon resources to firms when there is a carbon constraint. The model also offers an informative indicator of marginal output based on which policymakers can distinguish the green firm from the brown firm.

We corroborate the model through a set of analyses. We start by constructing our main variable, the *green index*, as a proxy for environmental ethics. We treat environmental ethics as a rooted corporate culture. We consider the culture time-invariant to mitigate the concerns about "greenwashing" and "window dressing." We compile a 56-keyword dictionary and use a text mining algorithm to scrape firms' earliest 10-K files during 1995 and 2000. We calculate the "green index" by calculating the proportion of the sentences where keywords appear to the total number of sentences in a 10-K.

We first examine the impact of environmental ethics on the absolute level of carbon emission by firms and find no significant relationship between firms' environmental ethics and their pollution levels. The empirical results don't seem to reconcile with the argument that firms sensitive to environment emit less pollution and indicates that the current measure of this relation is flawed.

We then test our hypothesis that firms with higher environmental ethics have higher marginal output. The dependent variable is scaled profit, profit scaled by the absolute value of greenhouse gas emission measured in short tons of CO_2 equivalent. We use facility-level data on greenhouse gas emissions from the Environmental Protection Agency's (EPA) Clean Air Markets Division (CAMD) database for 2001-2020. The results support our hypothesis showing that an increase in the green index by 10% increases the expected mean scaled EBIT for parent firms by $39 per unit of emission, corresponding to a rise in about 590 million USD for the mean level of emission in our sample.

One of the concerns with our sample is that it mainly concentrates on firms that have

large electricity-generating plants that required to report to EPA. Although we control for industry-fixed effect, it is possible that some unobservable characteristics shared by these firms drive our results. To mitigate the concern, we expand the sample to S&P 500 firms whose primary business relies on carbon emission, one of the critical assumptions in our model. The results support our hypothesis and show that the marginal effect of the environmental ethics is positive and statistically significant for top polluting industries, which contribute more than 70% of emission across S&P 500 companies, indicating that our model is more informative for carbon-intensive firms (SIC 29 and SIC 49).

The paper contributes to improving the understanding of firms' emission and output patterns through the perspective of environmental ethics. Unlike previous literature[6] that only takes a binary look at the association of environmental ethics with firms' emission reduction and financial performance, our paper advances a two-sided version of both emission and output. The synthesis of the two depicts a more broad picture of the conflicts and the equilibrium of pecuniary incentives and social norms. We may establish a plausible connection between environmental ethics and profitability with the new approach.

The relationship between firms' sustainable investing and financial performance is well established in literature. Although literature provides a vast number of comprehensive and extensive studies and meta-analyses (e.g. Galama and Scholtens (2021), Friede et al., Dixon-Fowler et al. (2013)) to understand this relation, the effect of sustainable investing on firm performance is still inconclusive. Some studies argue that firms' responsible behavior translates into rewards in the future. El Ghoul et al. (2011) show that firms with better CSR scores exhibit lower equity financing. Fatemi et al. (2018) find that increase in ESG strengths increases firm value. Other rewards can be interpreted as a lower cost of bank loans (Goss and Roberts (2011)) and human capital (Thakor and Bunderson (2021)), a lower tax rate (Huseynov and Klamm (2012)), and higher resilience during an unexpected shock (Lins et al. (2017)). Those works point out that responsible behavior serves as an evolved corpo-

[6]see : Hart and Ahuja (1996); Ferrat (2021); Miah et al. (2021);Galama and Scholtens (2021)

rate strategy to exploit advantages from norm-constrained customers and eventually leads to "doing well by doing good." Researchers have also shown a positive association between firms' environmental performance and their financial performance (e.g. King and Lenox (2001), Wang et al. (2014), Makridou et al. (2019)). On the contrary, some papers take a philanthropic view which states that performing pro-social initiatives in the interest of society or managers forgo profitable projects and results in over investment. Barnea and Rubin (2017) show that instead of being a part of the value-enhancing plan, socially responsible behaviors induce agency costs that destroy shareholder value. Hassel et al. (2005) study the Swedish companies and find that environmental performance has a negative impact on firm value. There are also studies which arrive at neutral effect[7].

If not financial performance, what is driving the firm's socially responsible activities? Huang (2021) conducts a review of meta-analytical studies to understand the motivation for a firm's ESG activities. The paper concludes that it is something other than corporate financial performance that drives the environmentally social behavior of the firm. Riedl and Smeets (2014) find that many investors are attracted to sustainable investing due to humanitarian motives. We provide a new perspective to this debate on firms' sustainable initiatives and firm performance by providing a new variable – scaled profit – to measure the socially responsible behavior of a firm. Differing from the existing literature, we provide both theoretical and empirical analysis supporting our view that firms with high environmental ethics generate higher profits per unit of emission.

Our paper also contributes to the debate on policy remedies to climate change and the effect they have on social welfare and economic activity. Natalia and Reguant (2014) find that emissions costs are almost fully passed on to consumer electricity prices. Recent literature finds environmental regulations to have a costly implication on employment, industrial economic activity, and workforce productivity[8]. A part of this literature focuses on the coordination and implementation problems of these climate policies. Fowlie et al. (2016);

[7]e.g. Konar and Cohen (2001)

[8]For eg. see Ryan (2012);Walker (2011) Walker (2013)

Bushnell et al. (2017); Martin et al. (2014) study the impact of the externalities of the climate policies on welfare and global emission levels. Building on this literature, we propose a differential carbon pricing approach based on the efficiency of emission of the firm. This pricing approach will help the government to route more carbon certificates towards green firms.

The remainder of the paper is as follows. Section 2 describes the theoretical model. Section 3 discusses our data and variable construction. Section 4 presents empirical analysis and results. Section 5 conducts robustness analysis. Section 6 concludes.

2 Theoretical Model

2.1 Scaled profit and environmental ethics

Environmental resources, such as clean air, are limited, and they have a price. Although this price may or may not be an immediate expenditure shown up on firms' balance sheets, it affects firms' decision-making process if they are sensitive to the consequences after the emission. Therefore, firms' profitability hinges upon the trade-off between the reduction of output and environment cost ($C(e_i)$). Following this, we assume that the output is a function of emission, and firms' objective is to maximize the output net of the cost of emission by choosing an emission level e.

$$\begin{aligned} \max_{e} \; Q_i^{free} &= \left\{ s_i f(e) - s_i C(e_i) \right\} \\ C(e_i) &= a_i g(e) \end{aligned} \tag{1}$$

The first component $s_i f(e)$ is the output of firm i with emission level e and asset size s_i (measured in dollars). The second component is the cost of emission $g(e)$ mediated by the firm's environmental ethic a_i. The multiplicative term indicates that the two types of cost, $g(e)$ and a_i, are complementary. We relax the connection between a_i and $g(e)$ to make sure

that firms' environmental ethics is exogenous.

We make assumption 1 to ensure the concavity of the net output.

Assumption 1. *The output $f(e)$ is concave in emission and $f(0) = 0$. The cost of emission $g(e)$ is convex in emission and $g(0) = 0$.*

The maximization leads to the first-order condition (primes denote first derivatives),

$$f^{'}(e) = a_i g^{'}(e) \tag{2}$$

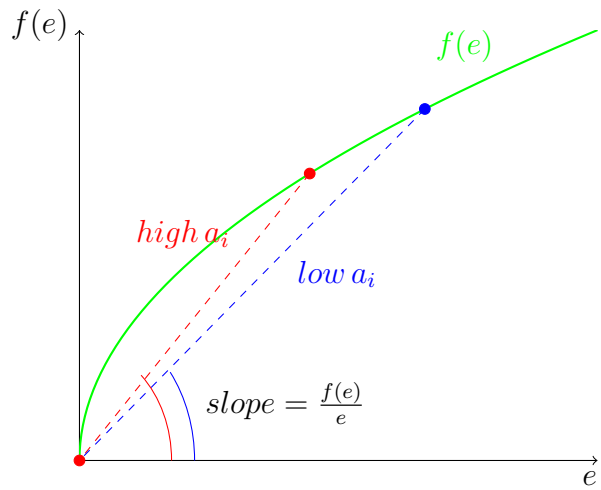
To simplify the model, we abstract from the possible nonlinear nature of the cost of emission and assume that $g(e) = e$, which means the emission cost linearly increases in the emission. Suppose e_b^* and e_b^* are the optimal emission levels for the green and brown firms. Then the relationship in equation (2) becomes,

$$f^{'}(e_i^*) = a_i \tag{3}$$

A firm's marginal output should equal environmental awareness to achieve optimal emission. Together with assumption 1, equation (3) shows that the optimal emission level of firms with high environmental ethics is lower than firms with low environmental ethics. Figure 1 shows these results. In Figure 1, the green line is the output function $f(e)$ and the slope of dashed line represents the marginal output $\frac{f(e)}{e}$. The slope of tangent lines passing through points on $f(e)$ is the environmental awareness. We can find that the slopes of the tangent line and the line connecting the origin and points on $f(e)$ both decrease with e. That is, a high environmental ethic leads to fewer emissions and high marginal output.

