Short-Termism and Carbon Emissions: Evidence from a Structural Estimation *

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This Version: July 31, 2024

Abstract

I examine how corporate short-termism affects carbon emissions. Firms that just meet analysts' targets have about 5.9 to 7.2 percentage points higher carbon emissions growth than firms that just miss. To quantify the aggregate impact of short-termism on carbon emissions and firm value, I develop and estimate a quantitative model with short-term incentives for managers and endogenous carbon emissions. Short-term incentives are optimally set by the board of directors to counteract managers' private incentives. In counterfactual simulations, I find that removing short-term incentives from managers' contracts lowers firms' market value by 0.6% and aggregate carbon emissions by 2.3%, or 146 million tons. To put this figure in perspective, short-termist carbon emissions are equivalent to 87% of US aviation emissions in 2022. My results highlight a trade-off between economic value and climate change mitigation.

JEL Codes: G30, G32, G34

Keywords: Short-termism, Carbon Emissions, Agency Conflict

*I thank Mark Egan, Larissa Ginzinger, Alexandra Niessen-Ruenzi, Stefan Ruenzi, Ulrich Roschitsch, Stephen Terry, Constantine Yannelis, and Josef Zechner for valuable feedback and comments. I gratefully acknowledge funding by the Julius Paul Stiegler Memorial Foundation. All errors are my own.

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1 Introduction

Corporate earnings reports are closely monitored by financial markets and evaluated against analysts' forecasts. A large literature in finance documents substantial negative stock price reactions when reported earnings fall short of expected targets. Consistently, survey evidence by Graham et al. (2005) shows that about 90% of US managers feel pressured to meet short-term goals. Several public and private institutions highlight the potential negative effects of short-termism. For example, the United Nations Global Compact proclaims that "short-termism in investment markets is a major obstacle to companies embedding sustainability in their strategic planning and capital investment decisions". In this paper, I focus on the environmental impact of short-term profit pressure and quantify the impact of short-termism on carbon emissions. To this end, I develop and structurally estimate a quantitative model with short-term incentives and endogenous carbon emissions. In counterfactual simulations, I find that removing short-term incentives from managers' contracts lowers carbon emissions by 2.3%, or 146 million tons. To put this figure in perspective, short-termist carbon emissions are equivalent to 87% of US aviation emissions in 2022. My results highlight a trade-off between economic value and climate change mitigation.

Investments in carbon-reducing technologies are particularly sensitive to short-term pressures. The economic benefits of such investments are highly uncertain and may only realize in the long term as climate change worsens, while the costs are incurred today. As a result, some managers on the verge of missing analysts' earnings targets may find themselves either cutting back on green investments or missing targets. As more than half of all managers prefer to forgo positive NPV projects over missing profit targets (Graham et al., 2005), short-term opportunistic cuts in green investments seem plausible. Unfortunately, direct data on green investments are largely missing. However, the outcome of green investment, carbon emissions, is observable. By making a standard structural assumption about the cost function of carbon abatement, I can overcome the data limitation and infer the extent of green investment from firm fundamentals and carbon emissions.

I document two stylized facts. Using data on realized earnings and analysts' earnings targets from IBES for all US listed firms between 2006 and 2022, I compute forecast errors as the difference between realized profits and the median analyst's forecast. First, I show that firms cluster disproportionately just above the zero forecast error threshold, with relatively few firms having small misses. This finding is consistent with the view that managers engage in opportunistic behavior to meet short-term earnings targets. Second, using data on carbon emissions from Trucost, I document a substantial discontinuity in the growth rate of carbon emissions around the zero forecast error threshold. In particular, I show that firms that just meet analysts' targets have carbon emission growth that is about 5.9 percentage points higher than firms that just miss, suggesting opportunistic cuts in carbon mitigation investments to meet short-term earnings targets. This effect is economically significant, amounting to 17 percent relative to the standard deviation of carbon emission growth rates. The discontinuity is more pronounced when evaluating the growth rate of carbon intensity, i.e., carbon emissions scaled by assets or sales, suggesting that firms to the right of the discontinuity become less carbon efficient.

The reduced-form results only represent the local effect around the zero forecast error threshold and should not be interpreted as the average causal effect of short-termism on carbon emissions. One potential concern is that there may be endogenous selection across the threshold. For instance, firms with managers of higher skill may be more likely to slightly beat analysts' forecasts, while firms with managers of lower skill are more likely to miss targets by a small margin. However, the reduced-form evidence serves as an endogenous detection mechanism for identifying short-term pressures and the associated opportunistic changes in carbon emissions. Motivated by this reduced-form evidence, I develop a quantitative model in the spirit of Terry (2023) with short-term incentives for conflicted managers and endogenous carbon emissions. The model allows me to directly quantify the aggregate impact of short-termism on carbon emissions, while explicitly accounting for equilibrium forces.

To establish the intuition for the quantitative model, I first present a simple two-period toy model. In the first period, firms earn exogenous revenues and choose their carbon emissions. Reducing carbon emissions is costly today, but creates value for firms in the long-term because of regulatory actions against brown firms or shifts in consumer demand toward green products. Managers communicate corporate emissions policies to the public, for example in earnings calls or press interviews, where they may be held accountable for their firm's carbon emissions. Being portrayed as an environmentally irresponsible manager is a risk to successful career advancement, so managers derive private disutility from carbon emissions. These private costs represent an agency conflict that pushes managers to reduce carbon emissions more than is privately optimal from the perspective of the firm. In response to this agency conflict, the board of directors optimally chooses to penalize managers for missing short-term profit targets. In equilibrium, the board-induced short-termism solves the agency conflict and increases carbon emissions to the value-maximizing level.

I incorporate the key mechanism of the toy model into a quantitative model of heterogeneous firms with short-term incentives for managers and endogenous carbon emissions. Firms generate unmanipulated sales that follow an exogenous lognormal process. In addition, firms are subject to non-fundamental profit noise. Risk-neutral managers with private costs of carbon emissions have private information about profit noise and choose firms' carbon emissions. As in the toy model, carbon emissions are costly to reduce today, but lower carbon emissions reduce the probability of negative cash flow shocks in the future. Analysts observe firms' fundamentals, correctly process managers' incentives, and issue rational profits forecasts. The board chooses short-term incentives for managers that maximize firm value. Short-term incentives increase carbon emissions, but are also distortive due to opportunistic actions when managers are close to the zero forecast error threshold. Unlike in the toy model, short-term incentives do not restore the equilibrium without agency conflicts because managers have private information about profit noise.

I structurally estimate seven parameters of the model using the Simulated Method of Moments (SMM). I target ten moments computed from the Compustat/IBES/Trucost merged data set. Truecosts compiles and reports carbon emissions of publicly traded companies. However, many observations are imputed by Truecost, i.e., firms did not report their emissions, but Truecost provides an estimate using a proprietary model that appears to depend heavily on firm fundamentals such as assets and sales (e.g., Aswani et al., 2024). I target the correlation of carbon emissions and firm fundamentals, so my estimation requires that carbon emissions are not deterministically related to fundamentals. Therefore, I exclude observations for which Truecost imputed carbon emissions. The parameters related to firm fundamentals are identified from the correlation matrix of sales, profits, carbon emissions, and forecast errors. In addition, the extent of bunching above the zero forecast error threshold helps to identify managers' private cost of carbon emissions, which is reflected in the degree of short-termism in the model. Finally, I target the average carbon emission intensity to calibrate the ratio of cost and benefits of reducing carbon emissions. Overall, the model matches the sign of the targeted correlations and the simulated moments are generally close to their empirical counterparts.

I use the estimated model to run counterfactual simulations and quantify the impact of short-termism on carbon emissions and firm value. I find that eliminating short-termism from managers' contracts reduces aggregate carbon emissions by about 2.3%, or as much as 146 million tons of carbon emissions when benchmarked against the level of aggregate emissions in the US economy in 2022. To put this in perspective, the effect size is equivalent to 87% of US aviation emissions in 2022. At the same time, however, the market value of firms decreases by 0.6%, suggesting a trade-off between climate change mitigation and financial value.

