Financing and the Green Paradox

Rui Albuquerque, Mathias S. Kruttli, Yiding Ma, Sumudu W. Watugala*

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Abstract

We study firms' investment decisions in anticipation of higher financing costs under future climate regulation. The model predicts that polluting firms increase investment before regulation intended to curb emissions and consequently emit more ex post. Using the Paris Climate Accord and the Waxman-Markey bill as shocks to the likelihood of climate regulation, we find that exposed firms increase investment prior to the shock. Post-Paris, we find that exposed firms increase emissions levels and intensity. These effects are stronger for firms with higher-volatility operating cash flows. We discuss the possibility of multiple equilibria and the implications for climate change regulation.

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1 Introduction

The green paradox refers to increases in emissions due to actions that fossil fuel producers take in anticipation of a policy intervention aimed at reducing the future rents from these resources (Sinclair, 1992; Sinn, 2008). This paper studies the investment decisions and polluting levels of high-emissions firms ahead of a shock to the saliency of climate risks and of increased future regulation. We develop a model of firm investment and financing where firms exhibit behavior equivalent to the green paradox and test its predictions empirically. Our model applies to any firm under threat of future climate regulation, not only fossil fuel producers and resource extraction.

We model a firm that can take an investment option and needs financing for it. The investment is sensitive to climate regulation: the period the firm is deciding over the investment option coincides with the possibility of a regulatory shock on emissions that increases the project's operating costs. The firm can contribute financing toward the cost of the project at the time of taking the option or prior to it. If the borrowing rate is the same prior to the option exercise and at the time of the option exercise, the firm does not borrow earlier, because the option may never materialize and all of the early investment would have been for nought. However, if the regulatory shock increases the expected financing cost for the polluting firm, then the higher future cost creates an incentive to invest earlier. By investing earlier the firm benefits from cost savings as more of the financing of the cost of the investment is done at the lower rate.

The model delivers several predictions. First, a higher probability of climate regulation affecting the firm leads the firm to borrow and invest more earlier on, akin to the green paradox. Importantly, this result only applies if borrowing costs are contingent on the passing of the regulation. If instead borrowing costs are higher in the future independently of whether the regulation shock realizes, then the firm will still want to do some early investment, but will do *less* of it if the probability of climate regulation increases. Second, the earlier investment by the firm is associated with a higher probability of completing the investment project, resulting in increased pollution. Third, if the regulatory event carries increased costs to the firm, then the firm faces higher borrowing costs in that state of nature. Fourth, firms in industries with higher cash flow volatility are predicted to invest more earlier on and thus also pollute more afterwards. Overall, the model emphasizes a cost uncertainty mechanism of the green paradox through financing costs that complements the traditional mechanism of price uncertainty.

When we introduce a regulatory body to the model, we show that the regulation equilibrium may exhibit multiple equilibria. In the spirit of Glazer and McMillan (1992) and others, the regulatory body is modeled to increase the probability of regulation when it sees higher investment earlier on by polluting firms. This threat coupled with the green paradox result can produce multiple equilibria: an equilibrium with low risk of regulation and low investment and low pollution, and an equilibrium with high risk of regulation and high investment and high pollution. In the high investment equilibrium, the industry's expectation of the likelihood of the regulator's action drives investment up by polluting firms (i.e., the model's green paradox effect), and the increased investment leads to a higher probability of regulation, thus validating those expectations. An immediate consequence of the multiplicity of equilibrium is that changes in expectations can drive the industry to the high-pollution equilibrium. This model prediction can explain why the Paris Accord appears to have impacted firms (see below), whereas other United Nations Conference of the Parties did not. It can also explain the differential investment patterns across private and public US firms (e.g. Duchin, Gao, and Xu 2025) subject to different sets of regulatory bodies. For example, if new rules introduced to standardize climate-related disclosures apply only to public companies. Second, the very actions of the regulator aimed at curbing firm investment in polluting technologies can be counterproductive.

To empirically analyze how the risk of climate regulation affects investment decisions and pollution levels, we consider two settings, the 2015 Paris Climate Accord as a shock to future regulatory risk (Ilhan, Sautner, and Vilkov, 2021; Bolton and Kacperczyk, 2021, 2023; Seltzer, Starks, and Zhu, 2025), and the 2009 Waxman-Markey bill (Meng, 2017; Ivanov, Kruttli, and Watugala, 2024).

The Paris Climate Accord is an international treaty on climate change whose signatories committed to tight climate policy objectives.[1] The US adopted the Paris Accord on December of 2015. We estimate difference-in-difference equations describing investment and emissions pre- and post-Paris Accord as well as new bond issuance. We use two variables to indicate treatment: a continuous variable equal to the lagged value of firm GHG-emissions intensity and an indicator variable equal to one if the lagged value of firm emissions intensity is above the sample median. We use data on facility-level greenhouse gas emissions from the US Environmental Protection Agency (EPA) Greenhous Gas Reporting Program (GHGRP) from 2010 to 2020. The EPA data have detailed information on a facility's parent companies, their names, addresses, and ownership stakes in a given year, which we use to assign emissions levels to parent companies. We merge our data with Capital IQ data and Mergent for balance sheet data and corporate bond data, respectively.

We first analyze firm investment policy for high and low emissions firms, as predicted by the model, by studying changes in firm capital expenditures (CAPEX) in the period following the passage of the Paris Accord. We find that the ratio of CAPEX to assets is lower for high-emissions intensity firms in the post-period. The effect we find is sizable. For the firms with above median emissions intensity, the investment rate is 1.1 percentage point smaller than for other firms, all else equal, in the post-Paris period versus the pre-period. When we repeat the regressions using the change in the level of CAPEX as the outcome, we again

[1] The 1997 Kyoto Protocol was the first-ever international commitment to reducing greenhouse gas emissions. Because it called for penalties for noncomplying countries, the Kyoto Protocol required Congress approval and was never implemented in the US. The US signed the Copenhagen Accord of 2009, but this Accord was a non-legally binding, political accord.

find a significant decrease in CAPEX for high-emissions intensity firms in the post-period compared to the control group. These results hold within industry after including industry interacted with time fixed effects.

Second, we find that the observed changes in investment policy post-Paris for high-emissions firms have a parallel effect in emissions. Recall that the model predicts that by investing more earlier, the more emissions inefficient firms have a greater likelihood of completing the investment and hence of polluting if the regulatory shock materializes. We find that firms with high-emissions intensity tend to have relatively higher emissions levels and emissions intensity in years subsequent to the Paris Accord. In addition, we find that the results on investment and emissions are stronger for firms with higher cash flow volatility, as predicted by the model.

Lastly, we find that firms with higher GHG-emissions intensity offer bonds with shorter maturity in the post Paris period, controlling for common firm determinants. For the firms with above median GHG-emissions intensity, the offering maturity of new corporate debt issues drops by about 1.7 years on average. This result is consistent with the finding in Seltzer, Starks, and Zhu (2025) regarding insurance companies' behavior around the Paris Accord. We do not find any statistically significant effect on maturity-weighted yields. One interpretation of the result on yields is that firms adjust to an upward shift of their yield curve post Paris (see Seltzer, Starks, and Zhu 2025 for evidence of tightening of financing costs for emissions-inefficient firms post Paris) by borrowing more short term, which typically carries lower yields. Arguably, with an upward sloped yield curve, they would be paying higher yields had they continued borrowing at similar maturities as before.

We use a second quasi-natural experiment to test the model predictions on investments. We use the near passage of the Waxman-Markey Bill as a laboratory to study the effect of climate policy risks.[2] The bill was introduced in May 2009, and passed the House of

[2]The introduction of the bill predates the EPA's GHGRP that provides emissions data only from 2010 onwards, precluding an analysis of firm emissions around its passage.

Representatives on June 26, 2009. Using prediction market prices, Meng (2017) notes that there was an elevated probability of the bill passing through the end of 2009 until early 2010. The bill never reached a Senate vote and Senate Democrats eventually dropped the bill from the discussion in July 2010. The bill included a feature that discriminated within the set of high-emission manufacturing firms in the U.S by giving free emission permits to qualifying firms with energy intensity above 5%. This discontinuity provides for the identification of effects and avoids confounding effects, for example, from a focus on the oil and gas industry or a simple comparison of high and low emission firms.. We find that manufacturing firms below the threshold of 5% of energy intensity, the treated firms, exhibit an increase in investment in the first quarter of 2010, the quarter when the likelihood of the bill passing started to decline. The evidence suggests that treated firms increased investments while the likelihood of the bill passing was high. The evidence is also consistent with Ivanov, Kruttli, and Watugala (2024) who show that banks boost discretion over the financing to treated firms 2009 after the bill passed the House, likely increasing firms' expectations of tighter financing after the implementation of the regulation.

The model emphasizes the increased bankruptcy cost associated with regulation as the incentive for firms to invest earlier, but higher external financing costs could come from other sources as well. The related literature discussion below lists evidence for increased cost of public equity and bank loans post Paris for high-emissions firms. We complement this evidence using new issuance in the corporate bond market. This market can capture two unmodeled dimensions that are of interest in our analysis. First, the bond market is a natural way to segment investors by investor horizon (Vayanos and Vila, 2021) and recent evidence suggests that there is a segment of the investor population that has longer-term investment horizon and non-pecuniary preferences toward the environment, social and governance (ESG) performance of firms (e.g. Starks, Venkat, and Zhu (2025)). The Paris Accord may induce a shift of these investors to less polluting firms, increasing the cost of borrowing to more polluting firms particularly at longer maturities. This shift may occur because of the perceived increase in the regulatory burden, or because these bond investors are concerned with increased awareness by the public at large to climate issues. Second, cash flows of bonds of longer maturity may be more sensitive to the uncertainty of future regulation. This added sensitivity may reflect in an higher borrowing cost for longer term bonds that forces polluting firms to consider shorter term debt.

The next section offers a brief review of the related literature. Section 3 presents the model and its main predictions. Section 4 discusses the data sources and the empirical strategy and Section 5 presents the results. Section 6 concludes.

2 Related literature

Relative to the literature on the green paradox hypothesis, we are the first to show firm investment and emissions effects. Norman and Schlenker (2024) shows that oil prices in futures markets decreased with increases in the daily change in the prediction market's expectations that the Waxman-Markey bill would pass. Lemoine (2017) finds that the U.S. Senate breakdown in negotiations of the Waxman-Markey bill lead to an increase in coal futures prices and in coal storage. These papers do not study the firm financing channel and firm emissions. Sinn (2015) argues that the failure of policies to curb CO2 emissions and to generate a significant increase in carbon prices is itself evidence of the green paradox. Jensen, Mohlin, Pittel, and Sterner (2015) study within the context of a model of the green paradox the effect that several factors may firm financing.

Seltzer, Starks, and Zhu (2025) find that after the Paris Accord credit ratings decrease and corporate bond yields on existing debt increase for high-emissions public firms (for the loan market see Ehlers, Packer, and de Greiff 2022), and that insurance companies (mutual funds) reduce (increase) their exposure to high-emissions firms. Also using the Paris Accord as a shock to the risk of regulation, Cao, Li, Zhan, Zhang, and Zhou (2025) find that liquidity deteriorates in bonds of high carbon-intensive public firms post-Paris. Ramadorai and Zeni (2024) show that firms increase carbon abatement investments post-Paris. Ladika, Pazaj, and Sautner (2025) estimate that agents expected a significant impact from the Paris Accord. Several papers find changes to firm risk in the public equity and options markets for high emissions firms in the post-Paris period. Seltzer, Starks, and Zhu (2025) find evidence of increased asset volatility which they back out using equity values pre- and post-Paris periods. Ilhan, Sautner, and Vilkov (2021) find that carbon tail risk is priced in stock options and that it increases after Paris for firms with carbon-intense business models. Bolton and Kacperczyk (2021) find a carbon risk premium in the cross section of U.S. stocks that also increases post Paris. Our paper provides further evidence on the effects of the Paris Accord on firm-level investment and emissions policies.

Beyene, De Greiff, Delis, and Ongena (2021) focus on a cross-country sample of fossil fuel firms and find those facing higher climate risk, using a climate change policy index, pay higher bond spreads but not higher syndicated loan spreads. Ivanov, Kruttli, and Watugala (2024) find that the passage of climate-related policies in Congress is associated with shorter loan maturities and higher loan interest rates for treated firms. Korganbekova (2023) finds positive spillovers across facilities in different states owned by the same firm following state-level climate regulation. Kacperczyk and Peydro (2022) find that banks with carbon commitments restrict loan supply to carbon intensive industries. Noailly, Nowzohour, and van den Heuvel (2022) create an index of US environmental and climate policy uncertainty and show that it spikes during the Waxman-Markey bill period among other periods. They also show that during periods of elevated levels of the index, there is a reduced probability for cleantech startups to receive VC funding.