Environmentally-conscious firms (green firms) emit less because the same amount of emission costs them more than the less conscious firms (brown firms). Furthermore, the marginal output, which is the output per unit of emission, is higher for green firms and lower for brown firms.

Figure 1: Output and Emission Level



Those arguments lead to our first hypothesis:

Hypothesis 1. *Firms with high environmental ethics have higher marginal output than firms with low environmental ethics.*

2.2 Carbon Pricing

There are variety of market-based approaches to price carbon. Cap-and-trade is one of the most prevalent carbon pricing strategies being used in the U.S. and worldwide. Cap-and-trade functions in a way that the government sets an upper limit on emissions and distributes carbon allowances equal to the emission cap given to firms. Firms trade allowances with each other with a price determined by market supply and demand of allowances. First introduced in the European union in 2005, cap-and-trade is adopted by Australia, New Zealand, South Korea, Canada (Quebec and Ontario), Mexico (pilot program in 2020), and China (regional program). In the U.S., 11 eastern states known as Regional Greenhouse Gas Initiative (RGGI)[9] and California[10] implement the cap and trade carbon pricing mechanism.

We frame our model in the existing cap and trade scheme[11] and discuss the social welfare

[9] `https://www.rggi.org/program-overview-and-design/elements`

[10] `https://www.c2es.org/content/california-cap-and-trade/`

[11] We note two points about our simplified cap-and-trade framework. First, we assume firms receive equal free carbon allowances. We show in equation (8) that the results do not depend on the initial allocation

in two types of carbon pricing framework: (1) the existing uniform carbon pricing, and (2) a proposed productivity-based carbon pricing.

2.2.1 Government's Objective

We consider an economy with two firms, one green firm and one brown firm. We assume the objective of the government is to maximize the overall output net of the environmental cost faced by the two firms and the emission-related disutility faced by the public, given a carbon cap ($\overline{E}$).

$$\begin{aligned} V(\overline{E}) = \sum_{i \in \{g,b\}} \left\{ s_i[f(e_i) - C(e_i)] - D(e_i) \right\} \\ s.t. \sum_{i \in \{g,b\}} e_i = \overline{E} \end{aligned} \tag{4}$$

We make assumption 2 to incorporate the notion that balanced emission combinations are less toxic than unbalanced emission combinations. It indicates that the public experiences less disutility from the average of two emission levels.

Assumption 2. *The disutility $D(e_i)$ is convex in the emission e_i and $D(e_i)$ is non-negative.*

The first-order condition for the social optimum is given by

$$f_i' = a_i + \frac{D_i' + \lambda}{s_i} \tag{5}$$

where λ is the Lagrange multiplier on the emission constraint. It indicates that for each firm, the marginal output should be equivalent to the sum of environmental ethics and the proportion of the marginal damage resulting from emission and the shadow value of the emission constraint in asset size. Any regulations that can help achieve this allocation as shown in equation (5) is economically efficient.

allowance. Second, we assume firms face the same carbon price in the market. It fits our setting of a two-firm economy, which means only one unique market price in the equilibrium.

2.2.2 Uniform Carbon Pricing

Assumption 3. *The government sets the carbon cap $2\overline{e}$ (equals $\overline{E}$), which is lower than the aggregate emission of firms without being charged on emissions ($2\overline{e} < e_g^* + e_b^*$, where e_g^* and e_b^* are the optimal emission levels for the green and brown firms without facing any emission charges). Firms face the same carbon price δ. The green and the brown firms' optimal emission levels and corresponding marginal outputs are e_g', e_b', $f'(e_g')$, and $f'(e_b')$, respectively.*

If we integrate the cap-and-trade scheme into the model, then firms' cost function becomes,

$$s_i a_i g(e_i) + \delta(e_i - \overline{e}) \tag{6}$$

the objective of firms is to choose an emission level to maximize the net output,

$$Q_i^{uni} = \left\{ s_i f(e_i) - s_i a_i g(e_i) - \delta(e_i - \overline{e}) \right\} \tag{7}$$

the first order condition is,

$$s_i[f'(e_i) - a_i g'(e_i)] = \delta \tag{8}$$

It indicates that the marginal profit, which is the difference between the marginal output and the internal marginal cost of emission, equals the price of a carbon certificate. In our simplified model, equation 8 is $s_i[f'(e_i) - a_i] = \delta$. This condition states that firms with a certain level of environmental consciousness reduce emissions to the point where the marginal profit equals the market value of the emission, δ. When the marginal profit is greater than the marginal cost of additional emissions, firms will emit more than they are allowed to and fund the additional emissions through purchasing.

Moreover, equation (8), together with assumption 1, illustrates that the government can reduce any amount of emissions by adjusting the market price of allowance δ. If the optimal emission levels for the green and brown firms without charge on emissions are e_g^*

and e_b^*, respectively. Given the carbon cap is $2\overline{e}$, a reduction in carbon emissions by ΔE ($\Delta E = e_g^* + e_b^* - 2\overline{e}$) is concave in the uniform carbon price δ.

Panel A of Figure 2 plots the optimal emission of each firm and the allowance trade mechanism. By decreasing emissions from e_g^* and e_b^* to respective e_g' and e_b', the green and brown firms achieve a higher marginal output by $\frac{\delta}{s_i}$ to meet the optimal condition. The emission reduction would be less for the green firm than for the brown firm because the green firm has higher marginal output to absorb the increasing cost of emission.

We make assumption 4 to satisfy the demand-supply condition.

Assumption 4. *The market is cleared of all allowances, and the green (brown) firm is the net seller (buyer).*

To reach the social optimum in equation (5), firms need to choose an emission level that satisfy the following condition.

$$a_i + \frac{\delta}{s_i} = a_i + \frac{D_i^{'} + \lambda}{s_i} \tag{9}$$

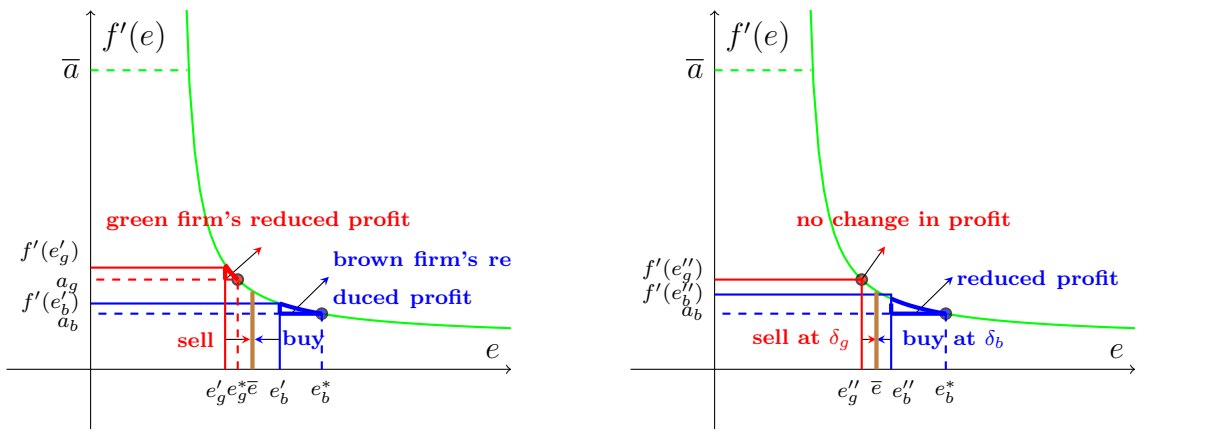
That is, δ needs to equal $D_i^{'} + \lambda$ for each firm. It means that the cost of emission has to be proportional to firms' marginal environmental impact. The condition indicates that the carbon price should reflect the efficiency of output and be lower for productive firms. (assumption 2)

Equation 8 suggests that the initial allowance allocation has no impact on firm decisions. Our model indicates the price channel, rather than the initial allowance allocation channel through which the government can improve the social welfare, as we consider next.