Related Literature. I contribute to two strands of literature. First, I add to the literature on the economic effects of short-termism. Graham et al. (2005) interview more than 400 executives and find substantial short-termism among US managers: about 90% of US managers feel pressure to meet short-term targets and 78% would sacrifice long-term value to smooth earnings. To reach short-term targets, managers use a variety of tools including accruals-based manipulation (e.g., Dechow et al., 1995, Kothari et al., 2005, Cohen et al., 2008), cuts in discretionary expenditures like advertising or R&D (e.g., Bhojraj et al., 2009, Corredoira et al., 2021, Terry, 2023), markup increases (e.g., Errico et al., 2023), or adjustments in the quantity produced (e.g., Roychowdhury, 2006, Zhang and Gimeno, 2010). Using different empirical settings, several authors find substantial evidence that short-term incentives inhibit investment and increase the likelihood of share repurchases as well as M&A transactions (e.g. Almeida et al., 2016, 2019, Edmans et al., 2017, 2022, Ladika and Sautner, 2020). Relative to these contributions, I highlight the environmental consequences of short-termism by providing novel evidence that short-term incentives are associated with an increase in carbon emissions.

Second, I contribute to the growing literature on climate finance, particularly the literature that focuses on corporate environmental policies. As argued by Dai et al. (2021), most of this literature focuses on asset pricing and financial market implications. Financial constraints are shown to play an important role for carbon emissions and toxic releases (e.g., Bartram et al., 2022, Xu and Kim, 2022). Akey and Appel (2021) document the role of firm boundaries in corporate pollution policy, while Dai et al. (2021) find that firms outsource their emissions to foreign suppliers rather than invest in abatement technology. Related to my paper, Atilgan et al. (2024) investigate whether the carbon premium reflects risk or mispricing. They find that higher carbon emissions are associated with superior earnings surprises, suggesting that the carbon premium is at least partly due to an unpriced externality. My study is distinct from theirs in two ways. First, my study differs methodologically in that I provide evidence from a structural estimation, while Atilgan et al. (2024) mainly present reduced-form evidence. Second, they focus on an asset pricing question, while I take a corporate perspective and ask how short-term incentives for managers affect carbon emissions. To the best of my knowledge, no previous study has investigated this question.

Two papers are methodologically close to my study, the first is Terry (2023) and the second is Errico et al. (2023). Terry (2023) examines the effect of short-termism on R&D investment. He develops and estimates a general equilibrium, endogenous growth model. In his model, short-term incentives mitigate an agency conflict and increase firm value. However, short-termism reduces R&D and thus aggregate welfare because of the positive externalities associated with R&D. In a similar spirit, Errico et al. (2023) incorporate short-term incentives into a macro model of customer capital. They show that short-termism leads to higher markups and firm value at the micro level. However, consumers' welfare and total market capitalization is reduced at the macro level. I extend this line of research by showing that short-term incentives increase both firm value and carbon emissions, highlighting a trade-off between financial value and climate change mitigation.

The remainder of this article is structured as follows. In Section 2, I present two stylized facts on short-termism and carbon emissions. Section 3 develops a toy model that features endogenous short-termism and carbon emissions. Section 4 introduces my quantitative model and presents results from the structural estimation. Section 5 concludes.

2 Short-Termism and Carbon Emissions in the Data

In this section, I provide evidence on the relation between short-termism and carbon emissions. I start by introducing my data and the variable definitions. Then, I show that firms bunch disproportionately just above the zero forecast error threshold, with relatively few firms displaying small misses. Finally, I document that firms that just meet analysts' targets have carbon emission growth that is 5.9 to 7.2 percentage points higher than firms that just miss.

2.1 Data and Variable Definitions

Data Sources. I use three different data sources to conduct my empirical analysis. First, I obtain firm fundamentals from Compustat. Second, I collect professional analysts' earnings forecasts from the Institutional Broker's Estimate System (IBES) database. I aggregate individual analysts' forecasts at the firm-year level by taking the median of all earnings forecasts across all analysts. Third, I obtain firm-level carbon emissions data from Trucost. Trucost compiles its data from several publicly available sources, including firms' financial reports and environmental data sources such as the Carbon Disclosure Project. Where companies do not report their emissions, Trucost imputes the missing data points using an extended input-output model. Aswani et al. (2024) show that imputed carbon emissions are an almost deterministic function of firm fundamentals such as assets and sales. Since my structural estimation requires observing variation in carbon emissions that is not deterministically linked to firm fundamentals, I exclude all data points that are imputed by Trucost.

I merge Compustat, IBES, and Trucost using gvkeys and cusips. Following the literature, I remove all regulated (SIC 4900-4999) and financial (SIC 6000-6999) firms. In my empirical analysis, I focus on Scope 1 and Scope 2 carbon emissions. Scope 1 includes direct emissions from sources owned or controlled by the firm, while Scope 2 includes emissions from the consumption of purchased energy associated with a firm's direct operations.[1] My final sample captures earnings surprises, financial data, and carbon emissions for 3,377 observations from 483 firms between 2004 and 2021.

Forecast Errors. I follow Terry (2023) and use IBES profits forecasts and realized annual earnings to construct the forecast error for firm i in year t as

$$fe_{it} = \frac{street_{it} - consensus_{it}}{assets_{it}}, \tag{1}$$

where $street_{it}$ is the dollar value of realized IBES street earnings and $consensus_{it}$ is the median of all analysts' four-quarter-ahead profits forecasts. I normalize by book assets, $assets_{it}$, to account for differences in firm size. In the Online Appendix, I show that scaling by lagged sales instead of assets, using a relative forecast error measure, and using the mean forecast across all analysts as the consensus forecast does not qualitatively affect my results.

Carbon Emissions. I first calculate the sum of Scope 1 and Scope 2 emissions to obtain a comprehensive measure of carbon emissions under the direct control of the firm.[2] I also construct two additional measures of carbon intensity, the first scales total emissions by assets and the second normalizes by sales. Finally, I compute the growth rate of scaled and unscaled emissions for firm i in year t as

$$\widehat{CO}_{2_{it}} = 2\frac{CO_{2_{it}} - CO_{2_{it-1}}}{|CO_{2_{it}}| + |CO_{2_{it-1}}|}, \tag{2}$$

which uses a robust growth rate formula from Davis and Haltiwanger (1992) that is frequently used in empirical papers on firm dynamics (e.g. Errico et al., 2023, Terry et al., 2023, Terry, 2023).

[1] Scope 3 includes indirect upstream and downstream emissions produced by assets not owned or controlled by the firm. I exclude Scope 3 emissions because they are not directly controlled by the firm itself.

[2] In a robustness test, I show that my results are not affected when Scope 1 and Scope 2 emissions are considered separately (see Table A.2).

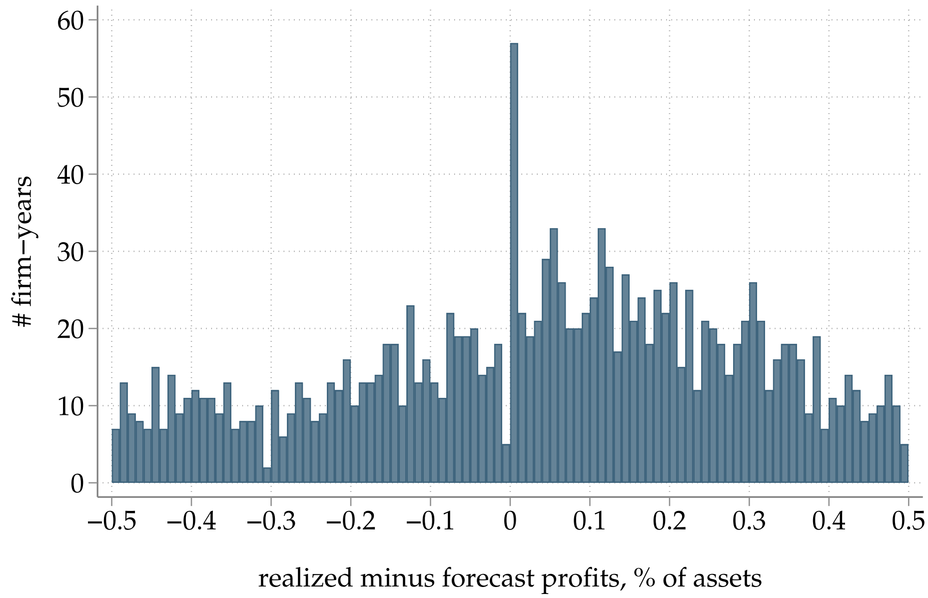

Figure 1—BUNCHING AT THE ZERO FORECAST ERROR

Notes: The figure plots the histogram of forecast errors based on the Compustat/IBES/Trucost merged sample, which includes 3,377 observations from 483 firms between 2004 and 2021. Realized profits are fiscal year dollar street earnings. Forecast profits are median analyst earnings forecasts at a four-quarter horizon. The difference between realized and forecast profits is scaled by book assets. Realized street profits and forecast profits are from IBES, while assets are from Compustat.