Bellon and Boualam (2024) argue that climate regulation risk makes dirty technologies more attractive to distressed firms, akin to a risk-shifting argument. Gupta, Kopytov, and

Starmans (2025) show that the anticipation of the arrival of an activist with pro-social preferences may adversely contribute to a high-emissions status quo of the firm. Huang and Kopytov (2024) propose that regulations can substitute for the value of investors with pro-social preferences discouraging the adoption of green technologies by polluting firms. van der Ploeg and Withagen (2012) discuss welfare implications of backstops, renewable resources that substitute perfectly for fossil fuels, and when a green paradox exists depending on the costs associated with the backstop technology. Acharya, Giglio, Pastore, Stroebel, Tan, and Yong (2025) study climate risk that arises from the arrival of breakthrough technologies in the renewable energy sector and from taxes on carbon emissions and restrictions on drilling. Engle (2024) suggests that the risk of stranded assets can lead polluting firms to underinvest, reducing the overall supply of fossil fuels. Acemoglu, Akcigit, Hanley, and Kerr (2016) study taxation and technology adoption when there is climate-related transition risk and the dirty technology is more advanced. Lanteri and Rampini (2023) and Bustamante and Zucchi (2024) study the adoption of clean technologies when firms are heterogeneously financially constrained. In Chen (2023), when investors have greater preference for ESG, the firm may decrease ESG investments if it cannot disclose credibly its ESG policies, and investors discount firm statements of being green. Piccolo, Schneemeier, and Bisceglia (2025) argue that concentration of ESG-oriented investors on a small set of green firms may discourage green investments by excluded firms. Similarly, in Goldstein, Kopytov, Shen, and Xiang (2024), the growth of green investors together with better ESG information quality can raise a firm's cost of capital.

3 A model of financing and investment and the green paradox

Consider the investment and borrowing decisions of a firm that faces the prospect of climate-related regulatory risk. There are three periods indexed by $0, 1, 2$. At time 1, the firm has an investment option (e.g. to drill oil from a new well, or build a new factory that uses gas-powered heating) that requires an investment of I. The investment pays out an operating profit of $\tilde{\pi}$, with continuous cdf $F(\tilde{\pi})$, at time 2. Without loss $\tilde{\pi}$ is observed at time 1. Also at time 1, there is a shock to climate regulation; the firm's probability of being affected by the shock is given by λ. This shock affects the operating profit from the investment opportunity reducing it by the constant κ. We view κ as the cost that results from having to adapt the investment opportunity to meet the new regulations, which includes any pollution-abatement actions by the firm, or carbon credits that need to be purchased.[3]

At time $t = 0$, the firm can borrow an amount $I_0 \leq I$. The borrowed amount I_0 is used to partially fund the investment needed at $t = 1$ to exercise the option. If the option is taken at time $t = 1$, then the additional borrowing of $I_1 = I - I_0 \geq 0$ is needed to undertake the investment. If, however, the option is not taken at $t = 1$, there are no cash flows and for simplicity we assume the liquidation value of the early investment to be zero. There is a convex cost to early investment of $\psi I_0^2/2$. This non-pecuniary cost is motivated by the reputational considerations that may arise from an empire-building motive or the lack of commitment not to abscond with the money. This cost is introduced to ensure an interior solution.

We assume that the firm can issue one-period bonds at the gross interest rate R in both periods 0 and 1, unless the regulatory risk materializes in which case the borrowing cost

[3] The effects of regulation do not have to come through the supply side via κ. Regulation that affects the firm's demand, captured by a reduction in the mean of π, is isomorphic in our model. Also, scaling the cost by the investment size does not change the results.

goes up to R_λ. For now, we take R_λ to be exogenous. Below, we show that $R_\lambda > R$, where the gap between the two is driven by κ and the existence of bankruptcy costs. Section 3.4 discusses an alternative interpretation for R and R_λ. For simplicity, the firm's rate of time preference is set to zero.

The firm's maximizing problem at time 0 is

$$\begin{aligned} \max_{0 \le I_0 \le I} &= (1-\lambda) E\left[\max_{I_1 \in \{I - I_0, 0\}} (\tilde{\pi} - R I_1, 0)\right] \\ &+ \lambda E\left[\max_{I_1 \in \{I - I_0, 0\}} (\tilde{\pi} - \kappa - R_\lambda I_1, 0)\right] - R I_0 - \frac{\psi}{2} I_0^2. \end{aligned} \tag{1}$$

In the regulation state, the investment option is less valuable for two reasons, the abatement cost κ and the higher financing cost R_λ. Rewrite the problem as

$$\begin{aligned} \max_{0 \le I_0 \le I} &= (1-\lambda) \int_{R(I-I_0)}^{\infty} (\tilde{\pi} - R(I - I_0))\, dF(\tilde{\pi}) \\ &+ \lambda \int_{\kappa + R_\lambda (I - I_0)}^{\infty} (\tilde{\pi} - \kappa - R_\lambda (I - I_0))\, dF(\tilde{\pi}) - R I_0 - \frac{\psi}{2} I_0^2. \end{aligned}$$

The first order condition with respect to I_0 yields:

$$(1-\lambda)\left[1 - F(R(I - I_0))\right] R + \lambda \left[1 - F(\kappa + R_\lambda (I - I_0))\right] R_\lambda - R - \psi I_0 \le 0. \tag{2}$$

The optimal choice of I_0 equates the marginal borrowing cost at time 0, R, plus the cost of investing early, ψI_0, to the marginal benefit at time 1. The marginal benefit at time 1 is the cost savings from having invested earlier: these are the weighted average of R times the expected option exercise $(1 - F(R(I - I_0))$ if there is no regulation, and R_λ times the expected option exercise $(1 - F(\kappa + R_\lambda (I - I_0))$ if there is regulation. The cost savings occur only if there is a regulatory shock and the option is exercised, so naturally, $I_0^* = 0$ when $\lambda = 0$.

If the marginal benefit of early investing evaluated at $I_0 = 0$ is larger than R (thus guaranteeing $I_0^* > 0$), and the marginal benefit of early investing evaluated at $I_0 = I$ is below $R + \psi I$ (thus guaranteeing $I_0^* < I$), then by continuity the problem admits at least one interior maximum. The later condition is easy to satisfy by appropriately choosing a high value of ψ, all else equal. For the former condition, it would seem that picking a high enough value of R_λ would do the trick. However, in the model, while a high R_λ increases the cost savings if the project is undertaken, it also reduces the likelihood of undertaking the project and hence the expected cost savings. It turns out that if the mean of operating profits is high enough, the second effect is attenuated and the problem admits an interior maximum. The following proposition gives sufficient conditions for an interior maximum for a specific functional form for F. All proofs can be found in Appendix A.

Proposition 1. *Let F be the cumulative normal distribution, μ_π and σ_π the mean and standard deviation of operating profits, respectively, and let $\mu_\pi = 1.96\sigma_\pi + \kappa + R_\lambda I$. There is an interior maximum if*

$$\frac{0.0256}{\lambda} < \frac{R_\lambda - R}{R} < \frac{\psi I}{R\lambda}. \tag{3}$$

The proposition gives sufficient conditions for an interior maximum in the form of upper and lower bounds to R_λ. The critical feature of these conditions is that as R_λ increases to meet the lower bound constraint, μ_π also must increase. The agency cost, ψ is needed to generate an interior optimum. If R_λ is sufficiently large relative to R, a high enough probability of exercising the option conditional on the regulatory shock occurring generates savings that will make the firm take the corner solution of investing all at time 0. The proposition shows that ψ can be used to construct an upper bound to R_λ for the problem to admit an interior maximum.

3.1 Model predictions

We highlight model properties related to variation in λ, the firm's probability of being affected by the regulatory shock.[4] Our main result is that a firm facing higher regulatory risk at time 1 (i.e., higher λ), invests relatively more at time 0, $dI_0^*/d\lambda > 0$. To see the intuition for this result note that in the state of the world where the regulatory shock occurs the likelihood of exercising the option is lower because of κ and the higher borrowing cost, i.e., $\kappa + R_\lambda(I - I_0) > R(I - I_0)$. Thus, a firm that faces a higher λ has a lower overall probability of exercising the investment option, which discourages early investment. However, the state where there is regulatory risk is also the state of cost savings, and an increase in λ increases the likelihood of cost savings and encourages early investment. At the optimum, under the conditions that guarantee an interior solution, the second effect dominates and I_0^* increases with λ.

Importantly this result is not due to having higher borrowing rates unconditionally in period 1: if at time 1 the cost of borrowing is R_λ across all states, then a higher λ puts more weight on the state of the world where the probability of exercising the option is lower and the marginal benefit of investing earlier declines, leading to lower I_0^*. In this sense, the result has the flavor of the 'green paradox' (Sinn, 2008): the higher financing cost faced by the firm in the state where regulatory risk occurs generates an incentive to invest early in the potentially polluting technology, which itself counteracts the efforts of the regulation.

A consequence of higher early investment for a firm with higher regulatory risk (i.e., higher λ) is that the firm also has a higher probability of exercising the option at time 1. Hence, firms with higher regulatory risk are more likely to see increases in pollution. The next proposition collects these results.

[4] Empirically, we shall think of λ has having a firm-specific component related to the exposure that firms have to regulation through their past policy decisions and technology choices, and an aggregate component related to the probability of new regulation. In the model, we make no distinction on which of the two is driving changes in λ.

Proposition 2. *At an interior maximum, a firm with higher λ:*

- *invests relatively more (less) in the period prior to (after) the regulatory shock;*
- *experiences a larger increase in pollution in the period after the regulatory shock.*

For the next result, we again assume that operating profit is a random normal variable. We then have:

Proposition 3. *Let the conditions in Proposition 1 hold. Then, at an interior optimum, I_0^* is decreasing in σ_π.*

We are interested in the cross-partial derivative $\partial^2 I_0^* / \partial\lambda\partial\sigma_\pi$. This derivative captures how changes in the likelihood of a regulatory shock affect polluting firms that have high cash flow volatility. In numerical simulations, and for values of μ_π specified in Proposition 3, $\frac{\partial^2 I_0^*}{\partial\lambda\partial\sigma_\pi} > 0$.[5] The positive sign of this cross-partial derivative is intuitive. Proposition 3 shows that in some parameter configurations, higher volatility reduces early investment, but higher λ shifts the weight to the investment option that is relatively less in the money (the state of the world with abatement costs and higher interest rates) and for which an increase in volatility is less costly. Hence, relatively speaking, early investment increases.

3.2 Cost of financing in the event of a regulatory shock

In this section, we endogenize the value of R_λ. We argue that one reason for a higher interest rate when the regulatory event occurs at time 1 is intrinsically linked to the regulatory event

[5] Using the implicit function theorem, and the short-hand notation $g_x = \partial g / \partial x$,

$$\frac{\partial^2 I_0^*}{\partial\lambda\partial\sigma_\pi} = -\frac{g_{\lambda\sigma}}{g_I} + \frac{g_{I\lambda} g_\sigma + g_{I\sigma} g_\lambda}{g_I^2} - \frac{g_{II} g_\lambda g_\sigma}{g_I^3}. \tag{4}$$

Under the assumption that $\mu_\pi = 1.96\sigma_\pi + \kappa + R_\lambda I$, it is cumbersome but straightforward to show that all terms are positive, except one. The term that is negative is $\frac{g_{I\lambda} g_\sigma}{g_I^2}$, since $g_{I\lambda} = -f(z_1)R^2 + f(z_2)R_\lambda^2 > 0$, while $g_I^2 > 0$ and $g_\sigma < 0$.

through a higher probability of bankruptcy. We continue to assume an exogenous interest rate R when borrowing at time $t = 0$ or in time $t = 1$ if the regulation shock does not materialize.[6] The introduction discusses other reasons why $R_\lambda > R$.

Upon the regulatory event, the firm pays a random abatement cost $\tilde{\kappa}$ with cdf $G(\tilde{\kappa})$. The realization of the random variable $\tilde{\kappa}$ occurs after the decision to invest I_1 at time 1. The time 0 expected payout in the event of regulation is

$$E_{\tilde{\pi}}\left[\max_{I_1\in\{I-I_0,0\}}\left[E_{\tilde{\kappa}}\max_{eqty,noeqty}\left(\tilde{\pi}-\tilde{\kappa}-R_\lambda I_1,0\right),0\right]\right], \tag{5}$$

where *eqty* and *noeqty* identify states of the world where equity holders are paid. If the option is undertaken, but the cost ends up larger than $\pi - R_\lambda I_1$ (which occurs with probability $1 - G(\pi - R_\lambda I_1))$, then equity holders get zero and lenders get only a fraction of their investment, or possibly nothing if the cost is high enough.