2.2.3 Marginal Output-Based Carbon Pricing

As mentioned in section *2.2.2*, the carbon price should reveal firms' marginal output. (assumption 5) We make an extreme case to help us understand the differential pricing mechanism. (assumption 6)

Figure 2: Marginal Output and Emission under Government Intervention



(A) Uniform Pricing on Carbon Emission **(B)** Scaled-Profit based Pricing on Carbon Emission

Assumption 5. *Under the marginal output-based carbon pricing, the carbon price δ decreases in marginal output $\frac{f(e)}{e}$. The green and brown firms' optimum emission levels and marginal outputs are e''_g, e''_b, $f'(e''_g)$, and $f'(e''_b)$ respectively. The difference in the optimal emission levels between two pricing schemes is Δe ($\Delta e = e''_g - e'_g$) for green firm, and $-\Delta e$ for the brown firm.*

Assumption 6. *The green firm's marginal output is so high that the carbon price for the green firm approximates to zero, $\delta_g \to 0$. The brown firm is charged a price, δ_b.*

Since it is costless for the green firm to emit, the optimal emission for the green firm is that in which the marginal output equals the environmental awareness, i.e. $e''_g = e^*_g$ referring to equation 3. The brown firm is disciplined to emit the remaining carbon budget $e''_b = 2\overline{e} - e''_g$ by being charged at a higher price for buying allowances.

According to equation 7, compared to being under the uniform carbon pricing, the

changes in net outputs for the green and brown firms under the differential pricing,

$$\begin{gathered}\Delta Q_g = Q(e_g) - Q(e'_g) = \\ \{s_g f(e_g) - s_g a_g g(e_g)\} - \{s_g f(e''_g) - s_g a_g g(e''_g) - \delta(e'_g - \overline{e})\} \\ \Delta Q_b = Q(e''_b) - Q(e'_b) = \\ \{s_b f(e''_b) - s_b a_b g(e''_b) - \delta(e''_b - \overline{e})\} - \{s_b f(e'_b) - s_b a_b g(e'_b) - \delta(e'_b - \overline{e})\}\end{gathered} \tag{10}$$

Plug in the optimum solutions in equation 3 and 8, we rearrange equation 10 and get the following results.

$$\begin{gathered}\Delta Q_g = s_g[f(e_g) - f(e''_g)] - s_g[f'(e''_g) - f'(e_g)] + \delta(e'_g - \overline{e}) \\ \Delta Q_b = s_b[f(e''_b) - f(e'_b)] - s_b[f'(e''_b) - f'(e'_b)] + \delta(e'_b - \overline{e}) - \delta_b(e''_b - \overline{e})\end{gathered} \tag{11}$$

Equation 11 suggests that the change in profits of the green (brown) firm comes from three parts: the increased (decreased) output, the decreased (increased) marginal output, and the loss of selling (buying) carbon allowances.

The third term, changes in returns of trading carbon allowances, is always negative for the green firm. Under a differential pricing scheme, the green firm is indifferent to buying extra allowances to emit more and selling more than needed allowances to earn credit. Unlike in the uniform carbon pricing scheme (assumption 5), the green firm loses the earning from selling additional allowances in the differential pricing framework. The new pricing scheme transfers part of the green firm's earnings from trading allowances to society.

Panel B of Figure 2 shows these results. The area enclosed in the blue frame represents the brown firm's reduced profit and is larger than the corresponding area in panel A of Figure 2. The change in the total profit is the difference between the sum of areas enclosed in red and blue frames.

Now, let us consider the change in social welfare. We plug the optimal emissions for the green and brown firms under two carbon pricing schemes into equation 4 and get the

following equation (the subscript "eff" and "uni" denote efficiency-based and uniform carbon pricing schemes).

$$
\begin{aligned}
V_{eff} - V_{uni} &= \sum_{i\in\{g,b\}} \left\{ s_i[f(e_i'') - C(e_i'')] - D(e_i'') \right\} - \sum_{i\in\{g,b\}} \left\{ s_i[f(e_i') - C(e_i')] - D(e_i') \right\} \\
&= \underbrace{\left[s_g \int_{e_g'}^{e_g} f'(e)de - s_b \int_{e_b''}^{e_b'} f'(e)de \right]}_{\text{production gain}} - \underbrace{\left[s_g a_g(e_g - e_g') - s_b a_b(e_b' - e_b'') - \delta\Delta E + \delta_b(e_b'' - \overline{e}) \right]}_{\text{social cost from firms' environmental cost}} \\
&\quad - \underbrace{[D(e_g) + D(e_b'') - D(e_g') - D(e_b')]}_{\text{disutility}}
\end{aligned}
\tag{12}
$$

Suppose the output function is $\theta log(e+1)$, where θ measures the business environment. We denote the increase (decrease) in carbon emission for the green (brown) firm compared to uniform carbon pricing as Δe. We replace the output in equation 12 and rearrange it to get the equation 13:

$$
\begin{aligned}
V_{eff} - V_{uni} &= \underbrace{\left[\theta log\left[1 + \frac{\Delta e}{e_g'}\right]^{s_g} \left[1 - \frac{\Delta e}{e_b'}\right]^{s_b} \right]}_{\text{output gain}} - \underbrace{[\Delta e(s_g a_g - s_b a_b) - \delta\Delta E + \delta_b(e_b' - \Delta e - \overline{e}))]}_{\text{social cost from firms' environmental cost}} \\
&\quad - \underbrace{\Delta D(\overline{E})}_{disutility}
\end{aligned}
\tag{13}
$$

The first term is the"output gain": since the green firm is allowed to produce free of charge until reaching its optimal output level, its output is greater than the one under which it is charged for extra emission. The output gain is an increasing function of Δe. The intuition is that the benefit of free emission for the green firm is larger when the uniform carbon price is high.

The second term is the "social cost" from firms' environmental costs: the green firm has to bear greater emission costs when privileged to emit without charge. The social costs increase in Δe. A greater emission "recovery", the difference between the two optimal emission levels for the green firm under two pricing strategies, adds value to the efficiency-based pricing.

The green firm passes intrinsically costly carbon emissions on to the brown firm that bears the less expensive marginal cost of emissions.

The third term is the "social cost" from the change in disutility. Given the same carbon cap $\overline{E}$ under two pricing schemes, the disutility decreases (assumption 2).