2.2 Forecast Errors and Carbon Emissions

I provide two stylized facts. The first concerns the empirical distribution of forecast errors and replicates existing evidence (e.g., Errico et al., 2023, Terry, 2023). The second concerns the discontinuity of carbon emission growth at the zero forecast error and is novel.

I start by examining the distribution of forecast errors, which is displayed in Figure 1. I find that firms bunch disproportionately just above the zero forecast error threshold, with relatively few firms showing small misses.[3] The figure suggests the existence of some systematic pressure to reach short-term profit targets, consistent with survey evidence (Graham et al., 2005). Managers may take opportunistic actions, such as cutting discretionary expenditures or delaying profitable long-term investments, to respond to these short-term pressures. Investments in carbon abatement are a likely target for earnings manipulation as the uncertain benefits may only materialize in the long-term, while the costs decrease earnings today.

[3] In the Online Appendix, I show that the pattern described in Figure 1 is robust to other forecast error measures (see Figure A.1).

Table 1—CARBON EMISSIONS AT THE ZERO FORECAST ERROR THRESHOLD

	(1)	(2)	(3)
Emissions Growth	CO_2	CO_2/Assets	CO_2/Sales
Mean Change at	5.90	7.33	6.62
0 Threshold (p.p.)	(3.70)	(4.10)	(4.04)
Standardized (%)	16.98	20.31	19.02
Fixed Effects	Firm, Year	Firm, Year	Firm, Year
Obs.	3,216	3,216	3,216

Notes: The table reports the estimated mean differences in firms' emissions policies around the zero forecast error threshold. Standardized values express the point estimates in terms of the standard deviation of the outcome variable. Column (1) compares the growth rate of carbon emissions, column (2) carbon emissions scaled by assets, and column (3) carbon emissions scaled by sales for firms that just beat and firms that just missed the consensus earnings forecast. Estimates are obtained using local linear regression with a triangular kernel and optimal Calonico, Cattaneo, and Farrell (2020) bandwidth. Standard errors are clustered by firm and robust t-statistics are shown in parentheses.

To measure opportunistic cuts in carbon abatement investments, I apply a standard regression discontinuity estimator and estimate the following local linear regression

$$\widehat{CO}_{2_{it}} = \alpha + \beta fe_{it} + \gamma fe_{it}\mathbb{1}(fe_{it} \geq 0) + \delta\mathbb{1}(fe_{it} \geq 0) + \tau_t + \eta_i + \varepsilon_{it}, \tag{3}$$

where $\widehat{CO}_{2_{it}}$ is the growth rate of carbon emissions or intensity and fe_{it} is the forecast error for firm i in year t. I include firm and year fixed effects when estimating equation (3) to control for time-invariant heterogeneity across firms and business cycle effects. The parameter of interest, δ, captures the average difference in carbon emissions growth between firms that just hit and firms that just missed their profit targets.

Table 1 reports the results. Column (1) shows that firms that just meet analysts' profit targets have carbon emission growth that is about 5.9 percentage points higher than firms that just miss, suggesting opportunistic cuts in carbon mitigation investments to meet short-term earnings targets. This effect is economically significant, amounting to 17 percent relative to the standard deviation of carbon emission growth rates. The discontinuity is more pronounced when I examine the growth rate of carbon intensity in columns (2) and (3), i.e., carbon emissions scaled by assets or sales, consistent with the interpretation that firms to the right of the discontinuity do not solely grow faster than firms to the left, but actually become

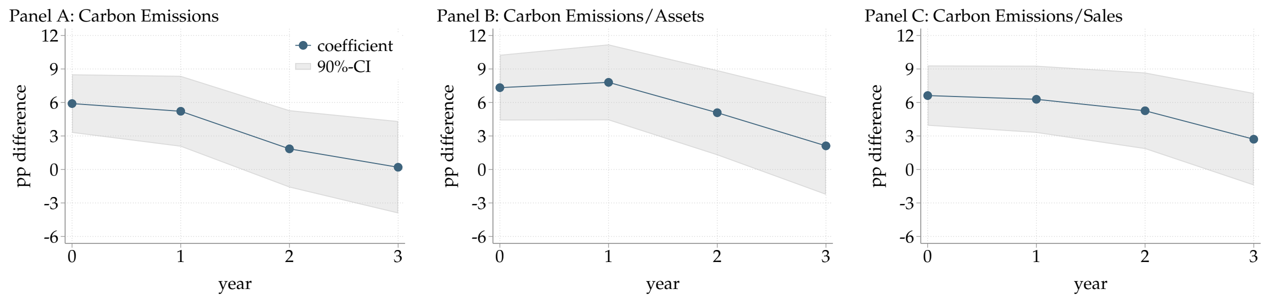

Figure 2—DYNAMIC EFFECT ON CARBON EMISSIONS

Notes: The figure plots the average difference in carbon emissions growth for the years t to $t+3$ between firms that just meet analysts' profit targets and firms that just miss them in year t. Panel A compares the contemporaneous and future growth rates of carbon emissions, Panel B carbon emissions scaled by assets, and Panel C carbon emissions scaled by sales for firms that just beat and firms that just missed the consensus earnings forecast in year t. Estimates are obtained using local linear regression with a triangular kernel and optimal Calonico, Cattaneo, and Farrell (2020) bandwidth. Standard errors are clustered by firm and 90% confidence bands are displayed.

less carbon efficient.

One caveat is that I do not observe actual carbon abatement investments, only firms' carbon emissions, which are the result of the abatement process. If the discontinuities documented in Table 1 were due to opportunistic cuts in abatement investment, I would expect some persistence in the effects. Figure 2 plots the average difference in carbon emissions growth for the years t to $t+3$ between firms that just meet analysts' profit targets and firms that just miss them in year t. When firms beat earnings targets by a small margin in year t, Panel A shows that their unscaled carbon emissions growth is significantly higher for two additional years. Moreover, Panels B and C indicate that the effect is slightly more pronounced for the carbon intensity, consistent with a rather persistent drop in carbon efficiency.

The results in this section do not represent the causal effect of short-termism on carbon emissions. As in Terry (2023), the discontinuities are not the causal effect of achieving a profit target, but serve only as an endogenous detection mechanism. Moreover, these reduced-form stylized facts represent only local, relative variation that may not survive aggregation. Finally, local discontinuities do not provide counterfactuals for an economy without short-term incentives. In the remainder of this paper, I develop and estimate a quantitative model to address these concerns.

2.3 Robustness of Reduced-Form Results

I perform several tests to show that the reduced-form results are robust. In Figure A.1, I document that the bunching pattern is robust to the use of alternative forecast error measures. In particular, I show that scaling by lagged sales instead of assets, using a relative forecast error measure computed via $2\frac{fe_{it}}{|street_{it}|+|consensus_{it}|}$, and using the mean forecast across all analysts as the consensus forecast does not qualitatively affect my results.

In my baseline estimation, I exclude observations for which Trucost imputed carbon emissions because their estimates are shown to depend heavily on firm fundamentals such as sales and assets (Aswani et al., 2024). In Table A.1, I document that the discontinuity results are robust to using the full sample. Specifically, the estimated effects become slightly smaller in magnitude but remain statistically significant. This result is expected since the imputed emissions may be well explained by firm fundamentals, which in turn are to some extent controlled by firm fixed effects. Moreover, I show that the results hold when considering Scope 1 and Scope 2 emissions separately (see Table A.2). The main specification in Table 1 uses the optimal bandwidth bw^* according to Calonico et al. (2020). In Figure A.2, I vary the bandwidth in the range $[0.5bw^*, 2bw^*]$ and find that the results are robust.