We assume lenders are risk neutral. Lenders break even on average across realizations of $\tilde{\pi}$, assuming a borrowed amount of $I_1 = I$. The interest rate R_λ solves:

$$RI = \int G\left(\tilde{\pi}-R_\lambda I\right)dF(\tilde{\pi})R_\lambda I + (1-\alpha)\int\int_{\tilde{\pi}-R_\lambda I}^{\tilde{\pi}}(\tilde{\pi}-\tilde{\kappa})dG(\tilde{\kappa})dF(\tilde{\pi}), \tag{6}$$

where $\alpha > 0$ is a proportional bankruptcy cost. Note that R_λ does not actually depend on the value of λ, contrary to what the subscript might suggest. The subscript merely indicates the states of the world where the cost of borrowing R_λ applies.

The first term on the right-hand side of equation (6) describes the full repayment to lenders when $\tilde{\kappa} < \tilde{\pi} - R_\lambda I$. The second term on the right-hand side of equation (6) shows

[6] It is possible to extend the model to endogenize R at time 0. Naturally, an endogenous R incorporates some premium for losses when the regulation shock hits. However, as R is a weighted average of future payouts to lenders, if lenders have less to lose when the regulation shock does not materialize, then a gap will exist between R_λ and R in equilibrium. Consistent with this hypothesis, Altavilla, Boucinha, Pagano, and Polo (2023) find a small benefit in interest cost to firms expecting lower emissions, controlling for their probability of default.

that for intermediate values of the cost, $\tilde{\pi} - R_\lambda I < \tilde{\kappa} < \tilde{\pi}$, lenders get a decreasing amount $\tilde{\pi} - \tilde{\kappa}$. The bankruptcy cost α is paid to recover a payout when the firm is in distress. Finally, for values $\tilde{\kappa} > \tilde{\pi}$, lenders get zero.

Because $\int_{\tilde{\pi}-R_\lambda I}^{\tilde{\pi}} (\tilde{\pi} - \tilde{\kappa}) dG(\tilde{\kappa}) < [G(\tilde{\pi}) - G(\tilde{\pi} - R_\lambda I)] R_\lambda I$, then $R < \int G(\tilde{\pi}) dF(\tilde{\pi}) R_\lambda \leq R_\lambda$. The bankruptcy cost α increases this gap. The result that $R_\lambda > R$ is the critical assumption we had made earlier on and that comes through in the model with a higher probability of default in the event of the regulatory shock.[7] The increased risk of bankruptcy in the event the regulatory risk is realized gives rise to the proposition:

Proposition 4. *A firm exposed to regulatory risk (i.e., with $\lambda > 0$) has higher interest rate at time 1 in the state of the world where the regulatory shock is realized compared to the interest rate it faces absent the regulatory shock.*

3.3 Equilibrium regulation

We introduce a regulator that determines the probability of the regulatory shock based on the level of investment made by the firms in the industry at time 0. We are motivated by the notion that regulators often use the threat of regulation to affect firm behavior (for early work see Glazer and McMillan 1992, and Erfle and McMillan 1990). Let m be the measure of firms in the industry and for simplicity let firms be ex ante identical so that mI_0 is the industry's investment at time 0. We model regulation as a binary random variable whose probability distribution, $\Lambda(mI_0)$, is an increasing function of industry early investment in the polluting technology. The regulator takes aggregate investment as exogenous.

[7] An alternative to close the model is to assume that lenders break even for every π and $I_1 > 0$. In this case lenders are paid a rate of return that equals R on average

$$RI_1 = G(\pi - R_\lambda I_1) R_\lambda I_1 + (1 - \alpha) \int_{\pi - R_\lambda I_1}^{\pi} (\pi - \tilde{\kappa}) dG(\tilde{\kappa}). \tag{7}$$

The interest rate R_λ that solves this equation is contingent on the realization of π and I_1 since the shareholder makes the investment decision knowing how much investment is still needed and what π is. Here, too, it can be shown that $R_\lambda > R$.

Firms have beliefs about future regulation, λ, and make investment decisions as a function of these beliefs, $I_0^*(\lambda)$, as discussed above.[8] Firms know that Λ is a function of aggregate investment, but they are atomistic and view the equilibrium aggregate investment and hence the probability of regulation as exogenous. In a rational expectations equilibrium (λ^*, I_0^*) firms correctly anticipate the regulator's probabilistic action λ^* and choose early investment accordingly $I_0^*(\lambda^*)$, and regulator's action $\Lambda\left(mI_0^*\right)$ is consistent with firms' investment decisions. That is, the equilibrium λ^* is a fixed point: $\lambda^* = \Lambda\left(mI_0^*(\lambda^*)\right)$. Figure 1 illustrates the regulation equilibrium. The solid line depicts the function $mI_0^*(.)$ (plotted on the y-axis) against values of λ. There is no investment at time 0 for low enough λ (as shown in the discussion preceding Proposition 2), after which I_0^* increases with λ. The dashed line depicts the function $\Lambda\left(.\right)$ (plotted on the x-axis) against values of I_0 (plotted on the y-axis). Points where the two curves intersect are equilibrium points.

[Insert Figure 1 here]

Depending on the curvatures of the $\Lambda(.)$ and $I_0^*(.)$, there can be multiple equilibria as the figure illustrates: an equilibrium with high regulatory risk and high investment at time 0, and an equilibrium with low regulatory risk and low investment at time 0. There are three reasons for the possibility of multiple equilibria in the model. First, firms take the probability of regulation as given, which leads to an externality. Firms do not incorporate the fact that as each of them invests more, the regulator increases the probability of the regulatory shock. Second, in our model, the benefit of investing early (through the borrowing-cost savings) accrues because of the possibility of future regulation. This feature is what gives the positive slope of the aggregate investment curve and is the main reason for the multiplicity of equilibria. Third, in the illustrated equilibrium, the regulatory function $\Lambda(.)$ penalizes industry investment sufficiently aggressively in order to intersect with $I_0^*(.)$.

[8] Chang, Kalmenovitz, Lopez-Lira, and Hajda (2025) document firm anticipatory behavior to an entire body of potential federal regulations in the US.

With multiple equilibria the risk of regulation can be self fulfilling: if firms anticipate high regulatory risk (i.e., a high λ), then it is advantageous for each of the firms to invest more at time 0. In other words, the industry's expectation of the likelihood of the regulator's action leads to increased investment, which then validates the original expectations. This gives rise to a complementarity between the likelihood of regulation and polluting-technology adoption. Our model differs from the model in Biais and Landier (2022) where there is a 'green' equilibrium with high regulation and high investment in the green technology. In their model, firms' adoption of the green technology make it less onerous for the regulator to impose emission caps. So, while both models offer stories of complementarities between regulation and firm investment, the complementarities have different implications for equilibrium outcomes.

The first prediction from the self-fulfilling nature of the equilibria is that the green paradox may manifest itself in some industries but not others, or to different degrees for different groups of firms, subject to different regulatory bodies, and exposed to different public pressure. This result may explain the differential behavior in terms of emissions by private and public firms found in Duchin, Gao, and Xu (2025) and Im (2023). Second, the existence of multiple equilibria suggests that the (threat of) regulatory action can be counterproductive, though not because the regulator is subject to the efforts of powerful lobbies in the way discussed in Stigler (1971) and Peltzman (1976). However, the symmetric nature of our predictions yields that changes in policy stance that suggest less future regulation, can result in less pollution.

3.4 Discussion

The paper's main result is that early investment in the polluting technology increases with the probability of climate regulation. As indicated above, this result relies on firms' facing a higher cost of financing only in the state where regulation occurs. It is worthwhile investigating what would be required to have higher borrowing rates unconditionally in period 1. First, aggregate conditions could be such that everyone expects higher borrowing rates in the future. Second, firms may feel threatened today of increased costs in the future unconditionally because the capital market decides to penalize them even if the regulatory shock does not occur. In both these cases, an increase in λ reduces early investment; the actions of regulator and financiers would be complementary in this case in bringing down investment in polluting technologies.

We assume that investment requires external financing. If no external financing is needed, and shareholders' required rate of return is constant over time, then it would not be optimal to invest early. There is no benefit to committing resources early to an investment option that realizes in the future and that can be fully funded at that point. This makes explicit that the hypothesis developed in this paper relies on firm exposure to financial markets, in particular to investor responses to the risk of bankruptcy when climate regulation is implemented.

The model assumes that firm value comes solely from the investment option. Under that assumption, which is too restrictive, shareholders would have to pay RI_0 in period 1 if the project is not implemented so that R is a risk free interest rate as assumed from period 1 onward. An alternative and perhaps more realistic assumption is that the interest rates in the model are project one-period hurdle rates and that the firm comprises the investment option studied as well as other assets. In that case, R and R_λ, being hurdle rates, are positively associated to the cost of outside financing though that link is not as transparent.

We model only a high-pollution investment option for the firm, but it is reasonable to assume in some instances that firms have investment options with cleaner technology. One relevant theoretical trade-off is that the cleaner technology does not require any technological abatement if climate-related regulation is imposed, but not taking the high-pollution option can result in a loss of firm value. The loss of value can come from stranded (polluting) assets, especially if these assets become obsolete, or from having to dispense with a low-marginal cost technology. Empirically, enlarging the set of firm responses to regulation uncertainty can result in a weakening of the mechanism we hypothesize, in which case we would be unlikely to find any evidence in favor of the green paradox.

4 Empirical design

4.1 Paris Accord

We analyze the adoption of the Paris Accord to test model predictions on the effect of heightened climate policy uncertainty on firm investments and emissions. The legally binding treaty was agreed by 195 Parties on December 12, 2015 and entered into force on November 4, 2016.[9] The adoption of the Accord likely increases firms' anticipation of more stringent future regulation of GHG emissions, thereby raising uncertainty for firms with carbon-intensive business (Ladika, Pazaj, and Sautner, 2025). Such uncertainty is particularly relevant for firms considering investments in high-emission projects, for which future regulatory constraints could tighten project financing availability.

4.1.1 Data

We use data from multiple sources. The emissions data measured in CO2 equivalents (CO2e) are from the EPA. Starting in 2010, the EPA requires that each production facility with more than 25,000 metric tons of CO2e emissions per year reports their emissions. This regulation covers carbon dioxide, methane, nitrous oxide, and fluorinated GHGs. These data are publicly available (https://www.epa.gov/ghgreporting), cover a wide range of industries, account for a substantial share of total U.S. emissions, and have been used in other studies (e.g., Shive and Forster (2020); Bartram, Hou, and Kim (2022); Ivanov, Kruttli, and Watugala (2024)). Firms are required to report direct and indirect GHG emissions. Direct CO2e emissions are

[9]See https://unfccc.int/process-and-meetings/the-paris-agreement.

those emitted from the facility itself, for example, emissions from industrial processes and through the combustion of fossil fuels by boilers and furnaces. Indirect emissions are the emissions from materials sold by the facility and combusted elsewhere. In Figure 2, we show the county-level distribution of high GHG-emitting facilities as of 2015 for EPA facilities that are mapped to Capital IQ firms. GHG emissions are geographically dispersed across the U.S.

We obtain the balance sheet data of U.S. public and private firms from S&P Capital IQ. Capital IQ collates data on private firms through publicly available disclosures, for example, private and public firms face SEC disclosure requirements when issuing publicly traded debt like corporate bonds.

We obtain the sample of U.S. corporate bond issuances from 2010 to 2020 from Mergent Fixed Income Securities Database (FISD) using standard processing based on Adrian, Boyarchenko, and Shachar (2017) and others. We aggregate bond issues by the same firm in a given year to a single observation. We merge Mergent FISD and Capital IQ data based on bond issuer-level CUSIP. The matched data are aggregated to the parent level to ensure a Mergent parent corresponds to an ultimate parent firm in Capital IQ. We use 2-digit SIC industry codes to filter out firms in financial (60-67), government (91-97) and "nonclassifiable" (99) industries.

The EPA data have detailed information on a facility's parent companies, their names, addresses, and ownership stakes in a given year. We match parent firms in the EPA data to parent firms in the Capital IQ and Mergent datasets, respectively, using the name and ZIP code of the parent company of each GHG-emitting facility. We first conduct a fuzzy name match and then verify each potential match manually. We use ownership stakes data to assign emissions levels of facilities to parent companies. Emissions are aggregated to parent level for the empirical analysis.

The summary statistics for the variables used in our empirical analysis are reported in

Table 1 Panels A (EPA sample) and B (Mergent sample). We reproduce descriptive stats for balance sheet information under both samples. Table B.2 in Appendix B presents the variable definitions.

Emissions intensity (emissions divided by revenues) is highly skewed so we take the logarithm of emissions intensity, resulting in a mean (median) of 5.56 (5.97). For capital expenditures, we also either take the log of the variable or divide by the firm's assets. The average (median) value of capital expenditures to assets of a firm in our sample is 6.9% (5.2%). The additional balance sheet variables shown are debt, net property plant and equipment, and cash, all divided by total assets. For the Mergent sample, shown in Table 1 Panel B, we have data on the total offering amount, yields, and time-to-maturity (TTM) of the issued bonds. Further, we show summary statistics for the same balance sheet variables for the Mergent-Cap IQ matched sample.