Take the first derivative of equation (13) with respect to Δe, we get

$$\frac{\partial[V_{eff} - V_{uni}]}{\partial \Delta e} = [\frac{s_g}{e_g^*} - \frac{s_b}{e_b''}] - (s_g a_g - s_b a_b - \delta_b) - D'(\overline{E}) \tag{14}$$

If two firms are of same size (s) and the marginal disutility is negligible, equation (14) can be written as

$$\frac{\partial[V_{eff} - V_{uni}]}{\partial \Delta e} = s(\frac{1}{e_g^*} - \frac{1}{e_b''}) - s[f'(e_g^*) - f'(e_b'')]$$

The equation above shows that the marginal value of switching to efficiency-based carbon pricing depends on how efficient the green firm is in emission and production compared to the brown firm. When the green firm has very high environmental ethics, which means the green firm emits and produces exceedingly efficiently, the gain in social value (equation 13) of shifting to differential carbon pricing increases in the green firm's reduced emission, Δe. Since Δe is proportional to the total emission reduction, ΔE, we have our second hypothesis:

Hypothesis 2. *When firms are of similar size and when there are "super green" firms that have high marginal output, switching from uniform carbon pricing to efficiency-based carbon pricing adds value. Moreover, the added value increases in the emission reduction target set by the government.*

We do not take the proceeds from trading carbon allowances into account because the trading mechanism suggests that the government facilitates the transactions between firms. Thus, the government will invest the revenue from selling sustainable projects. Similar to the California carbon auction scheme, the differential pricing setting shifts wealth from firms, especially the less efficient firms, or brown firms in our context, to the society given a particular carbon footprint.

3 Data and Variables

To examine the relationship between firms' environmental ethics and profits, we use data from multiple sources for the sample period between 2001-2020.[12] We deliberately choose the sample period starting from 2001 to remove the correlation with our main variable of interest, the green index, which is constructed using information during 1995 and 2000. We elaborate more on the green index in 'Section 3.1'. We extract yearly facility-level greenhouse gas emission data from the Clean Air Markets Division (CAMD) of the Environmental Protection Agency (EPA) to measure firms' pollution. The emission data covers electricity generating units with a capacity greater than 25 megawatts; therefore, the sample encompasses companies in industries, such as utilities (NAICS 2211), mining (NAICS 2122), petroleum, and petroleum products merchant wholesalers (NAICS 4247), etc. The CAMD documents three air pollutants, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), and carbon dioxide (CO_2), in carbon dioxide equivalent short tons and we sum up three emissions to compute the facility-level emission.[13]

We supplement emission data with facilities' owner and operator information in a separate file from the CAMD and manually check the historical ownership (parent company) through 10-K filings and Google search. We eliminate observations that never show up in any searchable documents and merge the remaining data with financial statistics from Compustat.

Our final sample has 6,460 facility-year observations for 400 facilities and 793 company-year observations for 53 firms over the period 2001-2020.

[12] The earliest Air Markets Program Data available on the EPA website is from 1995.

[13] According to the EPA data guide, CAMD's Power Sector Emission Data report approximately 96% of the fossil fuel generation in the U.S. in 2018. Apart from the three air pollutants mentioned above, electricity generating units began reporting mercury emissions to EPA between 2015 and 2017. For the consideration of consistency and comparability, we do not include mercury in the pollution calculation.

3.1 Measure of Firms' Environmental Ethics

Socially responsible investing, also called ethical or sustainable investing, is an investment strategy that aims to bring both social change and financial returns for an investor. Corporations are moving towards corporate sustainability. The academic interest has emerged following the rapid growth of socially responsible investing. Although a growing number of investors use SRI screening, there is no perfect standardized methodology that is used to evaluate and screen corporations. This paper focuses on the environmental dimension of sustainable investing, which we refer to as 'environmental ethics.'

The most commonly used measure of firms' environmental performance is the "E" pillar in ESG ratings from MSCI and Refinitiv that utilize a wide array of criteria to evaluate a company's "strengths" and "weaknesses" in dealing with environmental issues.[14] However, these ratings suffer from the concern that the composition of the indicators changes over time hence the aggregate score captures different perspectives of firms' environmental efforts and is not directly comparable in different periods.[15] Moreover, firms are incentivized to inflate ESG ratings to increase reputation, attract investors, and avoid regulatory scrutiny, leading to positive biases in the measure[16].

To mitigate the concerns, we construct a variable called *green index* as a proxy for firms' environmental ethics. Green Index is a time-invariant variable constructed in two steps. We establish a dictionary (provided in the Appendix) including 56 environment-related keywords following the work of Henry et al. (2021)[17]. Then we scrape firms' earliest 10-K filings between 1995 and 2000 for our dictionary of the environmental keywords and calculate the frequency as the ratio of the number of sentences that contain keywords to the total number of sentences. For example, if the first 10-K filing of company Z in the time window of 1995-2000 is in 1996, we use 10-K in 1996 to scrape words and calculate the

[14]see Liang and Renneboog (2017); Daugaard (2019).

[15]see Dorfleitner et al. (2015); Escrig-Olmedo et al. (2019)

[16]see Tang et al. (2021); https://www.marketwatch.com/story/this-is-what-youre-getting-wrong-about-esg-ratings-11644938978

[17]We read through some 10-Ks and drop keywords that are likely to appear in the irrelevant context.

frequency. We remove observations that do not have 10-K filings in this period because it is difficult to evaluate their environmental ethics and compute a comparable value to the frequency-based green index. The green index is a continuous variable between 0 and 1, with a larger value indicating higher environmental ethics.

Similar to Eccles et al. (2012) identification of high sustainability firms, we argue that when subject to relatively lax scrutiny, paying attention to environmental issues is more like a voluntary choice that reflects corporate culture and belief. Therefore, it is unlikely that the environmental attitude is correlated with profits or other firm characteristics or is pressured by forces outside. We thus choose the time period between 1995-2000 to construct our green index to relieve the endogeneity concern.

3.2 Dependent Variables

As our main dependent variable, we use "scaled_profit", the ratio of gross profit to the total greenhouse gas emission in short tons. We take net income, EBIT, and EBITDA as alternative measures of profit for the robustness check. In the facility-level analysis, we equally divide the parent firm's profit among all facilities on a yearly basis following Shive and Forster (2020). To handle large outliers, we winsorize our dependent scaled_profit variable at 2.5% and 97.5% in all analyses.

3.3 Control Variables

Following prior literature, we control for a set of firm characteristics that are known to affect profit, emission, and scaled profit (Xu and Kim (2022); Bartram et al. (2021)). Specifically, we control for firm size using the natural logarithm of total assets; leverage, which is the ratio of total debt to total assets and and Tobin' Q which is calculated as total assets less cash equivalent plus market equity divided by total assets to control for firms' growth and financial position. We also include capital intensity, the ratio of property, plant and equipment to the total asset to control the impact of total capital investment on our dependent variable.

4 Empirical Analyses and Results

4.1 Firms' Environmental Ethics and Emission

Higher environmental ethics calls for lower pollution emissions by firms. We examine this by studying the impact of firms' environmental ethics on emission level using a set of OLS regressions (model presented in equation (15)). The dependent variable is the absolute greenhouse gas emission in billions of short tons in year t, and the primary independent variable is the green index. For our sample, we find that the green index variable is right-skewed and thus, we log transform the green index to make it normal to maintain the statistical validity of our regression results. We include the year and industry fixed-effects to condition out time-invariant factors across time and industries trends and double cluster our errors at the firm and year level.

$$Emissions_{it} = \beta_0 + \beta_1 * ln(green_index_i) + controls_{it} + \epsilon_{it} \tag{15}$$

Table 2 tabulates the results with facility-level results presented in Column 1. It shows that the coefficient on the green index is insignificant, suggesting that firms' environmental ethics cannot predict their emission levels. In Column 2 of Table 2, we aggregate the emission at the parent level and repeat the regressions. We find that the emission is positively related to the green index, and the coefficient is statistically significant at the 1% level. The positive coefficient on the green index indicates that higher environmental ethics is associated with more emissions.

The interpretation of results is twofold. First, the inconsistency of the impact of environmental ethics on facility- and parent-level emissions indicate that environmentally conscious firms do not reduce emission uniformly across facilities. Second, by measuring the absolute emission, firms with high environmental ethics break the promise and emit more pollution. The results seem to be unsound and require further investigation.

4.2 Firms' Environmental Ethics and Scaled Profit

An alternative explanation of the positive relationship between the green index and the emission level is that, though firms care about the environment emit more, they produce more efficiently and generate a higher profit per unit of emission. From a social welfare perspective, sustainability and productivity both matter in the way that the total economic output needs to be maximized under a particular carbon emission constraint. As discussed in Section 2.1, we propose a new approach to test this relationship between firms' environmental ethics and emission by investigating the relationship between firms' environmental ethics and scaled profit. We replace the dependent variable with "scaled_profit" and repeat the regression in equation (15) and thus test our first hypothesis.