3 A Toy Model of Short-Termism and Carbon Emissions

Environment. I develop a stylized two-period toy model with optimal short-term incentives for managers and endogenous carbon emissions to illustrate the key mechanism through which short-termism affects carbon emissions. Consider a single firm that lives for two periods, t and $t+1$, and generates exogenous revenues Q per period. The firm faces a trade-off when deciding its carbon emissions policy: reducing carbon emissions e_t in t is costly, but high carbon emissions in t may trigger a negative cash flow shock in $t+1$. The cost of carbon mitigation is given by:

$$c(Q, e_t) = \psi \left(\frac{Q}{e_t}\right)^2,$$

where higher values for ψ imply that the firm is less cost-efficient in reducing carbon emissions. High carbon emissions in t may cause costly regulation or decreasing demand from consumers, so cash-flows in $t+1$ are reduced in expectation by αe_t. Firm value $V(e_t)$ is therefore given by

$$V(e_t) = Q - \psi\left(\frac{Q}{e_t}\right)^2 + \frac{1}{R}\left(Q - \alpha e_t\right),$$

where $R > 1$ is the real interest rate, which is taken given by the firm. Moreover, profits are cash flows plus accounting noise

$$\Pi_t = Q - \psi\left(\frac{Q}{e_t}\right)^2 + \nu_t, \quad \nu_t \sim N(0, \sigma_\nu^2).$$

The noise term ν_t, with cdf F_ν and pdf f_ν, is unobserved by managers when determining carbon emissions e_t. Outside analysts observe Q and issue profit forecasts

$$\Pi_t^f = Q - \psi\left(\frac{Q}{e_t^f}\right)^2.$$

The board of directors determines the compensation package for managers, which consists of an equity component θ_d and a short-term clawback θ_π. In addition, managers incur private costs $\phi_e < 0$ from carbon emissions. These private costs may arise for several reasons. First, some managers may care about climate change and therefore incur non-pecuniary costs from high carbon emissions. Second, even if managers do not care about climate change, they may care about their firm's carbon emissions because of career concerns. For example, managers communicate corporate emissions policies to the public, such as in earnings calls or press interviews, where they may be held accountable for their firm's carbon emissions. Being portrayed as an environmentally irresponsible manager is a risk to successful career advancement, so managers derive private disutility from carbon emissions. The manager's objective is

$$V_m(e_t|\theta_\pi, \Pi_t^f) = Q - \psi\left(\frac{Q}{e_t}\right)^2 + \frac{1}{R}\left(Q - \alpha e_t\right) - \theta_\pi \mathbb{P}(\Pi_t < \Pi_t^f) + \phi_e e_t,$$

where the probability of missing profit targets $\mathbb{P}\left(\Pi_t < \Pi_t^f\right) = F_\nu\left(\psi Q^2\left[(1/e_t)^2 - (1/e_t^f)^2\right]\right)$ is decreasing in carbon emissions e_t.

Equilibrium. An equilibrium with rational expectations, optimal short-term incentives, and unbiased analyst forecasts is defined as: i) managers determine carbon emissions e_t to maximize their utility conditional on analysts' profit forecasts and board-determined short-term incentives θ_π; ii) analysts issue rational forecasts conditional on their information set; iii) the board of directors optimally chooses short-term incentives to maximize firm value given managers' choices.

Optimal Policies. Figure 3 plots firm value and manager payoffs as a function of carbon emissions e_t in an illustrative paramterization. The level of carbon emissions e_t^* that maximizes firm value is given by

$$e_t^* = \left(\frac{2R\psi Q^2}{\alpha}\right)^{1/3}. \tag{4}$$

Manager payoffs without short-term incentives are depicted by the thick grey line in Figure 3. Since managers incur private costs from carbon emissions, the optimal level of carbon emissions from the manager's perspective and in the absence of short-term incentives is

$$e_t^{\text{noST}} = \left(\frac{2R\psi Q^2}{\alpha - R\phi_e}\right)^{1/3}, \tag{5}$$

with $e_t^{\text{noST}} < e_t^*$ as $\phi_e < 0$. Thus, without short-term incentives, the manager chooses a level of carbon emissions that is lower than the value-maximizing level from the perspective of shareholders. To restore the level of carbon emissions e_t^* that maximizes firm value, the board of directors optimally introduces short-term incentives according to

$$\theta_\pi^* = -\frac{R\phi_e}{\alpha f_\nu(0)}. \tag{6}$$

The resulting manager payoff is plotted by the blue thick line and shows that the optimal level of carbon emissions e_t^* from the perspective of shareholders is restored in equilibrium.

Intuitively, short-term incentives preserve firm value maximization because they impose cost discipline on conflicted managers. Since managers incur private costs from carbon emissions, in the absence of short-term incentives they would want to choose lower levels of carbon emissions relative to shareholders. However, with short-term incentives, reducing

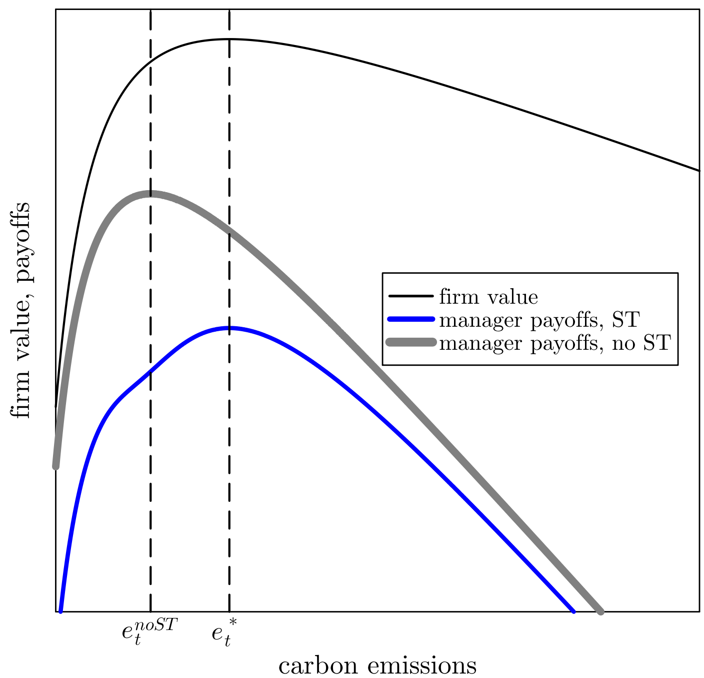

Figure 3—CARBON EMISSIONS IN THE TOY MODEL
Notes: The figure plots firm value (thin grey line) and manager payoffs (thick grey and blue lines) as a function of carbon emissions e_t in an illustrative parameterization.

carbon emissions increases the likelihood of missing short-term profit targets, which pushes managers back to the firm's value-maximizing level e_t^*. Although the toy model conveys the mechanism by which short-term incentives can increase carbon emissions, it lacks features that make it realistic enough to confront the data. I now develop a quantitative model of endogenous short-term incentives and carbon emissions that can replicate key moments in the data.

4 Quantitative Model

In the spirit of Terry (2023), I analyze the quantitative effect of short-termism on carbon emissions in a dynamic, infinite-horizon, discrete-time model with heterogeneous firms, optimal short-term incentives for managers, and endogenous carbon emissions. Although the quantitative model is more involved, the main intuition from the toy model carries over.

4.1 Model Environment

Firms. The economy is populated by a unit mass of firms, indexed by i. Each firm is managed by a risk-neutral manager whose compensation contract is determined by the board of directors. Firms generate unmanipulated sales that follow an exogenous lognormal process

$$\log q_{i,t+1} = \rho \log q_{i,t} + z_{i,t+1}, \quad z_{i,t+1} \sim N(0, \sigma_z^2). \tag{7}$$

I assume that variable inputs absorb a fixed share, so operating revenues are $(1-l)q_{i,t}$, where l is the labor share.