4.1.2 Regression specification

We analyze the effects of a shock to climate regulation risk on firm investments, emissions, and financing using the following baseline panel regression specification:

$$\begin{aligned} y_{i,t} = {} & \beta_0 EmissionsIntensity_{i,t-1} + \beta_1 EmissionsIntensity_{i,t-1} \times PostParis_t \\ & + \gamma Z_{i,t-1} + \theta_{i,t} + \epsilon_{i,t}, \end{aligned} \tag{8}$$

where i denotes the firm and t the current year. The sample period is from 2010 to 2020. We estimate multiple empirical specifications, where the dependent variables of interest, $y_{i,t}$, are firm annual capital expenditures and investment rate, or capital expenditures normalized by assets; firm emissions intensities or levels; and for the bond market analysis: offering amount, time-to-maturity of the issued bonds, and offering yield. The main independent variable of interest is the interaction between the indicator variable $PostParis_t$, which captures the period following the 2025 Climate Paris Accord, the lagged indicator for the firm having above median emissions intensity, $IsHighEOR_{i,t-1}$ (or the lagged value of emissions intensity, $Log\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}}$). The importance of scaling firm emissions to measure exposure to climate change regulation like a price on carbon has been discussed by, for example, Aswani, Raghunandan, and Rajgopal (2024); Zhang (2025).

We control for lagged firm-level variables, $Z_{i,t-1}$, which capture observed variation at the firm level of determinants of investment policy and bond characteristics. These controls include $log(Assets_{i,t-1})$ (size), $\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$ (leverage), $\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$ (asset tangibility), $\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$ (liquidity), and $\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$ (investment rate). We include specifications with different combinations of fixed effects, broadly identified as $\theta_{i,t}$: year and industry fixed effects; year and firm fixed effects; and firm and industry $\times$ year fixed effects to control for unobservables. Industry $\times$ year fixed effects allow us to account for industry-wide shocks that affect firm decisions, such as oil price shocks that may also affect firm investment in the oil and gas industry and related industries (see, e.g., Shi and Zhang (2025)). Any lower order terms (e.g., $PostParis_t$ by itself) that are not shown are absorbed by the fixed effects. The standard errors are clustered at the firm level.

The specification in equation (8) allows us to test the model predictions implied by Propositions 2 and 4 regarding λ. Empirically, we let the firm's probability of being affected by the regulatory event, λ, depend on the firm's exposure to future regulation, which we proxy by its emissions intensity, and on the aggregate state of additional regulation, which we proxy with $PostParis_t$. Thus, we capture λ in the data via the interaction $EmissionsIntensity_{i,t-1} \times PostParis_t$. The reasoning is that the Paris Accord delivered country-wide commitments to act to keep global warming at most at 1.5 degrees Celsius above pre-industrial temperatures. These commitments and the regulatory changes that they entail are likely to impact more acutely more polluting firms before the regulations take place.

Proposition 2 predicts that investment is relatively lower in more polluting firms following the regulatory shock, which we test with the hypothesis of a negative coefficient on the interaction term $EmissionsIntensity_{i,t-1} \times PostParis_t$ when the dependent variable is the log of capital expenditures or capital expenditures to assets. Proposition 2 also predicts that emissions increase following the regulatory shock. We therefore hypothesize a positive sign on the coefficient on the interaction $EmissionsIntensity_{i,t-1} \times PostParis_t$ when the dependent variable is log emissions intensity. Proposition 4 predicts borrowing frictions tighten following climate regulation. We thus hypothesize that the coefficient on the interaction term $EmissionsIntensity_{i,t-1} \times PostParis_t$ is positive for the dependent variable offering yield and negative for time to maturity.

We capture firms' exposure to future regulation (a component of λ) through their emissions intensity. We are motivated by evidence that in some industries institutional investors base their exclusionary screening on emissions intensity. In addition, Hsu, Li, and Tsou (2023) provides evidence of a premium in public equity linked to emissions intensity. Also, the 2010 Waxman-Markey bill, the only climate bill to ever pass one of the houses of Congress, selected firms to be included using energy intensity (a normalized measure of scope 2 emissions) as further discussed below. Also, if emissions intensity is a technology feature, with some technologies being more polluting than others, then there is a question of whether to target (via regulation, taxation, or subsidies to innovation) industries with high revenues and high emissions, but possibly low emissions intensity, or industries with intensive polluting technologies, especially given that the goal so far appears to have been to achieve decarbonization without compromising too much on output (see Nordhaus 2019 and Aswani, Raghunandan, and Rajgopal 2023).

We augment the baseline specification to test the prediction in Proposition 3 that exposed firms will invest more in the period prior to the regulatory shock if it has higher volatility operating cash profit. Consequently, exposed firms will have higher emissions following the regulatory shock. We use the panel regression specification:

$$
\begin{aligned}
y_{i,t} = {} & \beta_0 EmissionsIntensity_{i,t-1} + \beta_1 EmissionsIntensity_{i,t-1} \times PostParis_t \\
& + \beta_2 EmissionsIntensity_{i,t-1} \times PostParis_t \times CashFlowVol_{i,t-1} \\
& + \beta_3 EmissionsIntensity_{i,t-1} \times CashFlowVol_{i,t-1} + \beta_4 PostParis_t \times CashFlowVol_{i,t-1} \\
& + \beta_5 CashFlowVol_{i,t-1} + \gamma Z_{i,t-1} + \theta_{i,t} + \epsilon_{i,t}, \qquad (9)
\end{aligned}
$$

where $CashFlowVol$ is a measure of a firm's volatility of cash flows (i.e., operating profits). We use the standard deviation of quarterly $\frac{EBITDA}{Assets}$ over three or five year horizons. We consider both the continuous measure and an indicator $IsHighCashFlowVol$ that takes a value of one if a firm's $CashFlowVol$ is above the median and zero otherwise. The other variables are as defined in the baseline specification (8).

Here, the coefficient of interest is β_2 on the triple interaction. In this setting, a negative β_2 in regressions with investments outcomes and a positive β_2 for emissions outcomes will be consistent with Proposition 3 predictions.

4.2 Waxman-Markey cap-and-trade bill

The American Clean Energy and Security Act of 2009, commonly known as the Waxman–Markey Bill, named after its sponsors, Representatives Henry Waxman and Edward Markey, is to date the most significant attempt at a federally mandated emissions trading system, also known as cap-and-trade.[10]

During the period between the bill's passage in the House in June 26, 2009 and its

[10] Cap-and-trade systems are designed to set a limit on total GHG emissions (the cap component) and establish a market in which regulated emitters can buy and sell emission allowances (the trade component). Following the establishment of the first major emission trading system, the European Union Emission Trading System in 2005, the United States saw the implementation of cap-and-trade programs at the regional level (e.g., the Regional Greenhouse Gas Initiative launched in 2009 to regulate power-sector emissions in participating states, and the California Cap-and-Trade Program established in 2013).

subsequent consideration in the Senate, there was a high probability substantial uncertainty about whether the legislation will eventually be enacted (Meng, 2017). The bill ultimately did not pass in the Senate and the threat of regulation diminished after July 22, 2010 (i.e., in early 2010 Q3). An important design element of the Waxman-Markey Bill in implementing the cap-and-trade program is the issuance of emission allowance rebates, which are essentially free emission permits. The bill would grant free permits to manufacturing firms (NAICS code beginning with 31, 32, or 33) with an energy intensity above 5% and trade intensity above 15%.[11] The distribution of the free allowances was scheduled to gradually phase out from 2026 to 2035. As discussed in Meng (2017) and Ivanov, Kruttli, and Watugala (2024), this policy design enables us to use a difference-in-difference methodology to identify causal effects. For firms that satisfy the 15% trade intensity threshold, those near the 5% energy intensity threshold have similar emission profiles. The treated (non-exempt) group consists of firms with energy intensity below 5%, while the control group includes firms with energy intensity above 5% that would receive free permits. We show specifications both for the sample of all U.S. manufacturing firms and those with with energy intensity between 1% and 9%.

Ivanov, Kruttli, and Watugala (2024), studying bank loans in this Waxman-Markey (WM) setting, show that treated firms, those that do not receive free permits, are more likely to face higher borrowing constraints. They find that banks boost discretion and retain flexibility over the financing provided to exposed borrower firms. Given that these effects are observed by the end of 2009, it is likely that firms anticipated costlier financing if the bill were to eventually pass in the Senate and become law. Proposition 2 predicts that in that case the policy effects should manifest in both higher firm investment ahead of the future increases in borrowing costs and future increases in emissions. However, the EPA's GHGRP data are not available prior to 2010 and due to the absence of comparable comprehensive

[11] See description under "Subpart 1 – Emission Allowance Rebate Program", Section 763. https://www.congress.gov/bill/111th-congress/house-bill/2454/

emissions data for that period from other sources, we focus our WM analysis on investment effects.

We use a similar regression framework as that for the Paris Accord analysis and to conserve on space omit its full description here. To ameliorate any confounding effects due to the global financial crisis and narrow the focus around the passage of this in particular, we include eight quarters in our sample As with the Paris shock, the pre-period is the period of elevated probability of future enacted regulation. Hence, the interaction of the treated firm indicator ($NoExemption$) with quarter dummies from 2009 Q2 (after the House passed the legislation) to 2010 Q2 (after which the Senate dropped its consideration) capture the effect of the model parameter λ.

We use S&P Capital IQ quarterly financial data for U.S. public and private firms. The quarterly frequency allows us to better capture firms' responses during the policy uncertainty window from May 2009 to December 2010 (seven quarters). To identify firms' eligibility for free permits, we obtain six-digit NAICS codes from S&P Capital IQ and supplement missing or shorter codes using S&P Capital IQ Pro, Compustat, and Mergent Intellect. All codes are converted to the 2002 NAICS classification, which is the industry definition used in the original bill. We merge these data with energy intensity and trade intensity measures at six-digit NAICS code level from the bill to define the treated and control groups. We obtain the energy and trade intensity measures for six-digit NAICS industries from Meng (2017). For the six-digit NAICS industries that are not in the sample of Meng (2017) but are in ours, we use the Annual Survey of Manufacturers or alternatively the Census to compute the energy intensity and data from USITC to compute the trade intensity.

5 Results

We first show the results using the Paris Accord shock and then the Waxman-Markey bill passage.

5.1 Paris Accord

5.1.1 Corporate investment

Proposition 2 suggests that with higher financing costs in the regulation state, firms with higher emissions intensity invest relatively more in the pre-Paris period and less in the post-Paris period.

Table 2 presents results from estimating the regression specification described in equation (8) with changes to capital expenditures and capital expenditures to assets as the dependent variables. The independent variable of interest is the interaction $IsHighEOR \times PostParis$ For each dependent variable we present three regressions with different combinations of fixed effects. All regressions include the baseline set of control variables: firm size (the logarithm of assets), leverage (debt to assets ratio), fraction of tangible assets (property plant and equipment to assets), fraction of liquid assets (cash to assets), and CAPEX to assets.

The results show that n the post-Paris period, firms with a higher emissions intensity see a reduction in their subsequent capital expenditures, consistent with the model prediction in Proposition 2. The results are particularly economically significant for the regression specifications with firm and industry times year fixed effects. In column (5), in the post-Paris period, firms with above median emissions intensity experience an investment rate in the following year that is 1.1% lower than firms that are less emissions inefficient. This effect corresponds to 16% (1.1/6.9) of the average investment rate in our sample. When the dependent variable is the change in log capital expenditures (columns (2) and (3)) the results are qualitatively similar with growth in CAPEX decreasing by roughly 10%. This result is in line with unconditional changes in *aggregate* investment for heavy emitters versus low emitters pre- and post-2015 found in Jagannathan, Meier, and Sokolovski (2025). It is also consistent with evidence in Ladika, Pazaj, and Sautner (2025).

High-emissions intensity firms have a higher investment rate in the pre-Paris period (columns (4) through (6)), though none of the estimated coefficients are statistically significant. Regarding the other control variables, larger firms tend to invest more in dollar terms, but have a lower investment rate, suggestive of decreasing returns to scale. Firms with higher property plant and equipment in place also have lower investment and investment rates. More leveraged firms have lower investment, which could be an indication of many things, including possibly debt overhang. Firms with more cash to assets have higher investment. The negative coefficient on lagged CAPEX over assets potentially captures mean reversion in firm investment rates.

5.1.2 CO2e Emissions

Proposition 2 predicts higher emissions following the shock to regulatory risk. We test this prediction using our baseline regression specification (8) both both emissions intensity (i.e., emissions inefficiency) and emissions levels.

Table 3 presents the results with firm emissions intensity as the dependent variable. In columns (1) to (3), the treatment variable is lagged log emissions intensity, a continuous measure, and in columns (4) to (6) the treatment variable is the indicator variable for emissions intensity above the sample median. The control variables are the same as those used in Table 2, including the various combinations of fixed effects.