Table 3 presents the result of facility-level regression for four measures of profit: net income, gross profit, EBIT, and EBITDA measured in 000s of USD. The facility-level emission scales all profit-related items. The coefficient on the green index is positive and statistically significant at the 1% level across four measures and is consistent with Hypothesis 1. The results show that firms with high environmental ethics are more likely to earn a greater profit per unit of emission. The magnitude of the coefficient on the log of the green index, which represents the incremental effect of environmental consciousness on profit per unit of emission, is 0.321-1.22. That is, an increase in environmental ethics by 10% is associated with an increase in profit per unit on an average of $84. This is equivalent to an increase of 184.8 million US dollars for our sample's average emission of 2.2 million short tons.

Table 4 shows the estimates of parent-level regression. The coefficient on the green index continues to be positive and have statistical significant at the 1% level for scaled EBIT, indicating that highly conscious firms emit less for the same profitability level than firms with low environmental consciousness[18].

These results, combined with the results from environmental ethics and emission analysis

[18]We run the parent level regression trimming at top 5% (excluding 3 parent firms) and find our results to be positive and have higher economic significance. The result is tabulated in Appendix A2

in *4.1*, indicate that solely focusing on the absolute emission cannot justify a firm's environmental impact because it requires less emission to keep the same profitability for firms with high environmental ethics than firms with low environmental ethics.

5 Robustness

5.1 S&P 500 Companies

Since the emission data from CAMD focus primarily on industries that produce electricity (SIC two-digit Code 29 and 49), our results may be susceptible to unobserved characteristics shared by those industries. To prove that the results can shed light on other industries, we broaden the sample to S&P 500 companies that operate in SIC two-digit Codes 01-49. Basically, we exclude finance, insurance, real estate, services, retail trade, and wholesale trade. The rationale is that the business model of those firms is fundamentally different from that of firms in our sample as their profit-making businesses do not require the intake of carbon (emission). Therefore, we should not expect a finance firm's output function to be the same as a utility firm's, which contradicts the critical assumption in the model.

We extract the carbon emission of S&P 500 firms from Thomson Reuters Eikon database. The Eikon database either collects or projects the CO_2 emissions depending on whether firms self-report the data.[19] Figure 3 depicts the industry share of carbon emission for industries whose carbon contribution is larger than 4% from 2002 and 2020.[20] These polluting industries account for more than 75% of total emissions for S&P 500 firms. Moreover, two sectors, the electric, gas, and sanitary services and petroleum refining and related industries, generate the largest two shares totaling 67.53%-88.46% of the total emission. Figure 4 shows the total

[19]If a company has not reported its CO_2, a series of models will be triggered sequentially. Among 4,680 firm-year observations, 16.28% and 2.44% of them are estimated using Median model ad Energy model, respectively. The methodology is described on the website `https://www.refinitiv.com/content/dam/marketing/en_us/documents/fact-sheets/esg-carbon-data-estimate-models-fact-sheet.pdf`.

[20]We eliminate the year 2001 because very few firms reported emission. Additionally, the Eikon database cannot properly project emission because 2001 is the earliest year in the database, and no preceding data are fed into projection models.

emission trend and the top two polluting industries' emissions, represented by respective green and maroon lines. We can find that the changes in total emission are almost fully driven by the changes in the top two industries' emissions. Taken together, these two plots indicate that even for firms that consider carbon as one of the inputs in their output function, their sensitivity of carbon intake to profit, or the cost of emission in our model, differs considerably from firms operated in electric, gas, and petroleum refining industries.

To spot the marginal effect of environmental awareness of top polluting industries (refer to electric, gas, and petroleum refining industries thereafter for brevity), we create a "polluter" dummy that takes value one if firms' SIC is 29 or 49 and zero for others. We interact the dummy with the green index and report the result in Table 5. The coefficient on the green index is negative and statistically significant across four scaled profit measures, suggesting that higher environmental ethics relates to a lower scaled profit. However, the coefficient on the interaction term is positive and statistically significant. It means that compared to other firms, firms in polluting industries obtain a higher profit per unit of waste for an increase in environmental awareness.

5.2 Enforcement Variable as a Proxy for Environmental Ethics

An environmentally-aware firm will work towards being environmentally compliant and should thus have fewer environment-related violations. U.S. EPA Enforcement and Compliance History Online(ECHO) website provides data on environmental enforcement actions. Specifically, we use Federal Enforcement and Compliance (FE&C) data from the Integrated Compliance Information System (ICS) database. A facility is issued enforcement for violation on one of the eight environmental acts, including the Clean Water Act, the Clean Air Act, the Comprehensive Environmental Recovery and Liability Act, and the Resource Conservation and Recovery Act. We merge the data with our sample of facilities from the CAMD database.

We calculate the number of violations combined at the parent level per year from 2001-

2020 to obtain the 'cases per year' variable. We perform regression of equation (15) with Cases per year as the primary independent variable in place of the green index. The results are reported in Table 6. As conjectured, we see a negative relationship between enforcement cases and scaled profit. We do not find significance due to the small sample size and scanty matching between the two databases. Our results suggest that firms with higher number of violations have reduced environmental efficiency of profit.[21]

6 Conclusion

We develop a model of firms' optimal output-emission where firms make a trade-off between high output and high cost of emissions. Heterogeneity of environmental ethics may act as a moderating device in internalizing the optimal output-emission level. After controlling for asset size, we show that environmentally-conscious firms ("green firms") susceptible to intrinsically costly pollution emit less and maintain high marginal output than firms with low environmental ethics ("brown firms"). To support the theory, we provide empirical evidence in which we identify the positive relationship between firms' environmental ethics and their marginal output measured by the profit scaled by the emission.

Meanwhile, we attempt to furnish policymakers and the public with a new theoretical and empirical baseline for understanding firms' emission behavior and its respective social welfare impact. We show that incorporating the concept of scaled profit into carbon pricing incentivizes the green firm to consume rather than sell extra carbon certificates, creating more value in terms of higher output. Using efficiency-based carbon pricing as an instrument, the government serves as an intermediary to channel more carbon certificates toward the green firm. Simply put, firms compete for scarce carbon resources, and regulators distinguish green firms from brown firms according to their efficiency of emission and allocate carbon allowances across firms.

[21] We also have regressed scaled profit with time invariant enforcement variable equal to total cases for each firm upto year 2000 and the results are consistent.

The implications are threefold. First, our model sheds light on firms' "doing well by doing good" showing that environmental ethics generate a trade-off and discipline firms' profit-oriented behavior. Second, the model suggests that the efficiency of emission, namely the scaled profit, is a function of firms' environmental consciousness and is worth attention in market regulation and policy design. Lastly, society would benefit if policymakers could configure scaled profit for pricing carbon.

Our model opens avenues for future research. For example, we focus on firms with the same sensitivity of output to carbon. The simplified setting may not be the case as firms in the same industry could have different sensitivities. There is also a rich exploration of the dynamics and strength of environmental ethics. What if the environmental ethic is evolving and many factors such as the market competition, shareholder activism, management change, and the organizational structure change play roles in determining the optimal output-emission level? How do these factors change the social optimum accordingly, and under what circumstances?

Tables

Table 1: Summary statistics

This table represents the summary statistics for parent firms in our sample. 'Leverage' is defined as ratio of the total debt to the total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Facilities per firm' denotes the number of facilities for each firm in each year. 'Green index' is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics. Total emissions are measured in millions of short tons of CO_2 equivalent. 'Total Assets', 'Net income' and 'Gross Profits' are the firms total assets measured in million USD.