Managers choose the level of carbon emissions $e_{i,t}$. From the firm's perspective, carbon emissions are costly to reduce today, but high carbon emissions may trigger negative cash flow shocks in the future. As in the toy model, the cost of carbon mitigation is given by:

$$c(q_{i,t}, e_{i,t}) = \psi \left(\frac{q_{i,t}}{e_{i,t}} \right)^2 = \frac{\psi}{\eta_{i,t}^2}, \tag{8}$$

where higher values for ψ imply that the firm is less cost-efficient in reducing carbon emissions. Note that $c(q_{i,t}, e_{i,t})$ is increasing (decreasing) in $q_{i,t}$ ($e_{i,t}$), so the cost of carbon mitigation is increasing quadratically in the inverse of the carbon intensity $\eta_{i,t}$. High carbon emissions in t may cause costly regulation or decreasing demand from consumers, so cash-flows in $t+1$ are reduced in expectation by $\alpha e_{i,t}$.

Firm profits are operating revenues adjusted for cash flow shocks from past carbon emissions, carbon mitigation costs, and accounting noise:

$$\Pi_{i,t} = (1-l)q_{i,t} - \alpha e_{i,t-1} - \psi \left(\frac{q_{i,t}}{e_{i,t}} \right)^2 + q_{i,t}\varepsilon_{i,t} + q_{i,t}\nu_{i,t}, \tag{9}$$

where $\varepsilon_{i,t} \sim N(0, \sigma_\varepsilon^2)$ is noise observable to the manager when decisions are made, while $\nu_{i,t} \sim N(0, \sigma_\nu^2)$ is noise unobservable to the manager when decisions are made.

Managers. In each period, a risk-neutral manager maximizes her utility by choosing the level of carbon emissions. As discussed above, the manager incurs private costs $\phi_e < 0$ per unit of carbon emissions, which incentivizes the manager to reduce carbon emissions below the level that is optimal from shareholders' perspective. The manager's contract consists of an equity component θ_d, and a short-term clawback θ_π that the manager must pay if she fails to meet analysts' earnings targets. Thus, the manager solves the dynamic problem

$$\begin{aligned} V_M(e_{i,t-1}, q_{i,t}, \varepsilon_{i,t}) = \max_{e_{i,t}} \Bigg\{ \theta_d \left[(1-l)q_{i,t} - \alpha e_{i,t-1} - \psi \left(\frac{q_{i,t}}{e_{i,t}} \right)^2 \right] - q_{i,t}\theta_\pi \mathbb{P}_\nu \left(\Pi_{i,t} < \Pi^f_{i,t} \right) \\ + \phi_e e_{i,t} + \frac{1}{R_t} \mathbb{E}_t \left[V_M(e_{i,t}, q_{i,t+1}, \varepsilon_{i,t+1}) \right] \Bigg\}, \end{aligned} \tag{10}$$

where I set the equity share $\theta_d = 1$ without loss of generality when solving and estimating the model.

Analysts. A mass of risk-neutral, rational analysts receives private benefits from accurately predicting firms' profits. Analysts issue their optimal forecasts conditional on the available information at time t. In particular, analysts observe the unmanipulated revenues $q_{i,t}$ and past emissions $e_{i,t-1}$ of the firm. Moreover, analysts observe the cost structure of the firm. However, they do not observe either component of profit noise, $\varepsilon_{i,t}$ and $\nu_{i,t}$. I assume that analysts' private benefits decline in mean squared prediction error, so rational forecasts are characterized by

$$\Pi^f_{i,t}(e_{i,t-1}, q_{i,t}) = \arg\min_{\Pi^f_i} \mathbb{E}_t \left\{ \left(\Pi_{i,t} - \Pi^f_i \right)^2 \mid e_{i,t-1}, q_{i,t} \right\} = \mathbb{E}_t[\Pi_{i,t} \mid e_{i,t-1}, q_{i,t}]. \tag{11}$$

Board of Directors. Because of the private cost of carbon emissions, managers are conflicted and want to choose lower carbon emissions than is optimal from the firm's perspective. The board knowingly implements short-term incentives θ_π to impose cost discipline on managers and align their interests with those of shareholders. Given managers' emissions policy, the value of the firm reads as

$$V_F(e_{i,t-1}, q_{i,t}, \varepsilon_{i,t}) = \left\{ (1-l)q_{i,t} - \alpha e_{i,t-1} - \psi \left(\frac{q_{i,t}}{e^*_{i,t}} \right)^2 + \frac{1}{R_t} \mathbb{E}_t \left[V_m(e^*_{i,t}, q_{i,t+1}, \varepsilon_{i,t+1}) \right] \right\}. \tag{12}$$

Let $F(e_{i,t-1}, q_{i,t}, \varepsilon_{i,t})$ be the unconditional stationary distribution from a given choice of short-term incentives θ_π. The board of directors of each firm determines the optimal level of short-term incentives θ_π^* to maximize the firm's unconditional mean value by solving for

$$\theta_\pi^* = \arg\max_{\theta_\pi} \int V_F(e_{i,t-1}, q_{i,t}, \varepsilon_{i,t} \mid \theta_\pi) dF(e_{i,t-1}, q_{i,t}, \varepsilon_{i,t} \mid \theta_\pi). \tag{13}$$

Three points are worth discussing. Without the agency conflict, the manager problem coincides with the firm problem and the optimal short-term incentives are $\theta_\pi^* = 0$. With private costs from carbon emissions for managers, optimal short-term incentives increase firm value and carbon emissions. Unlike in the toy model, short-term incentives do not restore the equilibrium without agency conflicts because managers have private information about profit noise.

4.2 Equilibrium

An equilibrium with rational expectations and optimal short-term incentives consists of a policy function $e^*(q, \varepsilon)$, manager and firm value functions, $V_M(e_{t-1}, q, \varepsilon)$ and $V_F(e_{t-1}, q, \varepsilon)$, a schedule of optimal profit forecast $\Pi^f(q)$, optimal short-term incentives θ_π^*, and a stationary distribution of firms $F(e_{t-1}, q, \varepsilon)$ such that:

(i) The manager chooses $e^*(q, \varepsilon)$ to solve Equation (10) given analysts' short-term profit forecasts $\Pi^f(q)$ and board-determined short-term incentives θ_π;

(ii) Analysts' profit forecasts solve Equation (11) conditional on the optimal emissions policy $e^*(q, \varepsilon)$ set by managers;

(iii) The board of directors determines θ_π^* to solve Equation (13) conditional on managers' optimal emissions policies $e^*(q, \varepsilon)$ and analysts' forecasts $\Pi^f(q)$;

(iv) The stationary distribution of firms $F(e_{t-1}, q, \varepsilon)$ is consistent with the stochastic processes for q and ε and managers' emissions policies $e^*(q, \varepsilon)$.

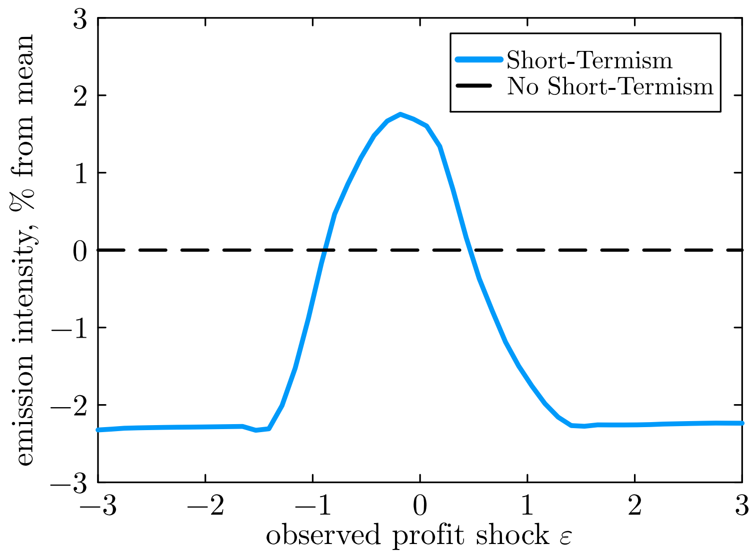

Figure 4—CARBON EMISSION POLICIES

Notes: The figure plots the model-implied emissions intensity as a function of the observed profit shock ε. The blue line illustrates the emissions policy with optimal short-term incentives (θ_π^*). The dashed line depicts the emissions policy with no short-term incentives ($\theta_\pi = 0$). The emission intensity is expressed in percentage deviations from the mean. The observed profit shock is expressed in standard deviations. The policies are based on the estimated parameters reported in Table 2.