In columns (1) to (3), we see that post-Paris, firms with higher emissions intensity, that is, the firms more exposed to the climate regulatory shock, subsequently have greater emissions intensity after accounting for baseline levels of autocorrelation in emissions intensity.[12] This indicates that, paradoxically, polluting firms become even more emissions inefficient and emit more CO2e per dollar of revenue following the Paris Accord. This result is consistent with model predictions. In related work, Hartzmark and Shue (2023) show that an increase in borrowing costs for brown firms makes them pollute more contemporaneously to the increase in costs, whereas a decrease in borrowing costs to green firms does not make them greener. Our hypothesis is that the prospect of climate regulation and the associated higher borrowing costs motivates current investment in the brown technology, a distinct and complementary mechanism. According to the hypothesis we study, investment occurs in anticipation of higher borrowing costs and increased pollution is a reflection of the earlier investment.

Of the control variables, we do not find that firm size affects the future level of emissions intensity. However, the share of property, plant, and equipment in total assets and the share of cash in assets are positively related to emissions intensity, suggesting that asset tangibility and asset liquidity are both linked to firm emissions efficiency. We also find that leverage is negatively associated with emissions intensity, which could be because debt financing dislikes the risks associated with being a high-emitter firm.

In Table 4, we present results for how the level of emissions changes post Paris. In Panel A, the dependent variable is log emissions and in Panel B the dependent variable is changes in log emissions. The two panels in the table follow the same structure as that in Table 3. We find that the level and growth of emission levels increase post Paris for high emissions intensity firms.

We conclude that high emissions intensity firms increased both their emissions intensity and levels post Paris, consistent with the model and the predicted anticipatory investment by these firms.

[12] In unreported results, we also include lagged emissions levels, $log(Emissions)$ and obtain qualitatively unchanged results.

5.1.3 Cash flow volatility

Proposition 3 predicts that the green paradox effects related to firm investments and subsequent emissions will be stronger for firms with higher cashflow volatility. We test these predictions as described in the regression specification in equation (9). In the post-Paris period, the model prediction is in line with more negative investments and more positive emissions for firms with higher cash flow volatility.

Table 5 presents the results for investments using the same two outcome variables as in the baseline investments analysis in Table 2, $\Delta log(CAPEX)$ and $\frac{CAPEX}{Assets}$. For parsimony, the table shows the coefficients and significance of the triple interaction variable of interest for both continuous and indicator variables capturing the volatility of firm operating profits. The coefficients are negative and significant, consistent with predictions.

Table 6 presents the results with the same emissions outcome variables that are in Tables 3 and 4, which capture emissions intensity ($log(\frac{Emissions}{Revenue})$) and emission levels ($\Delta log(Emissions)$ and $log(Emissions)$). For parsimony, the table shows the coefficients and significance of the triple interaction variable of interest for indicator variables capturing the volatility of firm operating profits. The coefficients are positive and significant, consistent with predictions.

5.1.4 Corporate bond issuance

Table 7 shows results from estimating the firm-year regression specification in equation (8) when the dependent variable is one of four bond market variables: log of the amount offered, average offered yield weighed by issued amount, average offered yield weighed by maturity, and average time to maturity weighed by amount issued. The right hand side variables are the same as those used in Table 2.

In columns (1) and (2), the dependent variable is the offering amount. The coefficient on the logarithm of Emissions/Revenue is positive but statistically insignificant. Same applies to the coefficient on the indicator variable, $IsHighEOR$. The interactions with $PostParis$ are also insignificant. In columns (3) and (4), the dependent variable is the average offering yield weighed by issued amount, and in columns (5) and (6), the dependent variable is the average offering yield weighed by time to maturity. We make this distinction because firms that shift to lower maturity bonds may benefit from lower yields due to the (generally positive) slope of the yield curve (e.g., a firm that issues two bonds with two years apart in offered maturity and shifts to lower maturities puts greater weight on the longer maturity bond). In fact, column (3) shows that more emissions inefficient firms experienced lower yields in the post Paris period of our sample, but this effect disappears when we weigh offered yields by the offered bonds' time to maturity. Lastly, columns (7) and (8) show results for time to maturity. The coefficient on the interaction variable on interest, emissions intensity interacted with $PostParis$, is negative and significant at the 1% level. The estimated coefficient suggests that an increase in firm emissions intensity by one standard deviation is associated with a decrease in bond maturity issuance of 1.33 years (-0.486×2.735 years). We find a quantitatively slightly larger result in column (8): in the post Paris period, a firm with above median emissions intensity issued bonds with 1.7 years shorter maturity than more emissions efficient firms. These decreases in maturity are economically significant, representing about 14% (16.6%) of sample mean (median) maturity (the average (median) maturity of offered bonds in our sample is 12.3 (10.2) years).

Overall, the results indicate that more emissions-inefficient firms offer bonds of shorter maturity following the Paris Accord consistent with a tightening of financing conditions as predicted in Proposition 4. We find no statistically significant change in offered yields in the post Paris period for the high polluters viz-a-viz the less polluting firms when weighing yields by maturity. One possible interpretation of this result is that firms adjusted to an upward parallel shift of their yield curve post Paris by borrowing more short term. By weighing offered yields by maturity we control for this effect. Despite this shift in maturity, firms were not able to lower their overall issuance yield. Seltzer, Starks, and Zhu 2025 and others find additional evidence of tightening of financing costs for emissions inefficient firms post Paris.

The coefficients on the control variables in these regressions are unsurprising. Larger firms tend to pay lower yields but also borrow at shorter maturities. Firms with higher leverage then to issue less and at higher yields and firms with more tangible assets (i.e., higher NPPE to assets) tend to issue larger amounts.

5.1.5 Total debt and cash holdings

We study two more financial variables, total debt and corporate cash holdings. We expect that debt grows at a slower pace for high-pollution firms after the regulatory shock compared to low-pollution firms, consistent with the prediction from Proposition 4 of costlier financing after the regulatory shock. In addition, in the spirit of the argument of the model, a riskier regulatory environment post-Paris may motivate a precautionary reduction in debt and an increase in cash holdings relative to total assets. The cash flow used to fund these changes in debt and cash may come from the investments made prior to the regulatory shock that start paying out or from the reduced investment post-Paris.

Table B.1 in Appendix B presents results for the growth rate of debt and cash and for the stock of debt to total assets and cash holdings to total assets. The regressions include lagged values of the following control variables: firm size (the logarithm of assets), leverage (debt-to-assets ratio), fraction of tangible assets (property plant and equipment to assets), fraction of liquid assets (cash to assets), and CAPEX to assets. The regressions include year, firm, or industry times year fixed effects.

The results in columns (3) and (7) suggest that cash holdings to assets increase post-Paris for the high polluting firms and debt to assets decrease consistent with the predictions above. In the regression that we saturate with firm and industry times year fixed effects, we no longer find significant effects–the coefficient on the interaction term is economically smaller only in the case of debt to assets–but the signs of the coefficient estimates remain the same.

5.2 Waxman-Markey bill

Table 8 contains summary statistics for the variables used in the analysis. Panel A contains the baseline sample, a sample that includes all firms in the relevant manufacturing NAICS codes (codes 31, 32, and 33) for which we have emissions and balance sheet data. There are a total of 8,587 firm-quarter observations, representing just under 1,100 unique firms. Panel B contains the sample of firms that are in a 4 percentage points range around the 5% threshold of energy intensity. There is a significant drop in the number of observations to 3,018 firm-quarter observations or roughly 380 unique firms. The firms in the smaller sample have higher energy intensity and higher CAPEX, but are not significantly larger firms; they are otherwise similar in terms of average statistics. Below, we present results using the baseline sample and the sample with tighter identification using the proximity to the threshold of 5%.

Table 9 presents the analysis of the effects of climate policy uncertainty on firm investment during the 8-quarter period surrounding the passage of the Waxman-Markey bill through Congress, as described in section 4.2. The table presents results for the two firm samples. In Panel A, we use the baseline sample and define treated firms as those with energy intensity below 5%. In Panel B, we again define treated firms as those with energy intensity below 5%, but restrict the sample to firms within 4 percentage points of this threshold. Treated firms are identified with the indicator variable $NoExemption$.

Both panels display results for changes in log CAPEX in columns (1) through (3) and for CAPEX to total assets in columns (4) through (6), mirroring the Paris CAPEX regressions in Table 2. We interact the $NoExemption$ with quarter dummies to track the treatment effect over time, with 2009 Q1 as the reference quarter. Regressions include a combination of year-quarter, industry, and firm fixed effects as indicated, and the baseline set of control variables: firm size (the logarithm of assets), leverage (debt to assets ratio), fraction of tangible assets (property plant and equipment to assets), fraction of liquid assets (cash to assets), CAPEX to assets.

Both panels show a significant increase in the growth rate of CAPEX and in CAPEX to assets in the first quarter of 2010 for the treated firms relative to the first quarter of 2009 compared to the control group. For example, the coefficient 0.548 in panel B column (3) associated with $NoExemption$ times 2010Q1 implies an increase in the growth rate of CAPEX of 0.0087 post Paris compared to the control group. Because of the high frequency of the analysis, we interpret this finding under the hypothesis that there are investment lags: firm investment plans started while the prediction markets priced in a high probability of the bill passing, i.e., during the second half of 2009 and early 2010, and these investments show up as actual spending in 2010 Q1. Towards the end of that quarter, the probability of the bill passing is already declining. Afterwards investment rates are not significantly different from those in the first quarter of 2009. While the identification strategy within the set of U.S. high-emission, manufacturing firms supports the isolation of casual effects, the relative high frequency of changes to regulatory risk in the WM analysis introduces challenges to empirical measurement.

Regarding the control variables, the coefficients are broadly similar to the investments analysis for the Paris analysis presented in Table 2. Firms with more tangible assets and cash to assets invest more during the period. Unsurprisingly, CAPEX to assets is autocorrelated. Also, firms with more CAPEX to assets have lower subsequent growth in investment levels, suggesting mean reversion in firm investment.

6 Conclusion

We show how financing can interact with firm policies inducing firms to exhibit behavior consistent with a "green paradox," where polluting firms increase ex ante investment in the expectation of future climate regulation and eventually pollute more. We develop a simple model of firm financing and investment that predicts higher investment prior to the regulatory shock and a worsening of credit terms after the regulatory shock for firms more exposed to the shock. In our empirical analysis, using the Paris Climate Accord and the Waxman-Markey bill as shocks to future climate regulation risk, we find evidence consistent with the model. In both settings, more exposed firms have higher investment prior the climate regulatory shock. For the Paris Accord setting where we have emissions data, we find an increase in emissions intensity and levels post Paris. These investment and emissions effects are stronger for firms with higher cash flow volatility. Further, these high-emissions intensity firms issue shorter-maturity bonds post-Paris without any significant decrease in yields at issuance. Overall, we find empirical evidence consistent with model predictions.

We allow for a regulatory decision maker in the model and consider the implications of a regulation equilibrium. We show that there can be multiple equilibria and the reason for the multiplicity of equilibria is tied directly to the existence of a green paradox. This is because the model predicts an increase in pollution when the regulatory state becomes more likely, and we assume that the regulator is more likely to initiate regulation if it observes increased investment by polluting firms. The multiplicity of equilibria suggests that changes in firms' expectation of regulation can trigger an escalade of investment by polluting firms. There are interesting attenuating forces to the multiplicity of equilibria. For example, if the early investments require growing the firm's labor force, then the regulator may feel less inclined to promote regulation that results in job loss. These predictions are worth further study.

Our findings show that high-emissions firms that expect financing frictions to intensify under future climate regulatory shocks may in fact initiate investments that eventually lead to increased pollution. As such, the green paradox hypothesis suggests that long periods where the threat of climate regulation remains high without the actual passage and implementation of binding regulation that puts a price on GHG emissions may have counterproductive effects. The model also suggests that these unintended effects of delays in regulation can be reversed if polluting firms' expect the capital market to penalize them independently of whether the regulator takes action, but it is yet unclear in the literature what financial trade-off are investors willing to accept to do so.