Variable	**Observations**	**Mean**	**Std.Dev.**	**Median**
Total Assets	776	20102.5	20262.48	12714.60
Leverage	789	0.39	0.12	0.36
Capital Intensity	789	0.68	0.12	0.70
Tobin Q	614	1.21	0.16	1.19
Net Income	790	483.11	899.56	301.50
Gross Profit	790	1764.03	1664.407	1132.404
Total Emissions	793	15.14	23.24	4.52
Facilities per firm	793	6.81	8.39	3
Green Index	793	0.028	0.013	0.025

Table 2: Green Index and Emission

This table presents a set of OLS regressions performed on our sample of annual data of companies from EPA's CAMD database for a period between 2001-2020. The dependent variable is the absolute greenhouse gas emissions in billions of short ton of CO_2 equivalent. The primary predictor variable is log of green index. Green index is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics. Column (1) tabulates the results for facility level data. Column (2) presents the results for regressions at parent level. 'Leverage' is defined as ratio of the total debt to the total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Standard errors, clustered by firm and year for facility level and robust for parent level are shown in parentheses.

	Facility Level	Parent Level
	(1)	(2)
Ln(Green Index)	-0.000	0.006**
	(0.000)	(0.003)
Leverage	0.001**	0.022**
	(0.000)	(0.009)
Ln (Asset Facility)	0.000***	
	(0.000)	
Ln (Asset Parent)		0.018***
		(0.001)
Tobin Q	0.000	0.002
	(0.000)	(0.005)
Capital Intensity	-0.003***	0.078***
	(0.001)	(0.012)
Constant	0.001*	-0.177***
	(0.001)	(0.015)
Observations	5,855	598
R- squared	0.068	0.459
Time FE	YES	YES
Industry FE	YES	YES

Table 3: Environmental Awareness and Scaled Profit (Facility Level)

This table presents a set of OLS regressions performed on our facility level sample of annual data of facilities from EPA's CAMD database for a period between 2001-2020. The dependent variable is scaled_profit defined as the ratio of profit in 000s USD to absolute greenhouse gas emissions in short ton of CO_2 equivalent. The primary predictor variable is log of green index. Green index is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics. Column (1) tabulates the results with gross profit as the profit measure in scaled_profit. Column (2) uses earnings before interest and taxes (EBIT) as the numerator in the dependent variable. Columns (3) & (4) use earnings before interest, taxes, depreciation &amortisation (EBITDA) and net income as the profit measure respectively. 'Leverage' is defined as ratio of the total debt to the total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Standard errors, clustered by firm and year are shown in parentheses.

	Gross Profit (1)	EBIT (2)	EBITDA (3)	Net Income (4)
Ln (Green Index)	1.220***	0.768***	1.220***	0.321***
	(0.329)	(0.198)	(0.329)	(0.091)
Leverage	-10.413***	-6.756***	-10.680***	-3.729***
	(1.823)	(1.080)	(1.833)	(0.560)
Ln (Asset)	1.541***	0.923***	1.554***	0.341***
	(0.247)	(0.146)	(0.249)	(0.069)
Tobin Q	0.678	1.080	0.737	0.938**
	(1.394)	(0.811)	(1.392)	(0.399)
Capital Intensity	1.430	1.075	1.433	1.120*
	(2.045)	(1.189)	(2.042)	(0.571)
Constant	-3.287	-2.644	-3.326	-1.239
	(2.846)	(1.723)	(2.863)	(0.805)
Observations	5,855	5,845	5,849	5,855
R-squared	0.080	0.077	0.077	0.067
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Table 4: Environmental Awareness and Scaled Profit (Company Level)

This table presents a set of OLS regressions performed on our parent level sample of annual data of companies from EPA's CAMD database for a period between 2001-2020. The dependent variable is scaled_profit defined as the ratio of profit in 000s USD to absolute greenhouse gas emissions in short ton of CO_2 equivalent. The primary predictor variable is log of green index. Green index is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics. Column (1) tabulates the results with gross profit as the profit measure in scaled_profit. Column (2) uses earnings before interest and taxes (EBIT) as the numerator in the dependent variable. Columns (3) & (4) use earnings before interest, taxes, depreciation & amortisation (EBITDA) and net income as the profit measure respectively. 'Leverage' is defined as ratio of the total debt to the total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Robust standard errors are shown in parentheses.

	Gross Profit (1)	EBIT (2)	EBITDA (3)	Net Income (4)
Ln (Green Index)	0.526	0.414*	0.523	0.119
	(0.427)	(0.221)	(0.426)	(0.116)
Leverage	-15.833***	-9.712***	-16.152***	-5.118***
	(4.030)	(2.386)	(4.086)	(1.149)
Ln (Asset)	-1.541***	-0.743***	-1.538***	-0.373***
	(0.429)	(0.221)	(0.431)	(0.106)
Tobin Q	3.081*	2.053**	2.964	1.362**
	(1.845)	(1.022)	(1.822)	(0.545)
Capital Intensity	-14.143***	-6.906***	-14.023***	-3.297***
	(4.185)	(2.211)	(4.179)	(1.170)
Constant	30.554***	15.093***	30.730***	7.335***
	(7.620)	(3.906)	(7.664)	(1.989)
Observations	598	594	597	598
R-squared	0.462	0.441	0.432	0.296
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Table 5: S&P 500 Companies

This table presents a set of OLS regressions performed on our sample of annual data of S&P 500 companies for a period between 2001-2020. The dependent variable is scaled_profit defined as the ratio of profit in 000s USD to absolute greenhouse gas emissions in short ton of CO_2 equivalent. The primary predictor variable is log of green index. Green index is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics. Column (1) tabulates the results with gross profit as the profit measure in scaled_profit. Column (2) uses earnings before interest and taxes (EBIT) as the numerator in the dependent variable. Columns (3) & (4) use earnings before interest, taxes, depreciation & amortisation (EBITDA) and net income as the profit measure respectively. 'Leverage' is defined as ratio of the total debt to the total assets. 'Polluter' is a dummy variable which takes a value of '1' for firms with two digit SIC as 29 or 49 and '0'otherwise. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Robust standard errors are shown in parentheses.

	Gross Profit	EBITDA	EBIT	Net Income
	(1)	(2)	(3)	(4)
Green Index	-0.25^{***}	-0.10^{***}	-0.08^{***}	-0.04^{***}
	(0.04)	(0.02)	(0.02)	(0.01)
Green Index$\times$*Polluter*	0.26^{***}	0.11^{***}	0.08^{***}	0.05^{**}
	(0.06)	(0.03)	(0.02)	(0.02)
Ln(Asset)	0.0005	0.0004^{***}	0.0002	0.0002^{**}
	(0.0003)	(0.0001)	(0.0001)	(0.0001)
Leverage	-0.004^{*}	-0.001	-0.001	-0.003^{***}
	(0.002)	(0.001)	(0.001)	(0.001)
Capital Intensity	-0.03^{***}	-0.01^{***}	-0.01^{***}	-0.01^{***}
	(0.003)	(0.001)	(0.001)	(0.001)
Tobin Q	0.002^{***}	0.001^{***}	0.001^{***}	0.001^{***}
	(0.0002)	(0.0001)	(0.0001)	(0.0001)
Constant	0.01^{**}	0.003	0.004^{**}	0.001
	(0.005)	(0.002)	(0.002)	(0.001)
Observations	2,124	2,124	2,124	2,124
R^2	0.52	0.50	0.48	0.38
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Table 6: Environmental Awareness and Enforcement Cases

This table presents a set of OLS regressions performed on our parent level sample of annual data of companies from EPA's CAMD database for a period between 2001-2020. The dependent variable is scaled_profit defined as the ratio of profit in 000s USD to absolute greenhouse gas emissions in short ton of CO_2 equivalent. The primary predictor variable is cases per year which is defined as the total number of violations at parent level per year reported by Federal Enforcement and Compliance (FE&C). Column (1) tabulates the results with gross profit as the profit measure in scaled_profit. Column (2) uses earnings before interest and taxes (EBIT) as the numerator in the dependent variable. Columns (3) & (4) use earnings before interest, taxes, depreciation & amortisation (EBITDA) and net income as the profit measure respectively. 'Leverage' is defined as ratio of the total debt to the total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Robust standard errors are shown in parentheses.