4.3 Manager Policies

In Figure 4, I plot the model-implied emission intensity as a function of the observed profit noise ε. The blue line shows the emissions policy under my baseline parameter estimates with optimal short-term incentives (θ_π^*), while the dashed line shows the counterfactual emissions policy with no short-term incentives ($\theta_\pi = 0$). The emissions intensity is expressed in percentage deviations from the mean. The observed profit shock is expressed in standard deviations. Without short-termism, managers rationally ignore the profit noise ε. With short-term incentives, however, managers react to profit noise. For small absolute values of profit noise, managers correctly infer that they are close to the target, and opportunistically cut spending on carbon mitigation to reduce the probability of missing analysts' profit targets. In contrast, for large absolute values of profit noise, managers understand that they will either miss or beat short-term profit targets, so their optimal emissions policy in such states is dominated by their private disutility from carbon emissions, leading to below-average emissions intensity.

In summary, short-termism affects carbon emissions in two ways. First, carbon emissions show increased sensitivity to profit noise due to opportunistic cuts in carbon abatement investments when managers are close to targets. Second, short-termism poses a persistent threat of missing targets for managers. This threat increases the mean costs of carbon abatement investments and therefore carbon emissions intensity in equilibrium. I estimate the size of this effect in my quantitative analysis.

5 Quantitative Results

In this section, I structurally estimate the model and quantify the impact of short-termism on carbon emissions. Section 5.1 discusses the structural estimation of the parameters, while section 5.2 documents the quantitative impact of short-termism on carbon emissions.

5.1 Structural Estimation

I externally calibrate the real interest rate and the labor share. Following Terry (2023), I set the real interest rate R to 1.06 per year. The labor share is set to 0.6 (Karabarbounis, 2024).

Simulated Methods of Moments. The remaining seven parameters of the model in Table 2 are estimated by SMM. I target ten moments computed from the Compustat/IBES/Trucost merged data set. Truecosts compiles and reports carbon emissions of publicly traded companies. Many data points for carbon emissions are imputed by Truecost based on a proprietary model that appears to depend heavily on firm fundamentals such as assets and sales (e.g., Aswani et al., 2024). I exclude observations for which Truecost imputed carbon emissions because my estimation strategy requires that carbon emissions are not deterministically related to fundamentals. My final estimation sample comprises earnings surprises, financial data, and carbon emissions for 3,377 observations from 483 firms between 2004 and 2021.

I focus on moments related to correlation matrix of sales, profits, carbon emissions, and forecast errors that are informative about the parameters that drive firm fundamentals. I also consider the probability of meeting analysts' forecasts, defined as the percentage of positive forecast errors. In addition, I focus on the extent of bunching above the zero forecast error

Table 2—BASELINE MODEL RESULTS

Panel A: Estimated parameters	Symbol	Estimate	Std. Error
Persistence of sales	ρ	0.1996	0.0007
Std of sales shock	σ_z	0.0195	0.0422
Std of observed profit shock	σ_ε	0.0583	0.0161
Std of unobserved profit shock	σ_ν	0.0137	0.0389
Private costs manager	ϕ_e	-0.3217	0.0634
Cost of carbon mitigation	ψ	0.0125	0.0072
Future cost of carbon	α	1.5228	0.0721
Panel B: Targeted moments	**Data**	**Model**	**t-stat**
Mean emission intensity	0.2165	0.2481	-1.3222
Std of forecast error	0.3422	0.3461	-0.7017
Std of profitability	0.0375	0.0606	-26.4614
Correlation of sales growth, profit growth	0.3879	0.1145	26.1452
Correlation of sales growth, emission growth	0.3044	0.4286	-15.4908
Correlation of pofit growth, emission growth	0.1221	0.0529	9.8556
Correlation of pofit growth, forecast error	0.4218	0.7133	-8.71
Correlation of emission growth, forecast error	-0.0281	-0.0345	1.1834
Prob of meeting forecast	0.5743	0.5904	-1.1567
Prob. of just meeting to prob. of just missing	1.4429	1.3373	0.7521
Panel C: Quantitative Impacts			
Change in firm value			-0.30%
Change in carbon emissions			-2.27%

Notes: The table reports the baseline results from the structural estimation. Panel A shows the parameter estimates using efficient moment weighting. Panel B documents a comparison of the actual data moments with the simulated moments using the optimal parameter vector $\hat{\theta}_{SMM}$. The actual data moments are computed from a panel that comprises earnings surprises, financial data, and carbon emissions for 3,377 observations from 483 firms between 2004 and 2021. Model moments use a panel of 1,000 firms and 25 years. Standard errors are clustered by firm. Panel C computes the quantitative impacts of removing short-termism on firm value and carbon emissions.

threshold. More specifically, this moment is defined as the ratio of the number of firms whose earnings exceed analysts' forecasts by a maximum of ten percent to the number of firms whose earnings fall short of analysts' expectations by a maximum of ten percent. These two local moments help to identify managers' private cost of carbon emissions, which is reflected in the degree of short-termism in the model. Finally, I target the average carbon emissions intensity to calibrate the ratio of cost and benefits of reducing carbon emissions.

I choose the parameter vector, θ, so that the simulated moments from the model are close to the actual data moments. More formally, the optimal parameter vector, $\hat{\theta}_{SMM}$, is defined by

$$\hat{\theta}_{SMM} = \arg\min_{\theta} \Big(m(X \mid \theta) - m(X)\Big) W \Big(m(X \mid \theta) - m(X)\Big)', \tag{14}$$

where $m(X)$ is the moment vector computed from the actual data and $m(X \mid \theta)$ is the moment vector computed from the simulated data. I use the optimal weight matrix W and cluster standard errors by firm (Hansen and Lee, 2019). For a given parameter vector θ, I generate a panel of 1,000 firms for 25 years with a burn-in period of 25 years. I then compute the simulated moments and compare them to the actual data moments. I use the Simulated Annealing algorithm to find the minimum in Equation (14).

Identification. Next, I discuss the identification of the parameters. Following Terry (2023), Figure 5 plots selected moments that are particularly helpful in identifying managers' private costs of carbon emissions ϕ_e. With lower ϕ_e and thus more short-termism, managers engage more in opportunistic cuts in carbon abatement investments. Hence, the correlation between profit growth and emissions growth increases moderately (top left). More short-termism increases the marginal cost of carbon abatement, so revenue growth is less correlated with emissions growth (top right). Moreover, a lower ϕ_e induces managers to meet profit forecasts more often (bottom left). Also, the bunching around the zero forecast error increases with the degree of short-termism (bottom right). Thus, the agency conflict parameter ϕ_e is identified from global correlation moments related to firm fundamentals and local moments related to forecast error patterns.