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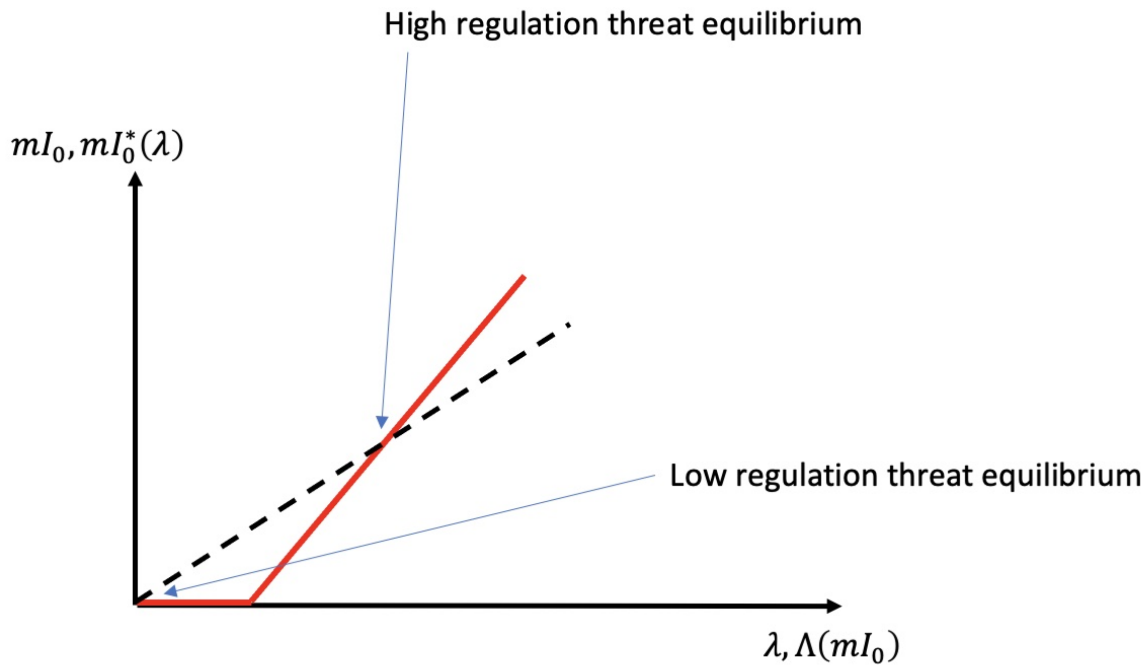

Figure 1: Equilibrium regulation levels and industry investment

The y-axis displays values for industry investment, $mI_0^*(\lambda)$, as a function of λ (solid line). The x-axis displays values of the regulatory function, $\Lambda(mI_0)$, as a function of mI_0 (dashed line). The points where the two curves intersect are equilibrium points.

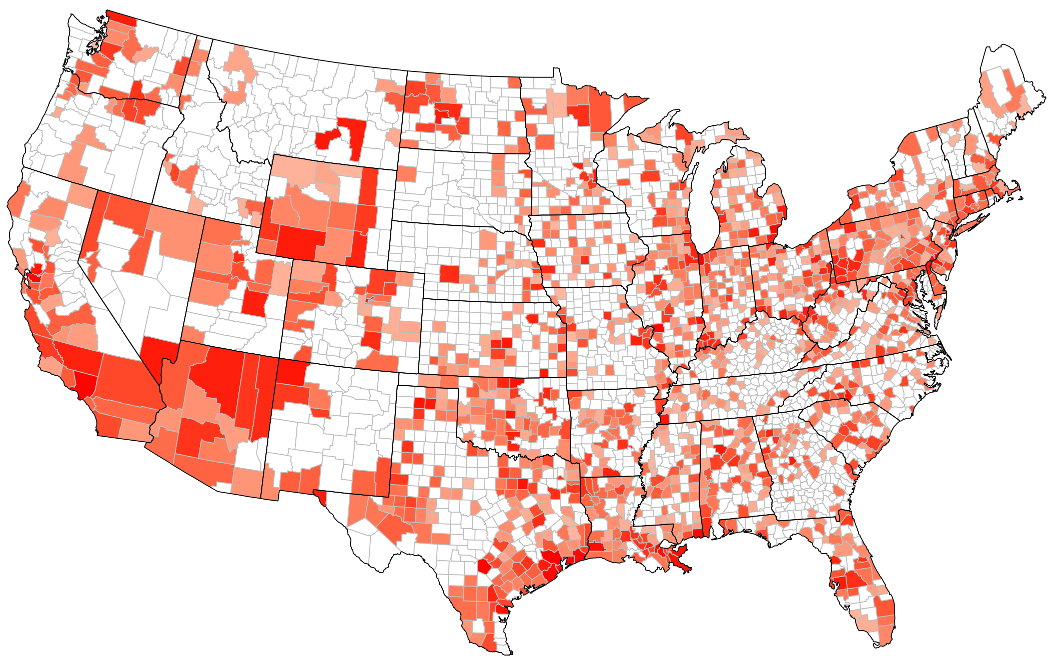

Figure 2: County-Level Emissions Based on EPA Facilities

This figure shows county-level emissions based on the EPA facilities located in a given county for public and private firms. Only facilities of EPA firms that are also in the Capital IQ data are included. The data illustrated in the figure are for 2015. Our analysis uses the time series.

Table 1: Summary Statistics - Paris Analysis

This table shows the summary statistics for the main variables used in the Paris analysis. The data are annual from 2010 to 2020. Table B.2 presents all variable definitions. Panel A presents summary statistics for the sample of EPA firms. Panel B gives summary statistics for the sample of Mergent firms. The N column shows the number of observations used to calculate the statistics in a particular row. The last four columns show percentiles.

Panel A: Firm emissions and balance sheet information (EPA sample)

	N	Mean	Median	Stdev	25th	75th	10th	90th
$log(Emissions)$	2,679	13.537	13.255	2.409	11.502	15.604	10.642	17.053
$log(\frac{Emissions}{Revenue})$	2,628	5.562	5.972	2.510	3.671	7.681	1.896	8.658
$\Delta log(Emissions)$	2,679	0.012	0.000	0.425	-0.083	0.082	-0.238	0.270
$log(CAPEX)$	2,599	5.667	5.759	1.971	4.505	7.150	3.155	8.127
$\Delta log(CAPEX)$	2,597	0.019	0.033	0.495	-0.188	0.247	-0.530	0.544
$\frac{CAPEX}{Assets}$	2,599	0.069	0.052	0.065	0.031	0.082	0.018	0.137
$log(Assets)$	2,666	8.579	8.647	1.826	7.422	9.980	6.259	10.873
$\frac{Debt}{Assets}$	2,666	0.359	0.338	0.205	0.231	0.460	0.127	0.610
$\frac{NPPE}{Assets}$	2,664	0.507	0.527	0.243	0.308	0.718	0.153	0.810
$\frac{Cash}{Assets}$	2,642	0.058	0.036	0.066	0.011	0.083	0.003	0.144
$CashFlowVol5Y$	2,590	0.014	0.009	0.016	0.005	0.016	0.004	0.029
$CashFlowVol3Y$	2,590	0.012	0.008	0.013	0.005	0.014	0.003	0.026

Panel B: Bond offerings information (Mergent sample)

	N	Mean	Median	Stdev	25th	75th	10th	90th
log(Total Offering Amount)	1,155	14.044	13.976	1.079	13.122	14.809	12.663	15.554
Amount-Weighted Offering Yield (%)	1,068	4.484	4.121	1.891	3.189	5.267	2.521	6.884
Maturity-Weighted Offering Yield (%)	1,068	4.653	4.326	1.802	3.487	5.375	2.823	6.885
TTM (in Years)	1,155	12.301	10.167	6.788	7.848	15.419	6.097	21.952
$log(\frac{Emissions}{Revenue})$	1,155	5.246	5.670	2.735	2.895	7.607	1.265	8.603
$log(CAPEX)$	1,151	6.823	7.057	1.460	5.879	7.905	4.717	8.525
$\frac{CAPEX}{Assets}$	1,151	0.079	0.058	0.078	0.032	0.086	0.020	0.169
$log(Assets)$	1,150	9.660	9.844	1.422	8.729	10.680	7.604	11.323
$\frac{Debt}{Assets}$	1,150	0.354	0.334	0.169	0.250	0.436	0.171	0.546
$\frac{NPPE}{Assets}$	1,150	0.504	0.528	0.255	0.283	0.717	0.138	0.841
$\frac{Cash}{Assets}$	1,140	0.048	0.029	0.054	0.008	0.070	0.002	0.115

Table 2: Firm Capital Expenditure

This table presents results of the panel regression model given in equation (8). The data are annual from 2010 to 2020. The dependent variables are $\Delta log(CAPEX_{i,t})$ in Columns (1) - (3), and $\frac{CAPEX_{i,t}}{Assets_{i,t}}$ in Columns (4) - (6). The specifications include a combination of year, industry, firm, and industry-year fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	$\Delta log(CAPEX_{i,t})$			$\frac{CAPEX_{i,t}}{Assets_{i,t}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$IsHighEOR_{i,t-1} \times PostParis_t$	-0.032	-0.093**	-0.126**	-0.004	-0.011***	-0.010**
	-0.910	-2.198	-2.382	-1.494	-3.375	-2.340
$IsHighEOR_{i,t-1}$	-0.003	-0.027	0.015	0.002	0.006	0.008
	-0.081	-0.414	0.238	0.708	1.060	1.491
$log(Assets_{i,t-1})$	-0.024***	-0.287***	-0.320***	-0.001*	-0.007	-0.011***
	-3.813	-4.575	-6.096	-1.650	-1.466	-2.762
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.212**	-0.595***	-0.442***	-0.016***	-0.069***	-0.056***
	-2.431	-3.995	-2.839	-3.253	-4.232	-3.490
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	-0.064	-1.342***	-1.311***	0.011	-0.106***	-0.112***
	-0.718	-5.312	-5.194	1.435	-5.202	-5.218
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.987***	1.076***	1.096***	0.073***	0.077***	0.084***
	4.213	3.646	3.645	3.600	3.180	3.453
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	-2.265***	-4.243***	-4.784***	0.639***	0.385***	0.328***
	-7.112	-10.069	-12.492	24.674	9.100	6.534
Year FE	Y	Y	N	Y	Y	N
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	Y	N	Y	Y
Industry × Year FE	N	N	Y	N	N	Y
Observations	2,567	2,567	2,567	2,569	2,569	2,569
Adjusted R^2	0.138	0.236	0.295	0.691	0.750	0.765

Table 3: Firm Greenhouse Gas Emissions Intensity

This table presents results of the panel regression model given in equation (8). The data are annual from 2010 to 2020. The dependent variable is $log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$. The specifications include a combination of year, industry, firm, and industry-year fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	(1)	(2)	(3)	(4)	(5)	(6)
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}}) \times PostParis_t$	0.028***	0.017**	0.034*			
	3.351	2.033	1.723			
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}})$	0.880***	0.470***	0.428***			
	45.043	9.599	7.513			
$IsHighEOR_{i,t-1} \times PostParis_t$				0.316***	0.177***	0.231**
				3.095	2.908	2.088
$IsHighEOR_{i,t-1}$				2.210***	0.689***	0.568***
				14.437	4.245	3.711
$log(Assets_{i,t-1})$	-0.000	-0.017	0.016	-0.125***	-0.094	-0.055
	-0.012	-0.338	0.313	-3.554	-1.246	-0.794
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.004	-0.287**	-0.240*	0.134	-0.305**	-0.290**
	-0.056	-2.278	-1.906	0.549	-2.205	-2.061
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	0.677***	0.702***	0.699**	2.200***	0.670**	0.640**
	5.565	2.652	2.402	5.779	2.136	2.005
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.211	0.709**	0.998***	0.912	0.765**	0.941**
	0.847	2.246	2.789	1.302	2.043	2.298
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	-0.054	-0.077	-0.024	-0.308	-0.123	-0.060
	-0.206	-0.213	-0.063	-0.384	-0.295	-0.136
Year FE	Y	Y	N	Y	Y	N
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	Y	N	Y	Y
Industry × Year FE	N	N	Y	N	N	Y
Observations	2,562	2,562	2,562	2,564	2,564	2,564
Adjusted R^2	0.946	0.958	0.959	0.815	0.948	0.950

Table 4: Firm Greenhouse Gas Emissions Level

This table presents results of the panel regression model given in equation (8). The data are annual from 2010 to 2020. The dependent variable is $log(Emissions_{i,t})$ for Panel A and $\Delta log(Emissions_{i,t})$ for Panel B. The specifications include a combination of year, industry, firm, and industry-year fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Outcome variable: $log(Emissions_{i,t})$

	(1)	(2)	(3)	(4)	(5)	(6)
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}}) \times PostParis_t$	0.034***	0.019**	0.043**			
	3.603	2.330	1.968			
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}})$	0.016	0.067	0.035			
	0.486	0.654	0.326			
$IsHighEOR_{i,t-1} \times PostParis_t$				0.179***	0.118**	0.197*
				3.509	2.317	1.809
$IsHighEOR_{i,t-1}$				-0.113	-0.086	-0.117
				-1.607	-0.719	-0.883
$log(Emissions_{i,t-1})$	0.855***	0.379***	0.371***	0.888***	0.452***	0.425***
	20.858	3.047	2.931	33.300	6.533	5.763
$log(Assets_{i,t-1})$	0.114***	0.297***	0.364***	0.085***	0.251***	0.332***
	3.043	3.572	3.907	3.747	4.127	4.660
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.013	-0.112	-0.101	-0.022	-0.122	-0.112
	-0.168	-0.837	-0.744	-0.272	-0.937	-0.841
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	0.501***	0.431*	0.509*	0.538***	0.465*	0.534*
	4.095	1.677	1.769	4.400	1.930	1.933
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.201	0.766***	1.051***	0.177	0.749***	0.990***
	0.771	2.805	3.201	0.680	2.803	3.125
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	0.103	-0.108	-0.057	0.095	-0.099	-0.051
	0.388	-0.257	-0.116	0.350	-0.233	-0.103
Year FE	Y	Y	N	Y	Y	N
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	Y	N	Y	Y
Industry $\times$ Year FE	N	N	Y	N	N	Y
Observations	2,610	2,610	2,610	2,610	2,610	2,610
Adjusted R^2	0.930	0.946	0.945	0.930	0.946	0.945