	Gross Profit (1)	EBIT (2)	EBITDA (3)	Net Income (4)
Cases per year	-0.403*	-0.183	-0.397*	-0.080
	(0.242)	(0.136)	(0.241)	(0.067)
Leverage	-15.791***	-9.722***	-16.107***	-5.111***
	(4.018)	(2.377)	(4.074)	(1.147)
Ln (Asset)	-1.568***	-0.771***	-1.565***	-0.380***
	(0.447)	(0.234)	(0.449)	(0.109)
Tobin Q	2.804	1.824*	2.688	1.298**
	(1.797)	(1.002)	(1.773)	(0.533)
Capital Intensity	-14.867***	-7.417***	-14.741***	-3.458***
	(4.217)	(2.239)	(4.212)	(1.159)
Constant	29.689***	14.459***	29.867***	7.144***
	(7.418)	(3.777)	(7.463)	(1.960)
Observations	598	594	597	598
R-squared	0.46	0.44	0.43	0.30
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

Figure 3: Large Polluting Industries (> 4% Total Emissions)

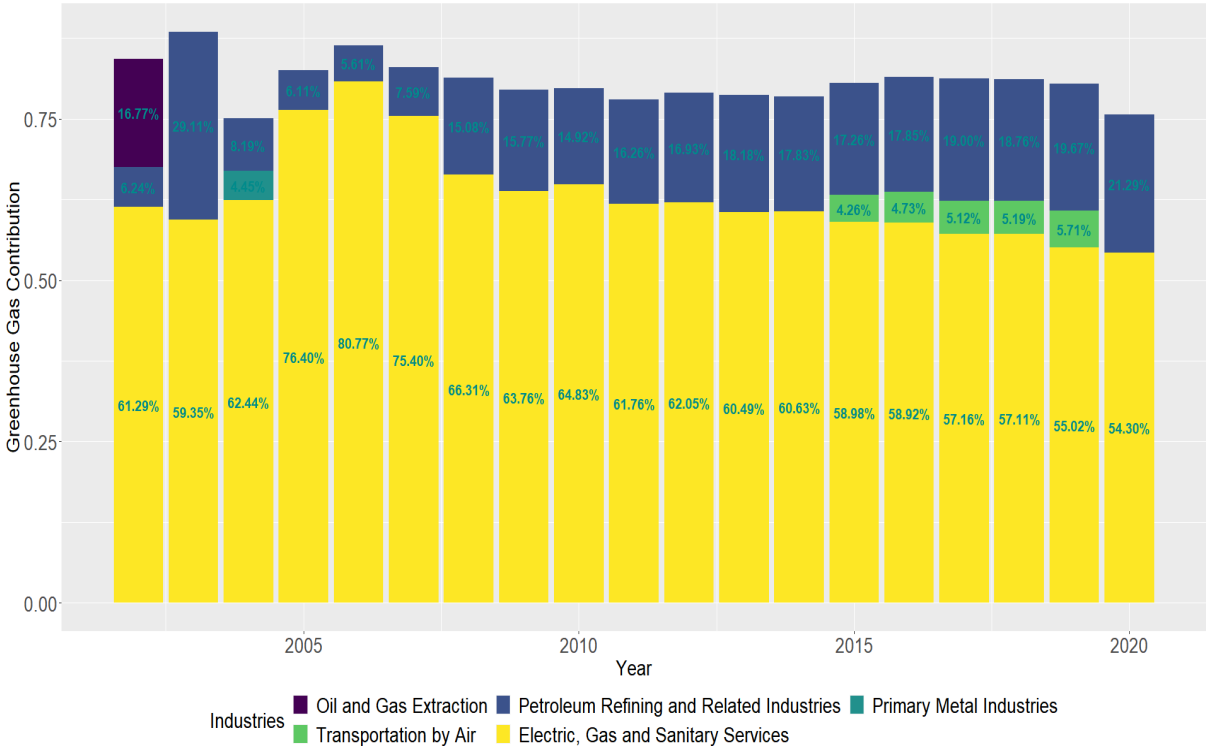
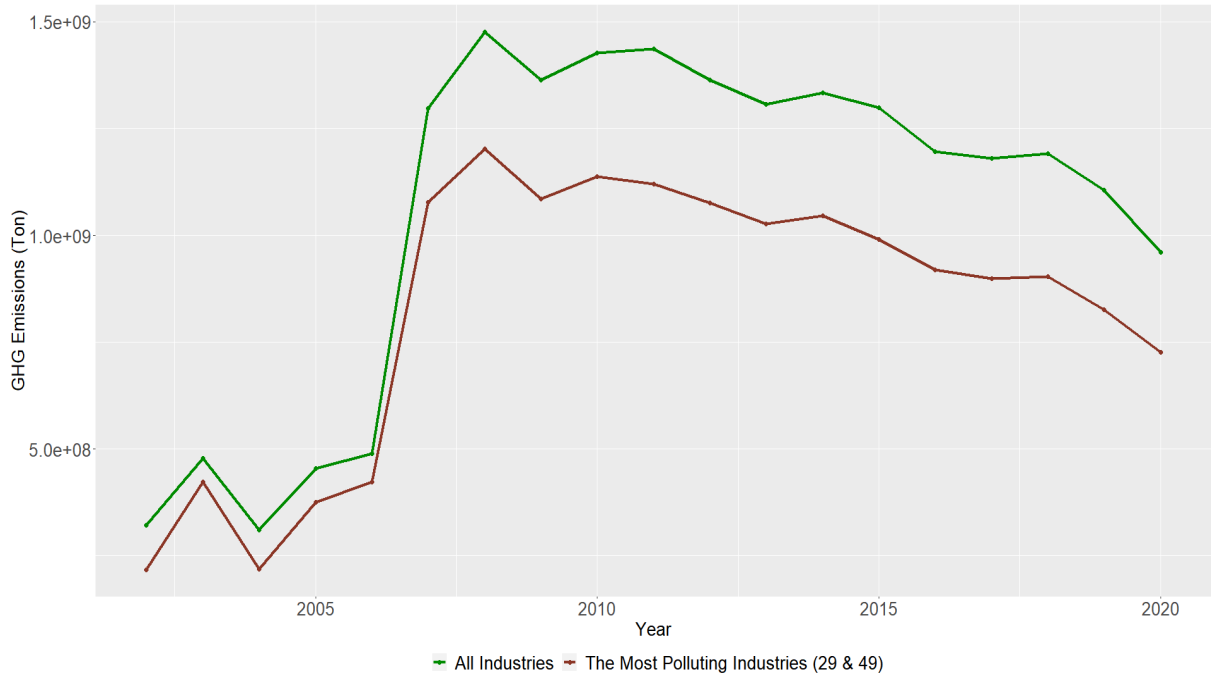


Figure 4: GHG Emissions from Top Polluting Industries vesus All Industries



Appendix

A1

Table 7: The Dictionary of Environment-Related Keywords

alternative energ	biofuels	biomass	biopower	bioprocess
bioproduct	biodegradable	biodiversity	carbon dioxide	contaminant
contamination	climate change	climate goal	climate action	circular economy
clean energy	clean tech	conservation	deforestation	disposable
decarbon	environmental friendly	ecosystem	emission	energy efficien
extinction	geothermal	ghg	global warming	global temperature
groundwater	green tech	green development	green electricity	green innovation
greenhouse gas	ISO 14000	landfill	ozone layer	paris climate
planet	pollut	recycl	rain forest	renewable energy
reusable	reforestation	solar	sustainabl	toxic
wildlife windmill	wind power	wind energy	wetland	waste
zero carbon				

A2

Table 8: Trimming Top 5% Environmentally-Conscious Firms

This table presents a set of OLS regressions performed on our parent level sample of annual data of companies from EPA's CAMD database for a period between 2001-2020. The dependent variable is scaled_profit defined as the ratio of profit in 000s USD to absolute greenhouse gas emissions in short ton of CO_2 equivalent. The primary predictor variable is log of green index. Green index is a continuous variable between 0 and 1 with a larger value indicating higher environmental ethics which is trimmed at 5% at right tail. Column (1) tabulates the results with gross profit as the profit measure in scaled_profit. Column (2) uses earnings before interest and taxes (EBIT) as the numerator in the dependent variable. Columns (3) & (4) use earnings before interest, taxes, depreciation & amortisation (EBITDA) and net income as the profit measure respectively. 'Leverage' is defined as ratio of the total debt to the total assets. 'Tobin Q' is calculated as the market value of equity plus book value of short and long term debt by total assets. 'Capital intensity' is defined as the ratio of plant, property and equipment to total assets. All our regressions control for time and industry fixed effects. Significance at 10%,5% and 1% level is denoted by *, ** and *** respectively. Robust standard errors are shown in parentheses.