The identification of the other parameters is standard. Figure B.3 in the Online Appendix shows selected targeted moments that are particularly useful for identifying the remaining parameters of the model. The correlation between sales growth and emissions growth decreases with the persistence of unmanipulated sales ρ (top left). Increased volatility in unmanipulated sales, σ_z, generates a stronger correlation between profit growth and emissions growth due to larger shifts in profits (top middle). The top right panel shows that an increase in observable profits noise, σ_ε, leads to a higher correlation between profits growth and forecast errors because the amount of private information available to managers increases. In contrast, an increase in unobservable profit noise, σ_ν, reduces the extent of bunching at zero forecast error because managers can no longer accurately target analysts' forecasts (bottom

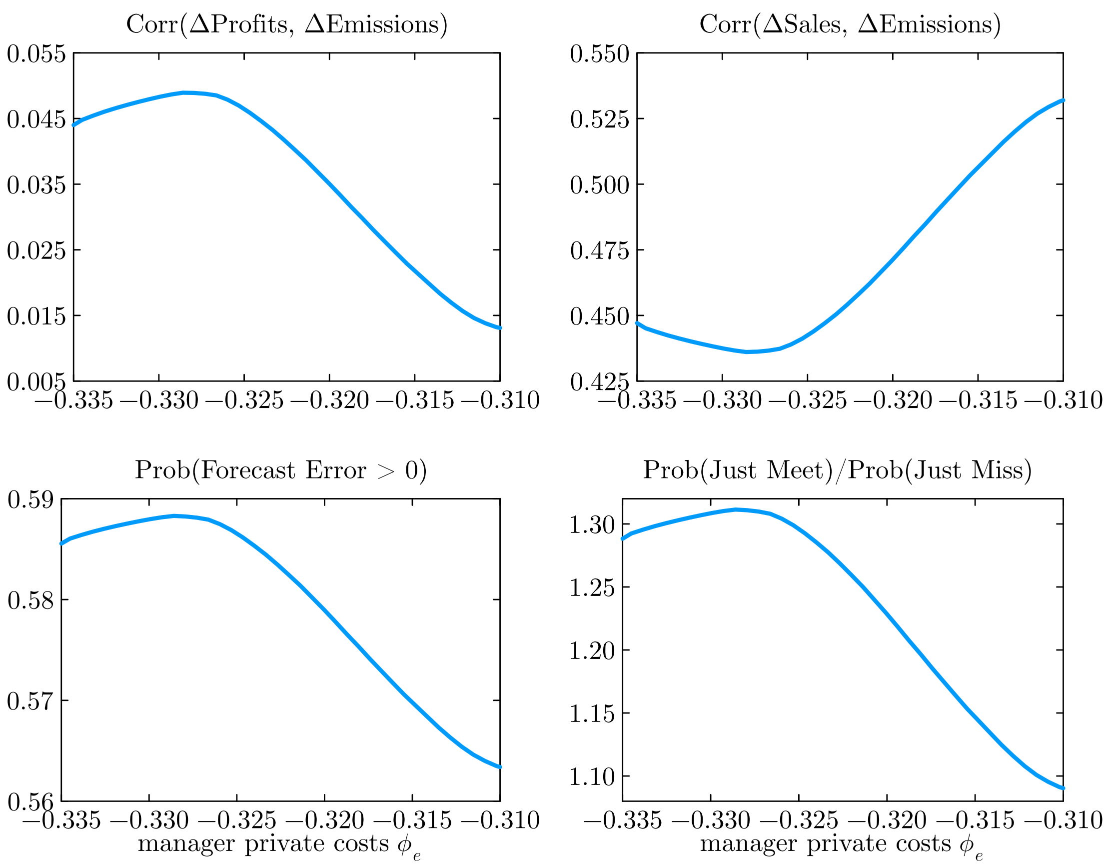

Figure 5—IDENTIFICATION OF PRIVATE MANAGER COSTS PARAMETER ϕ_e
Notes: The figure plots selected, smoothed moments as a function of managers' private cost of carbon emissions ϕ_e for values below and above the estimated $\phi_e = -0.322$.

left). A higher cost of carbon abatement, ψ, increases the correlation between profits growth and forecast error (bottom middle). Finally, carbon intensity intuitively decreases in the future cost of carbon, α, as carbon emissions become more costly to the firm (bottom right).

Baseline Estimates. Panel A of Table 2 reports my baseline parameter estimates. The estimated persistence of unmanipulated sales is comparatively low with $\hat{\rho} \approx 0.2$. Consistent with Terry (2023), the ratio of earnings noise observed by managers $\frac{\hat{\sigma}_\varepsilon^2}{\hat{\sigma}_\varepsilon^2+\hat{\sigma}_\nu^2} \approx 0.95$ is high, suggesting substantial information asymmetries. Managers incur quantitatively significant private costs from carbon emissions. These private costs amount to about 20% of the discounted firm-level future costs carbon emissions $\frac{\hat{\alpha}}{R} \approx 1.44$. In response, the board of directors chooses moderately large short-term incentives with $\hat{\theta}_\pi \approx 1.55\%$. Thus, missing analyst's targets is as costly for managers as a one-time loss of 1.55% of mean production profits, which is close to the estimate presented in Terry (2023).

Model Fit. Panel A of Table 2 compares the data moments with the simulated moments implied by my baseline parameter estimates. In summary, the model fits the data reasonably well. The mean carbon emission intensity in the data is about 0.22, while it is 0.25 in the simulated data. The standard deviations of the relative forecast error and profitability are closely reproduced by the model. Importantly, the model is able to correctly match the sign of the targeted correlations. In particular, the model jointly matches the negative correlation between emissions growth and the relative forecast error, as well as the overall positive correlation of emissions growth and sales/profit growth from fundamentals. Finally, the model fits the local moments associated with the probability of hitting analysts' profit targets and the bunching pattern at the zero forecast error threshold.

5.2 The Quantitative Impact of Short-Termism

I use the estimated model to run counterfactual simulations and quantify the impact of short-termism on carbon emissions and firm value. In particular, I compare carbon emissions and firm value in my estimated model with optimal short-term incentives $\hat{\theta}_\pi \approx 1.55\%$ to a counterfactual economy with no short-termism. I find that eliminating short-termism from managers' contracts reduces aggregate carbon emissions by approximately 2.3%. This amounts to approximately 146 million tons of carbon emissions when benchmarked against the level of aggregate emissions in the US in 2022. To put this in perspective, the effect size is equivalent to 87% of US aviation emissions in 2022. At the same time, however, the market value of firms decreases by 0.6%, suggesting a trade-off between climate change mitigation and financial value.

6 Conclusion

I examine how corporate short-termism affects firms' carbon emissions. I show that firms that just meet analysts' targets have about 5.9 to 7.2 percentage points higher carbon emissions growth than firms that just miss. Motivated by these reduced-form facts, I develop and estimate a quantitative model with short-term incentives for managers and endogenous carbon emission policies. Managers communicate corporate emissions policies to the public and may be held accountable for their firm's carbon emissions. I argue that a negative environmental performance is a risk to successful career advancement, so managers derive private disutility from carbon emissions. These private costs represent an agency conflict that pushes managers to reduce carbon emissions more than is privately optimal from the perspective of the firm. In response to this agency conflict, the board of directors optimally chooses to penalize managers for missing short-term profit targets.

I estimate the model using data on forecast errors, firm fundamentals, and carbon emissions. The model matches the moments in the real data reasonably well. I use the estimated model to run counterfactual simulations and find that removing short-term incentives from managers' contracts reduces firm value by 0.6% and carbon emissions by 2.3%, or up to 146 million metric tons. This effect size is quantitatively meaningful and equivalent to 87% of US aviation emissions in 2022. In summary, my results highlight a tradeoff between climate change mitigation and financial value.

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For Online Publication

Online Appendix to:

"SHORT-TERMISM AND CARBON EMISSIONS: EVIDENCE FROM A STRUCTURAL ESTIMATION"

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A Robustness of Reduced-Form Results

A.1 Alternative Forecast Error Measures

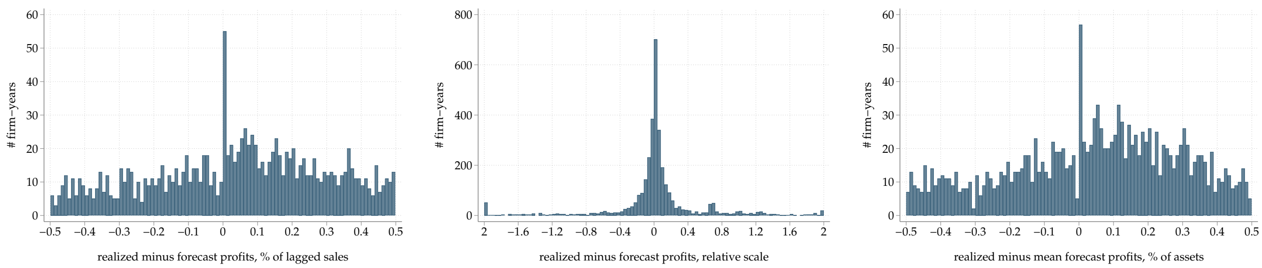

Figure A.1—ALTERNATIVE FORECAST ERROR MEASURES

Notes: The figure plots the histograms of alternative forecast error measures based on the Compustat/IBES/Trucost merged sample, which includes 3,377 observations from 483 firms between 2004 and 2021. Realized profits are fiscal year dollar street earnings. The left panel scales the baseline forecast error by lagged sales instead of assets. Following Terry (2023), the middle panel plots the relative forecast error computed via $2\frac{fe_{it}}{|street_{it}|+|consensus_{it}|}$. The right panel uses the mean across all analysts' earnings forecasts at a four-quarter horizon as the consensus estimate.