Panel B: Outcome variable: $\Delta log(Emissions_{i,t})$

	(1)	(2)	(3)	(4)	(5)	(6)
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}}) \times PostParis_t$	0.022***	0.010*	0.021			
	4.055	1.683	1.235			
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}})$	-0.022	-0.057	-0.101*			
	-1.047	-1.079	-1.823			
$IsHighEOR_{i,t-1} \times PostParis_t$				0.115***	0.050*	0.076
				3.383	1.711	1.201
$IsHighEOR_{i,t-1}$				-0.125***	-0.173**	-0.197**
				-2.799	-2.034	-2.229
$log(Emissions_{i,t-1})$	-0.049**	-0.264***	-0.243***	-0.048***	-0.285***	-0.293***
	-2.483	-4.791	-4.226	-4.372	-6.463	-5.886
$log(Assets_{i,t-1})$	0.038**	0.120***	0.150***	0.038***	0.140***	0.193***
	2.164	2.634	2.836	3.736	3.333	3.901
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.009	-0.084	-0.128	-0.021	-0.083	-0.125
	-0.178	-0.812	-1.252	-0.410	-0.797	-1.189
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	0.331***	0.414**	0.461**	0.340***	0.418**	0.457**
	4.367	2.192	2.276	4.504	2.279	2.262
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.155	0.568***	0.660***	0.125	0.551***	0.621***
	0.944	2.822	2.995	0.758	2.801	2.895
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	0.082	-0.110	-0.015	0.054	-0.139	-0.049
	0.396	-0.354	-0.039	0.259	-0.437	-0.128
Year FE	Y	Y	N	Y	Y	N
Industry FE	Y	N	N	Y	N	N
Firm FE	N	Y	Y	N	Y	Y
Industry × Year FE	N	N	Y	N	N	Y
Observations	2,610	2,610	2,610	2,610	2,610	2,610
Adjusted R^2	0.066	0.262	0.256	0.068	0.264	0.256

Table 5: Firm Cash Flow Volatility and Capital Expenditure

This table presents results of the panel regression model given in equation (9). The data are annual from 2010 to 2020. The dependent variables are $\Delta \log(CAPEX_{i,t})$ in Columns (1)–(4) and $\frac{CAPEX_{i,t}}{Assets_{i,t}}$ in Columns (5)–(8). The specifications include a combination of year and firm fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	$\Delta log(CAPEX_{i,t})$				$\frac{CAPEX_{i,t}}{Assets_{i,t}}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$IsHighEOR_{i,t-1} \times PostParis_t$								
$\times CashFlowVol5Y_{i,t-1}$	-10.222***				-0.573*			
	-2.841				-1.686			
$\times CashFlowVol3Y_{i,t-1}$		-12.710***				-0.662*		
		-2.769				-1.650		
$\times IsHighCashFlowVol5Y_{i,t-1}$			-0.219***				-0.016**	
			-2.732				-2.416	
$\times IsHighCashFlowVol3Y_{i,t-1}$				-0.182**				-0.019***
				-2.329				-2.760
Lower-order terms	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,501	2,501	2,501	2,501	2,502	2,502	2,502	2,502
Adjusted R^2	0.236	0.237	0.236	0.236	0.755	0.755	0.756	0.756

Table 6: Firm Cash Flow Volatility and Emissions

This table presents results of the panel regression model given in equation (9). The data are annual from 2010 to 2020. The dependent variables are $\log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$ in Columns (1)–(2), $\Delta\log(Emissions_{i,t})$ in Columns (3)–(4), and $\log(Emissions_{i,t})$ in Columns (5)–(6). The specifications include a combination of year and firm fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	$log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$		$\Delta log(Emissions_{i,t})$		$log(Emissions_{i,t})$	
	(1)	(2)	(3)	(4)	(5)	(6)
$IsHighEOR_{i,t-1} \times PostParis_t$						
$\times IsHighCashFlowVol5Y_{i,t-1}$	0.245**		0.111		0.212*	
	2.277		1.628		1.924	
$\times IsHighCashFlowVol3Y_{i,t-1}$		0.225**		0.119*		0.188*
		2.204		1.803		1.785
Lower-order terms	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Observations	2,502	2,502	2,547	2,547	2,547	2,547
Adjusted R^2	0.956	0.957	0.262	0.261	0.947	0.947

Table 7: Firm Corporate Bond Issuance

This table presents results of the panel regression model given in equation (8). The data are annual from 2010 to 2020. The dependent variables are log(offering amount) in Columns (1) - (2), amount-weighted yield (in %) in Columns (3) - (4), maturity-weighted yield (in %) in Columns (5) - (6), and time to maturity in Columns (7) - (8). All specifications include year fixed effects and firm fixed effects. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	log(Total Offering Amount)		Amount-Weighted Offering Yield (%)		Maturity-Weighted Offering Yield (%)		TTM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}}) \times PostParis_t$	0.015		-0.059**		-0.036		-0.486***	
	0.846		-2.174		-1.353		-3.029	
$IsHighEOR_{i,t-1} \times PostParis_t$		0.134		-0.196		-0.076		-1.702*
		1.262		-1.235		-0.488		-1.892
$log(\frac{Emissions_{i,t-1}}{Revenue_{i,t-1}})$	0.031		0.074		0.058		0.023	
	0.490		1.217		0.917		0.076	
$IsHighEOR_{i,t-1}$		0.179		0.148		0.055		0.624
		1.284		0.761		0.287		0.782
$log(Assets_{i,t-1})$	-0.021	-0.025	-0.157**	-0.172**	-0.176***	-0.190***	-0.461*	-0.383*
	-0.419	-0.577	-2.385	-2.558	-2.783	-2.972	-1.935	-1.802
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.376	-0.334	0.869*	0.934*	0.739	0.800*	-0.194	-0.192
	-1.022	-0.940	1.708	1.933	1.515	1.734	-0.112	-0.115
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	1.105***	1.054***	0.588	0.567	0.681	0.653	-0.081	-0.439
	2.799	2.728	0.803	0.757	0.970	0.912	-0.041	-0.218
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.698	0.640	-0.777	-0.852	-0.826	-0.892	-1.040	-1.136
	0.874	0.805	-0.572	-0.612	-0.623	-0.659	-0.264	-0.296
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	1.110	1.146	-3.791***	-3.794***	-3.910***	-3.875***	-3.001	-2.705
	1.402	1.429	-3.385	-3.355	-3.585	-3.533	-0.873	-0.806
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,140	1,142	1,054	1,056	1,054	1,056	1,140	1,142
Adjusted R^2	0.583	0.584	0.723	0.723	0.719	0.719	0.431	0.425

Table 8: Summary Statistics - Waxman-Markey Analysis

This table shows the summary statistics for the main variables used in the Waxman-Markey analysis. The financial data are quarterly from 2009 to 2010. Table B.2 presents all variable definitions. Panel A presents summary statistics for the baseline sample. Panel B gives summary statistics for the sample with energy intensity between 1% and 9%. The N column shows the number of observations used to calculate the statistics in a particular row. The last four columns show percentiles.

Panel A: Baseline sample

Variable	N	Mean	Median	Stdev	25th	75th	10th	90th
$log(CAPEX)$	8,587	-0.112	0.129	3.066	-2.404	2.097	-4.279	3.761
$\Delta log(CAPEX)$	8,587	-0.017	0.000	1.039	-0.496	0.464	-1.198	1.108
$\frac{CAPEX}{Assets}$	8,526	0.010	0.005	0.017	0.002	0.010	0.001	0.020
$log(Assets)$	8,587	5.255	5.299	2.626	3.388	7.087	1.765	8.614
$\frac{Debt}{Assets}$	8,586	0.266	0.158	0.415	0.013	0.333	0.000	0.582
$\frac{NPPE}{Assets}$	8,586	0.207	0.163	0.172	0.079	0.290	0.035	0.428
$\frac{Cash}{Assets}$	8,526	0.173	0.111	0.183	0.043	0.238	0.014	0.425
EI	8,587	0.015	0.008	0.025	0.006	0.012	0.004	0.026
TI	8,107	0.504	0.482	0.300	0.298	0.720	0.112	0.849

Panel B: With energy intensity between 1% and 9%

Variable	N	Mean	Median	Stdev	25th	75th	10th	90th
$log(CAPEX)$	3,018	0.619	0.987	2.873	-1.418	2.650	-3.320	4.102
$\Delta log(CAPEX)$	3,018	0.007	0.016	0.990	-0.445	0.449	-1.053	1.055
$\frac{CAPEX}{Assets}$	2,996	0.012	0.006	0.020	0.003	0.013	0.001	0.025
$log(Assets)$	3,018	5.717	5.859	2.502	4.012	7.552	2.160	8.759
$\frac{Debt}{Assets}$	3,018	0.273	0.214	0.334	0.048	0.370	0.000	0.572
$\frac{NPPE}{Assets}$	3,017	0.292	0.264	0.193	0.145	0.391	0.073	0.560
$\frac{Cash}{Assets}$	2,991	0.130	0.085	0.143	0.031	0.177	0.009	0.309
EI	3,018	0.024	0.017	0.018	0.012	0.026	0.011	0.052
TI	2,766	0.474	0.435	0.296	0.220	0.764	0.157	0.785

Table 9: Firm Capital Expenditure - Waxman-Markey Bill

This table presents results of the panel regression model for Waxman-Markey analysis. The data are quarterly from 2009 to 2010. Panel A presents results for the baseline sample. Panel B shows results for the sample with energy intensity between 1% and 9%. For both panels, the dependent variables are $\Delta log(CAPEX_{i,t})$ in Columns (1) - (3), and $\frac{CAPEX_{i,t}}{Assets_{i,t}}$ in Columns (4) - (6). The specifications include a combination of year-quarter, industry, and firm fixed effects as indicated. The standard errors are clustered at the six-digit NAICS level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

Panel A: Baseline

	$\Delta log(CAPEX_{i,t})$			$\frac{CAPEX_{i,t}}{Assets_{i,t}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$NoExemption_i$ $\times 2009Q2_t$	0.206	0.191	0.078	0.005	0.005	0.004*
	1.592	1.505	0.544	1.520	1.583	1.655
$\times 2009Q3_t$	-0.094	-0.098	-0.117	0.001	0.002	0.002
	-0.578	-0.592	-0.803	0.440	0.507	0.930
$\times 2009Q4_t$	0.120	0.114	0.023	0.003	0.003	0.002
	0.637	0.604	0.144	0.819	0.827	0.797
$\times 2010Q1_t$	0.457***	0.457***	0.462***	0.005**	0.005*	0.006**
	3.652	3.469	3.095	2.083	1.965	2.444
$\times 2010Q2_t$	-0.050	-0.066	-0.031	0.007*	0.007*	0.008***
	-0.253	-0.321	-0.193	1.845	1.798	2.643
$\times 2010Q3_t$	0.003	-0.005	0.107	0.000	0.000	0.004
	0.016	-0.022	0.607	0.022	0.063	1.037
$\times 2010Q4_t$	-0.016	0.002	-0.065	0.004	0.005	0.004
	-0.083	0.010	-0.361	1.466	1.491	1.537
$NoExemption_i$	-0.084			-0.004		
	-0.628			-1.271		
$log(Assets_{i,t-1})$	-0.007**	-0.009**	-0.257***	-0.000***	-0.000*	-0.001
	-2.013	-2.109	-3.910	-2.773	-1.865	-0.959
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	0.039	0.055	0.026	0.001	0.001	-0.002
	1.138	1.383	0.198	0.933	1.008	-0.762
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	0.383***	0.360***	-0.930*	0.011***	0.013***	-0.032**
	4.945	2.980	-1.940	4.524	4.014	-2.564
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.192***	0.251***	0.430**	0.005**	0.006***	0.004
	2.945	2.897	2.366	2.391	2.650	1.130
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	-13.532***	-15.234***	-28.742***	0.482***	0.431***	0.068
	-11.837	-11.008	-14.524	14.730	11.060	1.503
YearQtr FE	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	N	Y	N
Firm FE	N	N	Y	N	N	Y
Observations	8,524	8,524	8,524	8,464	8,464	8,464
Adjusted R^2	0.087	0.074	0.101	0.351	0.375	0.559