	Gross Profit (1)	EBIT (2)	EBITDA (3)	Net Income (4)
Ln (Green Index)	0.920*	0.685**	0.916*	0.232
	(0.544)	(0.286)	(0.543)	(0.144)
Leverage	-17.411***	-10.889***	-17.742***	-5.746***
	(4.375)	(2.679)	(4.437)	(1.304)
Ln (Asset)	-1.780***	-0.861***	-1.776***	-0.424***
	(0.505)	(0.262)	(0.507)	(0.122)
Tobin Q	4.074*	2.781**	3.940*	1.725***
	(2.091)	(1.254)	(2.065)	(0.649)
Capital Intensity	-16.317***	-8.148***	-16.178***	-3.881***
	(4.869)	(2.652)	(4.868)	(1.361)
Constant	35.664***	17.788***	35.843***	8.593***
	(8.966)	(4.589)	(9.018)	(2.290)
Observations	547	543	546	547
R-squared	0.47	0.45	0.44	0.30
Time FE	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES

References

Akey, P., Appel, I., 2021. The limits of limited liability: Evidence from industrial pollution. *The Journal of Finance* LXXVI, 5–55.

Barnea, A., Rubin, A., 2017. Corporate Social Responsibility as a Conflict Between Shareholders. *Journal of Business Ethics* 72, 2505–2550.

Bartram, S.M., Hou, K., Kim, S., 2021. Real effects of climate policy: Financial constraints and spillovers. *Journal of Financial Economics* .

Bushnell, J.B., Holland, S.P., Hughes, J.E., Knittel, C.R., 2017. Strategic policy choice in state-level regulation: The epa's clean power plan. *American Economic Journal: Economic Policy* 9, 57–90.

Daugaard, D., 2019. Emerging new themes in environmental, social and governance investing: a systematic literature review. *Accounting and Finance* 60, 1501–1530.

Dixon-Fowler, H., Slater, D., Johnson, J., Romi, A., Ellstrand, A., 2013. Beyond "does it pay to be green?" a meta-analysis of moderators of the cep–cfp relationship. *Journal of Business Ethics* .

Dorfleitner, G., Halbritter, G., Nguyen, M., 2015. Measuring the level and risk of corporate responsibility – An empirical comparison of different ESG rating approaches. *Journal of Asset Management* 16, 450–466.

Eccles, R., Ioannou, I., Serafeim, G., 2012. The impact of corporate culture of sustainability on corporate behavior and performance. *SSRN Electronic Journal* doi:`10.2139/ssrn.1964011`.

El Ghoul, S., Guedhami, O., Kwok, C.C., Mishra, D., 2011. Does corporate social responsibility affect the cost of capital? *Journal of Banking & Finance* 35, 2388–2406.

Escrig-Olmedo, E., Fernández-Izquierdo, M., Ferrero-Ferrero, I., Rivera-Lirio, J., Muñoz-Torres, M., 2019. Rating the raters: Evaluating how esg rating agencies integrate sustainability principles. *Sustainability* 11.

Fatemi, A., Glaum, M., Kaiser, S., 2018. Esg performance and firm value: The moderating role of disclosure. *Global Finance Journal.* 38, 45–64.

Ferrat, Y., 2021. Carbon emissions and firm performance: A matter of horizon, materiality and regional specificities. *Journal of Cleaner Production* 329.

Fowlie, M., Reguant, M., Ryan, S.P., 2016. Market-based emissions regulation and industry dynamics. *Journal of Political Economy* 124.

Friede, G., BUsch, T., Bassen, A., . *Journal of Sustainable Finance Investment* 5, 210–233.

Galama, J.T., Scholtens, B., 2021. A meta-analysis of the relationship between companies' greenhouse gas emissions and financial performance. *Environmental Research Letters* 16.

Goss, A., Roberts, G.S., 2011. The impact of corporate social responsibility on the cost of bank loans. *Journal of Banking & Finance* 35, 1794–1810.

Hart, S.L., Ahuja, G., 1996. Does it pay to be green? an empirical examination of the relationship between emission reduction and firm performance. *Business Strategy and the environment* 5, 30–37.

Hassel, L., Nilsson, H., Nyquist, S., 2005. The value relevance of environmental performance. *European Accounting Review* , 41–61.

Henry, E., Jiang, X., Rozario, A., 2021. The evolution of environmental discourse: Evidence from conference calls. *Working paper.* .

Huang, D.Z.X., 2021. Environmental, social and governance (esg) activity and firm performance: a review and consolidation. *Accounting and Finance* 61, 335–360.

Huseynov, F., Klamm, B.K., 2012. Tax avoidance, tax management and corporate social responsibility. *Journal of Corporate Finance* 18, 804–827.

King, A.A., Lenox, M.J., 2001. Does it really pay to be green? an empirical study of firm environmental and financial performance: An empirical study of firm environmental and financial performance. *Journal of Industrial Economy* , 105–116.

Konar, S., Cohen, M.A., 2001. Does the market value environmental performance? *The Review of Economics and Statistics* , 281–289.

Liang, H., Renneboog, L., 2017. On the foundations of corporate social responsibility. *The Journal of Finance* LXXII, 853–910.

Lins, K.V., Servaes, H., Tamayo, A., 2017. Social Capital, Trust, and Firm Performance: The Value of Corporate Social Responsibility during the Financial Crisis. *The Journal of Finance* 18, 1785–1824.

Makridou, G., Doumpos, M., Galariotis, E., 2019. The financial performance affirms participating in the eu emissions trading scheme. *Energy Policy* , 250–9.

Martin, R., Muûls, M., de Preux, L.B., Wagner, U.J., 2014. Industry compensation under relocation risk: A firm-level analysis of the eu emissions trading scheme. *American Economic Review* 104, 2482–2508.

Miah, M.D., Hasan, R., Usman, M., 2021. Carbon emissions and firm performance: Evidence from financial and non-financial firms from selected emerging economies. *Sustainability* 13.

Natalia, F., Reguant, M., 2014. Pass-through of emissions costs in electricity markets. *American Economic Review* 104, 2872–99.

Riedl, A., Smeets, P., 2014. Why do investors hold socially responsible mutual funds? *The Journal of Finance* 60, 2835–2857.

Ryan, S.P., 2012. The costs of environmental regulation in a concentrated industry. *Econometrica* 80, 1019–1061.

Shive, S., Forster, M., 2020. Corporate governance and pollution externalities of public and private firms. *Review of Financial Studies.* 33, 1296–1330.

Stern, N., 2006. Stern review: the economics of climate change .

Tang, D.Y., Yan, J., Yao, C.Y., 2021. The determinants of esg ratings: Rater ownership matters. *Working paper* .

Thakor, A., Bunderson, S., 2021. Higher purpose, banking and stability. *Journal of Banking & Finance.* .

Walker, R., 2011. Environmental regulation and labor reallocation: evidence from the clean air act. *American Economic Review* 101, 442–447.

Walker, R., 2013. The transitional costs of sectoral reallocation: evidence from the clean air act and the workforce. *The Quarterly Journal of Economics* 128, 1787–1835.

Wang, L., Li, S., Gao, S., 2014. Do greenhouse gas emissions affect financial performance?–an empirical examination of australian public firms. *Business Strategy and the Environment* , 505–19.

Xu, Q., Kim, T., 2022. Financial constraints and corporate environmental policies. *The Review of Financial Studies* 35, 576–635.