A.2 Discontinuity Results for Full Sample

Table A.1—Regression Discontinuity Results for Full Sample

	(1)	(2)	(3)
Emissions Growth	CO_2	CO_2/Assets	CO_2/Sales
Mean Change at	3.21	3.46	1.73
0 Threshold (p.p.)	(3.39)	(3.37)	(2.35)
Standardized (%)	9.44	9.91	7.23
Fixed Effects	Firm, Year	Firm, Year	Firm, Year
Obs.	9,646	9,646	9,645

Notes: The table reports the estimated mean differences in firms' emissions policies around the zero forecast error threshold. Compared with the baseline estimates, I also include observation for which Trucost imputed carbon emissions based on a proprietary model that depends on firm fundamentals. Standardized values express the point estimates in terms of the standard deviation of the outcome variable. Column (1) compares the growth rate of carbon emissions, column (2) carbon emissions scaled by assets, and column (3) carbon emissions scaled by sales for firms that just beat and firms that just missed the consensus earnings forecast. Estimates are obtained using local linear regression with a triangular kernel and optimal Calonico, Cattaneo, and Farrell (2020) bandwidth. Standard errors are clustered by firm and robust t-statistics are shown in parentheses.

A.3 Discontinuity Results By Emissions Scope

Table A.2—Regression Discontinuity Results By Emissions Scope

	(1)	(2)	(3)
	CO_2	CO_2/Assets	CO_2/Sales
Panel A: Scope 1 Emissions			
Mean Change at	6.87	8.60	8.02
0 Threshold (p.p.)	(2.79)	(3.29)	(3.16)
Standardized (%)	14.90	18.34	17.42
Fixed Effects	Firm, Year	Firm, Year	Firm, Year
Obs.	3,213	3,213	3,213
Panel B: Scope 2 Emissions			
Mean Change at	6.20	5.07	6.91
0 Threshold (p.p.)	(3.68)	(2.85)	(3.79)
Standardized (%)	16.30	12.90	18.36
Fixed Effects	Firm, Year	Firm, Year	Firm, Year
Obs.	3,216	3,216	3,216

Notes: The table reports the estimated mean differences in firms' emissions policies around the zero forecast error threshold. Compared with the baseline estimates, I estimate the discontinuity for Scope 1 and Scope 2 emissions separately. Standardized values express the point estimates in terms of the standard deviation of the outcome variable. Column (1) compares the growth rate of carbon emissions, column (2) carbon emissions scaled by assets, and column (3) carbon emissions scaled by sales for firms that just beat and firms that just missed the consensus earnings forecast. Estimates are obtained using local linear regression with a triangular kernel and optimal Calonico, Cattaneo, and Farrell (2020) bandwidth. Standard errors are clustered by firm and robust t-statistics are shown in parentheses.

A.4 Bandwidth Choice

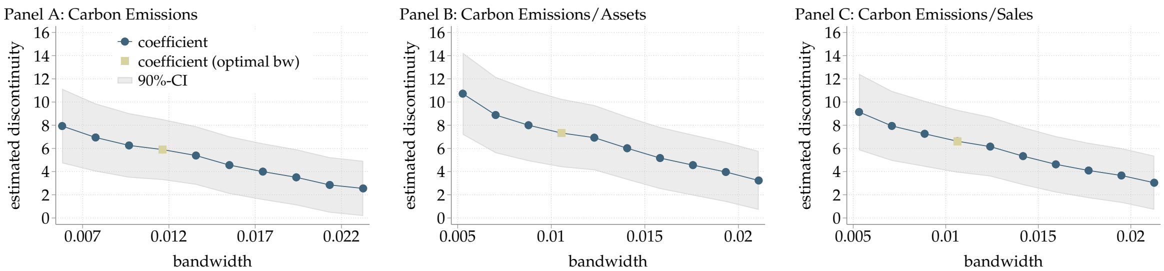

Figure A.2—Regression Discontinuity Results for Various Bandwidth Choices

Notes: The figure plots the estimated discontinuity in carbon emissions growth for firms just hitting analysts' forecasts as a function of different bandwidth choices (on the horizontal axis). Panel A compares the growth rate of carbon emissions, Panel B carbon emissions scaled by assets, and Panel C carbon emissions scaled by sales for firms that just beat and firms that just missed the consensus earnings forecast. I estimate Equation (3) using a local linear regression discontinuity with triangular kernel and a bandwidth ranging between 0.5 and 1.5 times the optimal bandwidth according to Calonico et al. (2020). The square represents the estimated discontinuity when using the optimal bandwidth that is considered in the main specification. The 90% confidence bands take clustering at the firm level into account.

B Appendix to Quantitative Model

B.1 Identification of Other Parameters

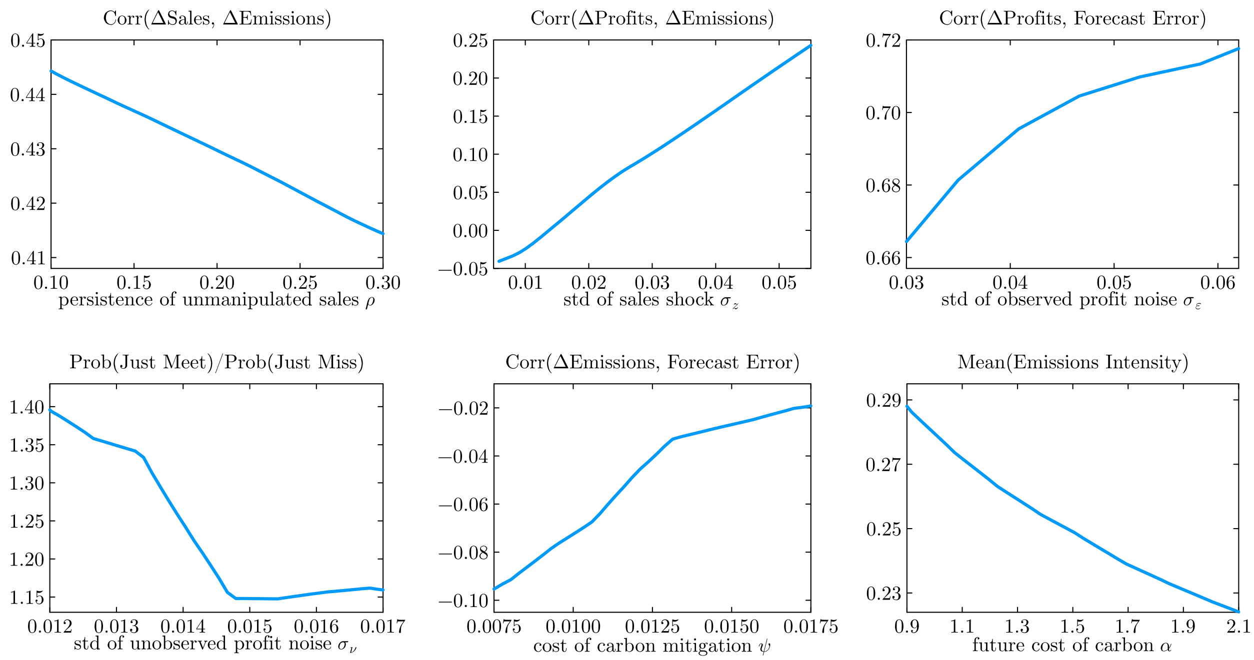

Figure B.3—IDENTIFICATION OF OTHER PARAMETERS

Notes: The figure plots selected, smoothed moments used for estimating the remaining parameters. I vary the parameter values above and below their estimated value.