Panel B: With energy intensity between 1% and 9%

	$\Delta log(CAPEX_{i,t})$			$\frac{CAPEX_{i,t}}{Assets_{i,t}}$		
	(1)	(2)	(3)	(4)	(5)	(6)
$NoExemption_i$	0.078	0.054	-0.057	0.005	0.005	0.003
$\times 2009Q2_t$	0.468	0.326	-0.300	1.110	1.143	1.224
$\times 2009Q3_t$	-0.220	-0.221	-0.218	0.001	0.001	0.002
	-1.011	-1.010	-1.088	0.131	0.225	0.659
$\times 2009Q4_t$	-0.017	-0.024	-0.129	0.004	0.004	0.002
	-0.067	-0.095	-0.587	0.786	0.793	0.708
$\times 2010Q1_t$	0.542***	0.546***	0.548***	0.006*	0.006*	0.007**
	3.656	3.526	3.144	1.866	1.859	2.335
$\times 2010Q2_t$	-0.148	-0.164	-0.112	0.008*	0.008*	0.009***
	-0.607	-0.646	-0.529	1.787	1.760	2.712
$\times 2010Q3_t$	-0.076	-0.078	0.083	0.000	0.001	0.005
	-0.295	-0.294	0.352	0.010	0.092	1.057
$\times 2010Q4_t$	-0.040	-0.009	-0.071	0.006	0.007*	0.006*
	-0.164	-0.036	-0.298	1.622	1.722	1.683
$NoExemption_i$	-0.013			-0.005		
	-0.080			-1.260		
$log(Assets_{i,t-1})$	-0.019***	-0.013	-0.303***	-0.001**	-0.000	-0.000
	-3.036	-1.594	-2.942	-1.980	-0.697	-0.084
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	0.029	0.068	-0.322	0.002	0.002	-0.005
	0.497	1.039	-1.375	1.043	1.023	-0.926
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	0.183	0.103	-0.904	0.008**	0.009*	-0.035**
	1.617	0.679	-1.458	2.566	1.773	-2.270
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	0.523***	0.597***	0.886**	0.019***	0.022***	0.013
	4.510	3.778	2.356	3.384	2.949	1.331
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	-12.790***	-14.846***	-26.029***	0.466***	0.395***	0.047
	-6.887	-6.136	-11.753	8.301	5.218	0.555
YearQtr FE	Y	Y	Y	Y	Y	Y
Industry FE	N	Y	N	N	Y	N
Firm FE	N	N	Y	N	N	Y
Observations	2,990	2,990	2,990	2,968	2,968	2,968
Adjusted R^2	0.115	0.100	0.129	0.329	0.366	0.547

Appendix

A Proofs

In this appendix we offer proofs for the various propositions in the paper.

Proof of Proposition 1. To obtain a sufficient condition for $I_0^* > 0$, the marginal benefit evaluated at $I_0 = 0$ must be larger than R:

$$(1-\lambda)\left[1-F(RI)\right]R + \lambda\left[1-F(\kappa+R_\lambda I)\right]R_\lambda > R. \tag{A.1}$$

With $\mu_\pi = 1.96\sigma_\pi + \kappa + R_\lambda I$, $F(\kappa + R_\lambda I) = 0.025 > F(RI)$. Hence,

$$(1-\lambda)\left[1-F(RI)\right]R + \lambda\left[1-F(\kappa+R_\lambda I)\right]R_\lambda > (1-\lambda)0.975R + \lambda 0.975 R_\lambda. \tag{A.2}$$

Thus, inequality (A.1) holds provided $(1-\lambda)0.975R+\lambda 0.975R_\lambda > R$, which results in the left inequality in (3). To obtain a sufficient condition for $I_0^* < I$, the marginal benefit evaluated at $I_0 = I$ must be smaller than $R + \psi I$:

$$(1-\lambda)\left[1-F(0)\right]R + \lambda\left[1-F(\kappa)\right]R_\lambda < R + \psi I. \tag{A.3}$$

Notice that

$$(1-\lambda)\left[1-F(0)\right]R + \lambda\left[1-F(\kappa)\right]R_\lambda < (1-\lambda)R + \lambda R_\lambda. \tag{A.4}$$

The right inequality in (3) holds if and only if $(1-\lambda)R+\lambda R_\lambda < R+\psi I$, and thus guarantees inequality (A.3).

The second-order condition for a maximum is satisfied the first time the marginal benefit curve intersects the marginal cost curve. Noting that both the marginal benefit curve and the marginal cost curve slope upward with I_0, by intersecting from above, the marginal benefit curve must have a smaller slope than the slope of the marginal cost curve. Hence, the second order condition is satisfied. Other maxima may exist.

□

Proof of Proposition 2. Denote the left-hand side of (2) by $g(I_0, \lambda)$. Then, using the implicit function theorem on g obtains

$$\frac{dI_0^*}{d\lambda} = -\frac{-\left[1 - F(R(I - I_0))\right] R + \left[1 - F(\kappa + R_\lambda(I - I_0))\right] R_\lambda}{(1-\lambda) f(R(I - I_0)) R^2 + \lambda f(\kappa + R_\lambda(I - I_0)) R_\lambda^2 - \psi} \tag{A.5}$$

where f is the density function of operating profits. The denominator is negative as required in a maximum. To show that the numerator is positive, note that at the optimum, $g(I_0^*, \lambda) = 0$, and rewrite to get

$$-\left[1 - F(R(I - I_0))\right] R + \left[1 - F(\kappa + R_\lambda(I - I_0))\right] R_\lambda = \frac{F(R(I - I_0))R + \psi I_0}{\lambda} > 0. \tag{A.6}$$

With increased early investment, the probability of exercising the investment option at $t = 1$ is higher. $\square$

Proof of Proposition 3. Assuming that F is the cumulative normal distribution with parameters μ_π and σ_π, consider the partial derivative of $g(I_0, \sigma_\pi)$ with respect to σ_π, g_σ,

$$g_\sigma = (1-\lambda)\frac{z_1}{\sigma_\pi}\phi(z_1)R + \lambda\frac{z_2}{\sigma_\pi}\phi(z_2)R_\lambda \tag{A.7}$$

where $z_1 = \frac{R(I-I_0)-\mu_\pi}{\sigma_\pi}$ and $z_2 = \frac{\kappa+R_\lambda(I-I_0)-\mu_\pi}{\sigma_\pi}$ and $\phi()$ is the standard normal density function. Under the condition in Proposition 1 that $\mu_\pi = 1.96\sigma_\pi + \kappa + R_\lambda I$, then $z_1, z_2 < 0$ and I_0^* is decreasing in σ_π. $\square$

B Additional tables

Table B.1: Firm Cash and Debt

This table presents results of the panel regression model given in equation (8). The data are annual from 2010 to 2020. The dependent variables are $\Delta log(Cash_{i,t})$ in Columns (1) - (2), $\frac{Cash_{i,t}}{Assets_{i,t}}$ in Columns (3) - (4), $\Delta log(Debt_{i,t})$ in Columns (5) - (6), and $\frac{Debt_{i,t}}{Assets_{i,t}}$ in Columns (7) - (8). The specifications include a combination of year, industry, firm, and industry-year fixed effects as indicated. The standard errors are clustered at the firm level. t-statistics are shown below the corresponding coefficient estimates. The significance of the coefficient estimate is indicated by * for $p < 0.10$, ** for $p < 0.05$, and *** for $p < 0.01$.

	$\Delta log(Cash_{i,t})$		$\frac{Cash_{i,t}}{Assets_{i,t}}$		$\Delta log(Debt_{i,t})$		$\frac{Debt_{i,t}}{Assets_{i,t}}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$IsHighEOR_{i,t-1} \times PostParis_t$	0.112	0.100	0.008**	0.009	-0.082*	-0.044	-0.019**	-0.007
	1.419	0.710	2.141	1.576	-1.943	-0.747	-2.349	-0.555
$IsHighEOR_{i,t-1}$	-0.100	-0.069	-0.004	-0.003	0.033	0.009	0.020*	0.015
	-0.787	-0.489	-0.740	-0.614	0.559	0.139	1.806	1.341
$log(Assets_{i,t-1})$	-0.408***	-0.413***	-0.020***	-0.021***	-0.168***	-0.198***	0.025**	0.019
	-4.764	-4.324	-4.830	-4.857	-2.709	-3.163	2.128	1.575
$\frac{Debt_{i,t-1}}{Assets_{i,t-1}}$	-0.046	-0.192	-0.014	-0.023	-1.555***	-1.513***	0.541***	0.542***
	-0.156	-0.629	-0.955	-1.451	-8.795	-9.044	15.125	16.895
$\frac{NPPE_{i,t-1}}{Assets_{i,t-1}}$	-0.211	-0.150	-0.052**	-0.050**	0.433*	0.444**	0.114***	0.102**
	-0.491	-0.332	-2.366	-2.149	1.901	1.998	2.851	2.427
$\frac{Cash_{i,t-1}}{Assets_{i,t-1}}$	-9.334***	-9.555***	0.252***	0.264***	0.926*	0.683*	-0.042	-0.084
	-11.934	-11.581	5.482	5.445	1.842	1.853	-0.560	-1.223
$\frac{CAPEX_{i,t-1}}{Assets_{i,t-1}}$	1.115*	0.890	-0.017	-0.032	1.419***	1.244***	-0.097	-0.108
	1.849	1.376	-0.550	-1.118	4.130	3.407	-1.016	-1.083
Observations	2,564	2,564	2,564	2,564	2,506	2,506	2,571	2,571
Adjusted R^2	0.069	0.043	0.667	0.676	0.157	0.234	0.852	0.861
Year FE	Y	N	Y	N	Y	N	Y	N
Firm FE	Y	Y	Y	Y	Y	Y	Y	Y
Industry × Year FE	N	Y	N	Y	N	Y	N	Y

Table B.2: Variable Definitions

This table presents definitions of the main variables. The first column gives the variable name. The second column includes a short description. The last column gives the reference to the raw data source. Detailed descriptions and summary statistics of these variables are in Section 4.

Variable	Description	Source
$\Delta log(Emissions_{i,t})$	Change in the natural log of emissions (aggregated to parent-firm level)	EPA Greenhouse Gas Reporting Program (GHGRP)
$log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$	Natural log of emissions over revenue (i.e., emission intensity)	EPA, S&P Capital IQ
$\Delta log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$	Change in the natural logarithm of emissions to revenue	EPA, S&P Capital IQ
$IsHighEOR_{i,t}$	Indicator variable that takes the value of 1 if $log(\frac{Emissions_{i,t}}{Revenue_{i,t}})$ is above the median, 0 otherwise	EPA, S&P Capital IQ
$log(CAPEX_{i,t})$	Natural logarithm of firm capital expenditures	S&P Capital IQ
$\frac{CAPEX_{i,t}}{Assets_{i,t}}$	Ratio of firm capital expenditures to total assets	S&P Capital IQ
$log(Assets_{i,t})$	Natural logarithm of firm total assets	S&P Capital IQ
$\frac{Debt_{i,t}}{Assets_{i,t}}$	Ratio of firm total debt to total assets	S&P Capital IQ
$\frac{NPPE_{i,t}}{Assets_{i,t}}$	Firm net property plant and equipment to total assets. A measure of asset tangibility (Lemmon, Roberts, and Zender, 2008).	S&P Capital IQ
$\frac{Cash_{i,t}}{Assets_{i,t}}$	Ratio of firm cash to total assets	S&P Capital IQ
$CashFlowVol3Y_{i,t}$	Standard deviation of quarterly $\frac{EDITDAi,t}{Assets_{i,t}}$ over the last three years	S&P Capital IQ
$CashFlowVol5Y_{i,t}$	Standard deviation of quarterly $\frac{EDITDAi,t}{Assets_{i,t}}$ over the last five years	S&P Capital IQ
$IsHighCashFlowVol3Y_{i,t}$	Indicator that takes a value of 1 if $CashFlowVol\_3Y_{i,t}$ is above the median, 0 otherwise	S&P Capital IQ
$IsHighCashFlowVol5Y_{i,t}$	Indicator that takes a value of 1 if $CashFlowVol\_5Y_{i,t}$ is above the median, 0 otherwise	S&P Capital IQ
$PostParis_t$	Indicator variable that equals one if the year is after the 2025 passage of the Paris Accord	

Variable	Description	Source
$log(Total\ Offering\ Amount)$	Natural log of total notional amount of all bonds issued by a parent firm in a year	Mergent FISD
Amount-Weighted Offering Yield (%)	Average offering yield weighted by the offering amount of the bonds issued by a parent firm in a year	Mergent FISD
Maturity-Weighted Offering Yield (%)	Average offering yield weighted by the time-to-maturity of the bonds issued by a parent firm in a year	Mergent FISD
TTM	Average time-to-maturity (in years) weighted by the offering amount of the bonds issued by a parent firm in a year	Mergent FISD
EI	Energy intensity of the six-digit NAICS	Meng (2017), Annual Survey of Manufacturers, and the Census
TI	Trade Intensity of the six-digit NAICS	Meng (2017), USITC
$NoExemption_i$	Indicator variable that equals one if the firm do not receive free emission trading permits under the Waxman-Markey bill.	